PACIFIC REGION SALMON STOCK MANAGEMENT PLAN

H

West Coast of Vancouver Island

Statistical Areas - 22, 23, 24, 25, 26 & 27

DISCUSSION DOCUMENT

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PACIFIC REGION
SALMON RESOURCE MANAGEMENT PLAN

VOLUME H

WEST COAST OF
VANCOUVER ISLAND

Department of Fisheries and Oceans
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TO: THE READER

This discussion document was prepared to replace the April, 1985, edition of the Pacific Region Salmon Resource Management Plan. This edition differs from the original in title, in format, and in the inclusion of additional management options.

The title has been changed to the Pacific Region Salmon Stock Management Plan to make clear the distinction between stock management and fleet management. This document contains options for managing salmon stock production and harvest to make best use of the salmonid resource. It is hoped that a first edition of a Salmon Fleet Management Plan will be published by mid-1987. That document will contain options for managing the salmon fishing fleet to make best use of the labour, capital and other resources that are employed in harvesting the salmonid resource.

This edition was prepared in a new format to encourage review and comment by area, and to facilitate a regular revision process. This volume is one of twelve dealing with salmonid stocks by geographical area (individual or small groups of Statistical Areas) and by species (for Chinook and Coho salmon). Discussed in this volume are the salmon resources of the West Coast of Vancouver Island.

This document contains information on the status of salmon stocks, habitat, and fisheries, and a detailed discussion of some of the management problems that exist. Its purpose is to present existing information to provide a context for some management and enhancement options that have been suggested to rebuild the salmon resources. The local and specialized knowledge of advisors and others familiar with the West Coast of Vancouver Island is vital to improving existing options, creating new ones if necessary, and to choosing the best possible combination of options to form the basis of our long-term management plans.

Pending such a review, no endorsement of the analysis or proposals contained in this document is implied or intended. Rather, I see a consultative process being applied to develop long-term management plans using the Salmon Stock Management Plan as a basis for discussion. Please approach this document constructively strengthening its weaknesses and building on its strengths. Working together, we can develop a plan to manage the Pacific salmon resource to the detriment of none and for the benefit of all.

Yours truly,

P.S. Chamut

P.S. Chamut
Director General
Fisheries - Pacific

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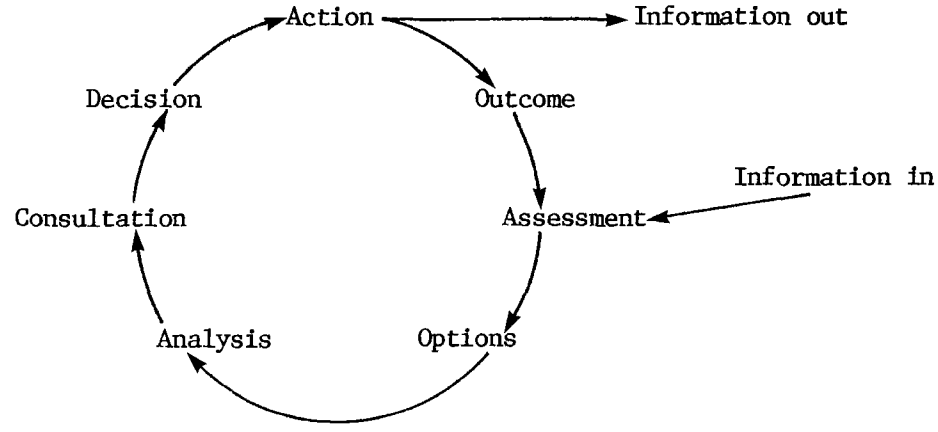
FOREWORD

This document contains plans for managing Pacific salmon fisheries. No decisions have yet been taken on these plans; they remain options from which to choose a direction for the future of Pacific salmon fisheries. Starting soon, but probably extending over a long period and subject to review and revision, decisions will be made in concert by all parties with an interest in the resource. The Salmon Stock Management Plan has been produced to motivate discussion and assist the decision-making process by identifying current strategies and problems, stating goals, and describing means by which they might be achieved.

The genesis of this document can be found on the first page of the Pearse Report, where the most serious criticism of the Department of Fisheries and Oceans was identified as, "the lack of cohesive, consistent, and forward-looking policies and programs with respect to fisheries management, enhancement, and environmental protection".* The Department has responded to this criticism, and to the subsequent recommendations made by Pearse,** by devoting considerable effort and resources, beginning in mid-1984 and continuing to date, to the production of the Salmon Stock Management Plan.

Nevertheless, this document is not finalized; in fact, it probably can never be finalized. The Salmon Stock Management Plan has been written as a discussion document that will evolve over time as the planning cycle, illustrated below, proceeds.

The Planning Cycle



* P.H. Pearse, Turning the Tide: A New Policy for Canada's Pacific Fisheries, (Ottawa, Supply and Services Canada, (1982), p.1.

**Pearse, p. 39.

Past actions and outcomes of salmon management are documented and assessed in this report. New ideas and options for future management strategies are also analysed and will be the subject of informal and formal consultation. In this way, options can be transformed into decisions to take new and different actions leading to better outcomes. Because fisheries in general, and salmon fisheries in particular, are susceptible to rapid change, these outcomes will, in turn, generate renewed discussions as the cycle continues. The Salmon Stock Management Plan, then,is a record of management planning and action that is intended to motivate and facilitate this planning cycle.

This document contains information on the status of salmon stocks, habitat, and enhancement. As well, it discusses in some detail the fisheries that exist in each area, management problems, and options to rebuild our salmon resource by management and enhancement. The Salmon Stock Management Plan is a diverse document that will continue to evolve through annual updates to incorporate new information, assess performance, review objectives, identify problems, describe strategies, and analyse new options for managing salmon stocks. It should be read in this spirit. It is a document that is meant to stimulate thought and discussion with a view to generating interesting and useful new ideas that will find their way back into the document.

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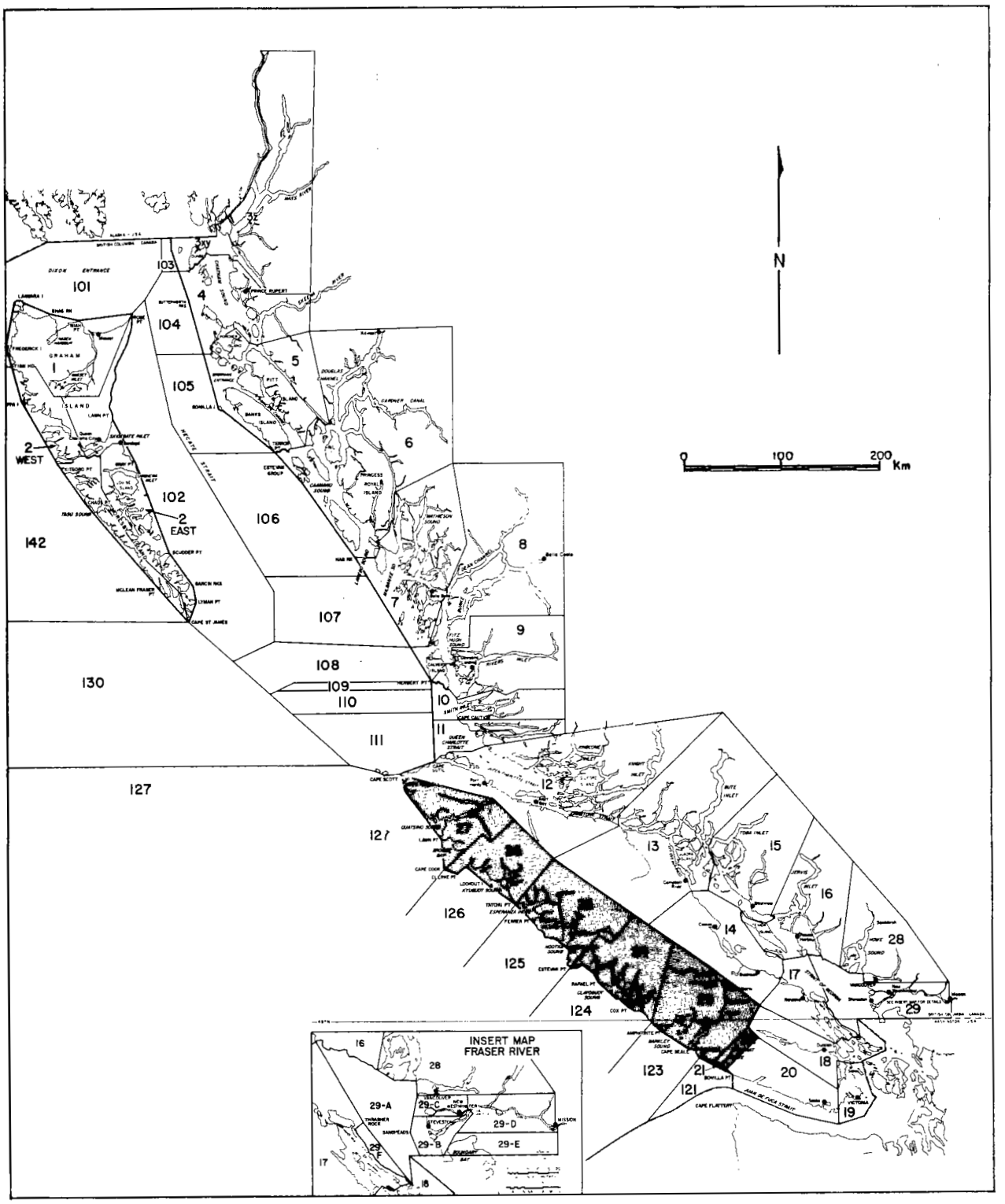

Figure 1. Department of Fisheries and Oceans Statistical Areas, British Columbia.

WEST COAST VANCOUVER ISLAND

1. INTRODUCTION

The west coast of Vancouver Island is divided into seven Statistical Areas (Figure 1). From south to north (Areas 21-27) these include: Nitinat (Areas 21 and 22), Barkley Sound, Clayoquot, Nootka, Kyoquot and Quatsino.

The coastline of this region is irregular. The terrain is generally rugged and the dominant plant community is temperate rain forest. Seasonally-high rainfall in combination with steep slopes contribute to extreme fluctuations in flow regimes on many watercourses.

The west coast of Vancouver Island supports all five salmon species as well as steelhead, although sockeye and chum constitute most of the natural salmon production in the region. Major enhancement facilities currently operate in three Statistical Areas (Areas 22, 23, 25) and produce chum, chinook, coho and steelhead. Lake enrichment for enhancement of sockeye stocks has been undertaken in Great Central, Sproat, Henderson, Kennedy and Hobiton lakes with varying degrees of success. In addition, numerous small-scale enhancement activities and public involvement projects have resulted in the production of small numbers of salmon in various areas along the coast.

Salmon are taken in both commercial net and troll fisheries. The troll fishery harvests passing stocks bound for the Strait of Georgia, Fraser River and parts of the United States,[1,2] as well as local stocks from the western side of Vancouver Island. The fishery generally takes place outside the surfline. Historically, trollers caught primarily chinook and coho. However, effort has been directed at all salmon species in recent years. Net fisheries occur in several areas within the region and include both seine and gillnet operations. The largest net fishery occurs in Area 23 and is directed at sockeye stocks. Later in the season, chum fisheries take place at various locations along the coast. These fisheries are directed at hatchery stocks or harvestable surpluses of wild chum stocks.[3] There is also a small terminal net harvest of hatchery chinook in Alberni Inlet.

In addition to commercial fisheries, there are sport and native fisheries. Native fisheries are for the purpose of fulfilling food requirements and are

directed primarily at salmon stocks in rivers adjacent to Indian settlements. Sport fisheries are expanding and now include guided operations.

Logging has been the major development activity on Vancouver Island affecting salmon-producing stream environments and there are few remaining pristine watersheds in the region. Forestry-related activities and removal of tree cover can affect salmon-producing streams by causing exaggeration of stream flows, changes in water temperature, scouring, siltation and debris deposition.[4]

The following text is divided into six major sections discussing successive Statistical Areas along the west coast of Vancouver Island from south to north. Area 21 is primarily a fishing area and is discussed in conjunction with Area 22. Each section includes a description of the local stocks, fisheries, enhancement and management activities. The discussion of fisheries is focused primarily on the commercial sector because it accounts for the majority of the salmon harvest. Native fisheries tend to be small local harvests and the sport fishery targets primarily on chinook and coho, which are discussed in Volumes K and L. Results of simulation modelling of various management options are also discussed. Detailed information on stock attributes, habitat status and distribution of disease agents in each of the Statistical Areas is provided in Appendices I-III.

2. STATISTICAL AREAS 21/22

Statistical Area 21 is located between Bonilla Point and Pachena Point, and Area 22 encompasses the tidal waters of Nitinat Lake approximately midway between these two locations (Figure 2). Most of the salmon production in this region originates from the Nitinat drainage system, which includes the Hobiton sub-basin (Hobiton Lake and Hobiton River), Caycuse River, Doobah Creek, and Nitinat River. Other systems that support salmon are the Klanawa River and Cheewhat Creek, both of which drain into Area 21.

2.1 Stock Description

Runs of chum, sockeye, chinook, and coho salmon and steelhead occur in Area 22. However, chum are the most abundant and economically important species. Pink salmon have not been recorded in the Nitinat or Cheewhat systems since 1964.[5]

2.1.1 Sockeye

The Hobiton drainage is the only major sockeye-producing system in Area 22. A smaller sockeye run also occurs in the Cheewhat River.[5] Among all of the salmon stocks that return to the Nitinat watershed, Hobiton sockeye have the earliest run timing. Sockeye enter the Nitinat system between March and July and hold in Nitinat Lake until October before moving into Hobiton Lake to spawn.[5,6] The Hobiton stock are beach spawners.[1]

Prior to enrichment of Hobiton Lake, escapements indicated that spawner returns were relatively stable at an average of about 5700 between 1950 and 1980.[7] Enrichment of Hobiton Lake began in 1977. The first significant returns from broods raised under enriched conditions were in 1981. During this year, sockeye escapement was estimated at 13,300.[8] Average escapements for the period 1950-1985 are summarized below:

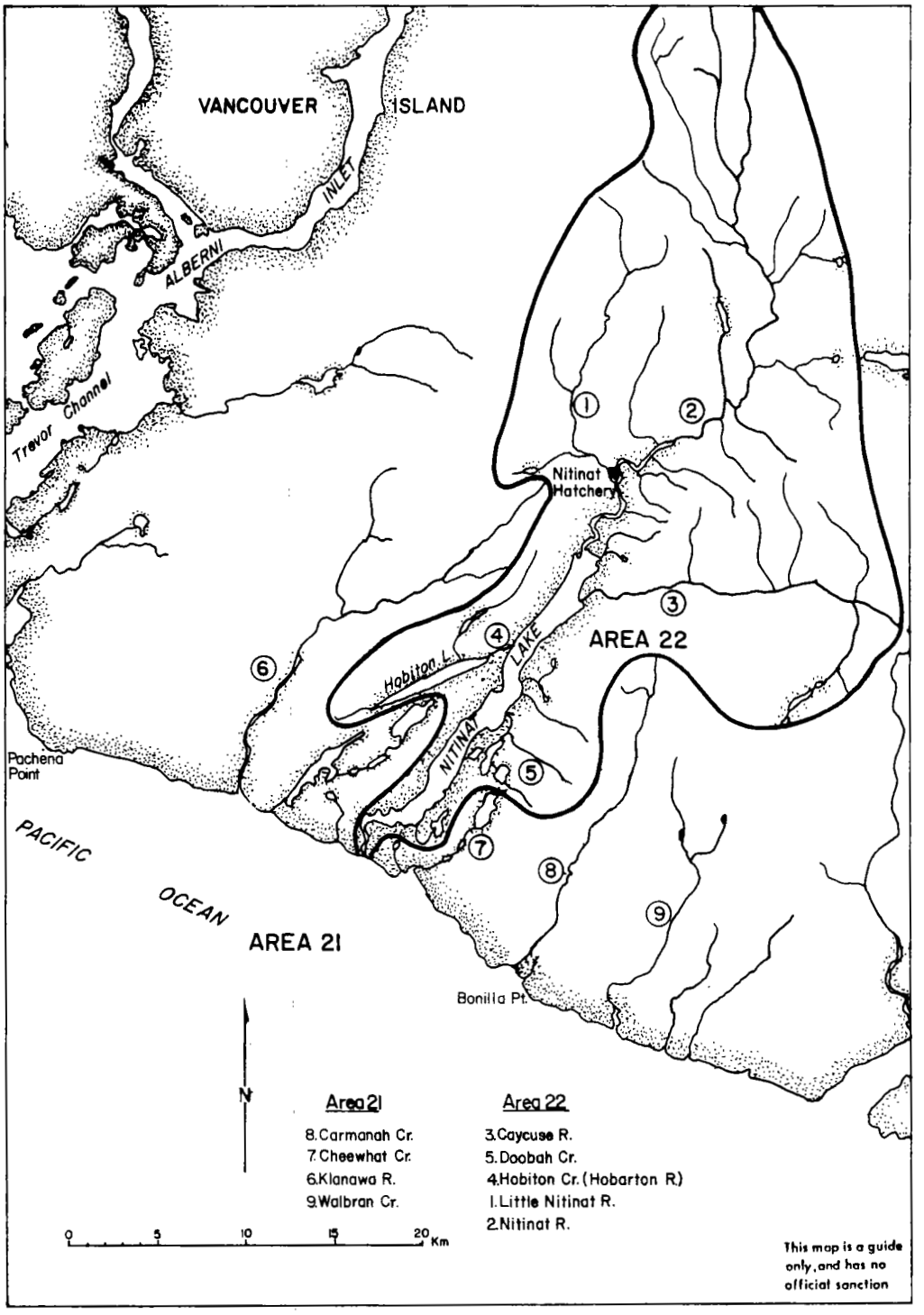

Figure 2. Statistical Areas 21 and 22, showing major salmon-producing streams.

Years	Average Escapement[9]
1950-59	6200
1960-69	6300
1970-79	4600
1980-85	17200
1986	1800

Based on historic escapements, the target for Hobiton sockeye was initially set at 15,000 spawners. Returns in recent years have frequently exceeded that level, which indicates that the production capacity may be greater than expected under enriched conditions. As a result, the escapement target for Hobiton sockeye was increased to 20,000 spawners.[10] Unfortunately, 1986 escapement was well below target level for Hobiton Lake, but an additional 2000 sockeye were counted in the Cheewhat River.

2.1.2 Chum

Chum spawn in all of the major streams in Areas 21 and 22. However, 95% of the total escapement originates in the Nitinat River.[11] Spawner estimates indicate that chum abundance in the area has increased over time, with average escapements of 36,300, 41,100 and 68,400 for the three decades beginning in 1950.[9] Despite this apparent increasing trend, annual chum returns to Area 22 have fluctuated widely and the target escapement of 125,000 has been reached on only 4 occasions between 1951 and 1983 (the first returns to Nitinat hatchery occurred in 1983). From an estimated total stock of 2.1 million chum, the 1985 escapement (including hatchery returns) was 225,000.[12] In 1986 escapement to the Nitinat system was 140,000 spawners; Area 22 chum escapement was about 143,400.[12]

Environmental factors have had a major influence on the stock abundance of chum in the area. However, catch and escapement data indicate that intense fishing occurred between 1951 and 1960, which also likely influenced stock abundance. In addition, there is uncertainty regarding the reliability of historic escapement data for this area.[11]

Results of stock assessment indicate that there is extreme variability in the rates of return, age composition, and sex ratio of Nitinat chum. The number of adult returns relative to brood-year escapements averaged 4.71:1 during the period 1968-1981. However, extremes of 0.09:1 and 19.97:1 were recorded in 1972 and 1981, respectively. The average age composition of the Nitinat stock was 34% three-year-old, 62% four-year-old and 4% five-year-old spawners (return years 1971-1982).[11] However, major differences in age composition have been apparent among years. For example, three-year-old fish comprised only about 3% of total returns in 1968 compared with 93% of total returns in 1971.[11] The extreme variability in return rates observed may partially reflect the uncertain escapement estimates.

As a result of variability in return rates and lack of correlation between returns and brood-year escapement, run forecasting is speculative. Optimum escapement levels are not apparent from existing stock data[11] and, therefore, current escapement targets are based on estimates of spawning capacity and records of historic escapement.

Nitinat chum are considered to have a late migration timing relative to other West Coast Vancouver Island stocks.[11] The adults arrive at their natal streams in early October and peak spawning occurs during the first week of November. Spawning is complete by the end of November. Migration timing of the Nitinat stock is based on catch data and spawning records.

The Nitinat watershed has been logged extensively and this may have contributed to the extreme fluctuations in stock size due to amplification of run-off conditions.[11] Despite these erratic hydrologic conditions, Nitinat Lake generally provides a favourable rearing environment for chum and available data show excellent growth rates for juvenile fish.[6]

Below depths of 20-30 m, Nitinat Lake is oxygen deficient. Since 1950, there have been five documented fish kills that resulted from mixing of the deeper hydrogen sulphide waters with surface water.[11,6] Environmental factors that contribute to this partial inversion of lake waters are tides, extreme winds, storm conditions and low precipitation.[6]

2.1.3 Chinook

The Nitinat River supports the only chinook stock in Area 22. Nitinat chinook are fall-run, ocean-type fish typical of West Coast Vancouver Island stocks. They mature primarily as three- and four-year-old fish.[13]

As indicated below, there is no apparent trend in chinook escapements from Area 22 during the period 1950 to 1984. Chinook escapement in 1985 was the highest on record, but this was due in part to escapement of hatchery fish. There were roughly 8000 chinook spawners to the Nitinat River in 1986:

Years	Average Chinook Escapement[9]
1950-59	1580
1960-69	2225
1970-79	1375
1980-85	3750
1986	8000

The migration timing of chinook follows that of Nitinat sockeye. Chinook enter Nitinat Lake during mid-August and spawning generally occurs from September through October.[6]

2.1.4 Coho

Although coho are found in all of the major watercourses of Area 22, production of wild stocks is not large. The Nitinat River is the single most important coho producer in the area.[6]

The run timing for coho is late relative to the other salmon stocks that return to the Nitinat watershed. Adult spawners begin entering Nitinat Lake during September, but arrival on the spawning grounds does not occur until October through December.[6]

Although escapement data for Nitinat coho are considered insufficient for developing stock-recruitment relationships, inferences regarding general trends in

escapements can be made. A summary of average escapements for Area 22 coho from 1950 to 1985 is provided below:

Years	Average Escapement
1950-59	3400
1960-69	3000
1970-79	1800
1980-85	200
1986	4425

Coho escapements from Area 22 appear to have declined considerably since 1979. However, this trend must be interpreted with caution due to uncertainties in the escapement data.

Due to limited resources and inconsistent estimation techniques, it has been difficult to obtain accurate escapement data for the West Coast Vancouver Island salmon stocks. For coho stocks, this problem is compounded by the fact that[1]:

1. the migration of coho to natal streams occurs over a period of several months;

2. coho often return in late fall/early winter when visibility is poor and DFO manpower and resources are reduced;

3. collection of coho escapement data is often not given high priority; and

4. the number of streams or sections of streams that are surveyed is inconsistent among years.

The latter point is of particular concern when reviewing historical escapement trends because total spawner counts for the area (aggregate of stream counts) are not comparable between years.

2.1.5 Pink

There is no pink salmon production from Area 22.

2.1.6 Steelhead

Area 22 supports both winter and summer runs of steelhead. The major runs occur in the Nitinat and Caycuse Rivers. Information regarding steelhead escapement is poor, but annual returns of adult fish are believed to number 100 to 300 for each of the two rivers.[14] Winter-run steelhead return to fresh water from November through April and are more abundant than the summer-run steelhead. Summer steelhead arrive in the area from May through August. Populations are currently depressed due to historical sport fishing pressure, incidental harvest of steelhead in the Indian food fishery, and interception by commercial net fisheries that target on Fraser River sockeye and pink salmon.[14]

2.2 Managed Fisheries

2.2.1 Sockeye

Hobiton sockeye have not been commercially harvested since 1957.[15] However, this stock sustains a local food fishery by the Nitinat Band. Since 1982, the fishery has been administered and regulated by the Indian band under permit from DFO. The lake enrichment section of Fisheries Research Branch (FRB) in Nanaimo provides advice to the band regarding stock abundance.

The Indian food fishery occurs primarily at the mouth of Hobiton Lake, but sets are occasionally made in Nitinat Narrows. Although gillnets are the major gear type used in this fishery, drag seines are occasionally used.

Available catch data indicate that sockeye catches in the Indian food fishery have ranged from 1000 to 3000 fish since the 1950s.[5,6,12] In 1985, the reported catch totalled 1000 sockeye, although the actual number of sockeye taken in the fishery may have been higher.[12]

2.2.2 Chum

Commercial openings for Area 22 chum have been sporadic since the 1950s due to reduced stocks. Between 1951 and 1985, only thirteen fisheries were permitted in the area. Recent openings occurred outside Nitinat Lake in Area 21 during 1984, 1985 and 1986. Prior to 1984, the fishery for Area 22 chum was last opened in 1980. Although returns were sufficient to permit a commercial fishery, effort was excessive and less than half of the target escapement was achieved that year. Annual catch and escapement of Area 22 chum are provided in Table 1.

Fisheries have operated both inside (Area 22) and outside (Area 21) Nitinat Lake. Fishing vessels are less exposed to harsh weather and sea conditions within the lake, but entry and exit from the lake can be difficult due to the narrow entrance and shallow waters around Nitinat Bar.[11] Chum stocks are more susceptible to net harvests in the lake due to their avoidance of deeper oxygen-depleted waters. However, the economic return for these chum is significantly less than for those harvested outside the lake. A study completed in 1981 to assess the condition of chum before and after entering Nitinat Lake indicated that adults generally hold outside the lake until they are sexually mature, and this results in a marked difference in the quality of individuals between the two areas (Table 2). Incidental harvest of other (non-Nitinat) chum stocks occurs when the fishery takes place outside the lake.

Area 22 chum are currently managed as a single stock aggregate, and fisheries are regulated in an attempt to achieve the target escapement of 125,000.[11] Unfortunately, escapement estimates are poor due to the infrequency of surveys and the flooding of streams, which is common during the fall. The commercial fisheries involve gillnet and seine vessels and usually commence during the second week of October. Peak catches of chum generally occur during the third and fourth weeks of that month.

Commercial and test fisheries data indicate that the age structure and sex ratio of Nitinat chum varies widely among years, which makes run forecasting extremely difficult. Due to the large exposed coastline outside of Nitinat Lake and tendency of large schools of fish to appear without any prior indication, test fishing data is not currently considered sufficiently reliable for estimating stock strength.[12]

Table 1. Catch, escapement, total return and harvest rate of Nitinat chum salmon, 1974-1986.[9,11,12]

Year	Catch	Escapement	Total Return	Harvest Rate
1974	0	98,100	98,100	0
1975	0	9,900	9,900	0
1976	0	19,700	19,700	0
1977	0	43,700	43,700	0
1978	0	8,400	8,400	0
1979	0	4,500	4,500	0
1980	273,904	54,500	328,404	83.4
1981	0	115,000	115,000	0
1982	0	22,500	22,500	0
1983	0	8,000	8,000	0
1984	186,663	76,000	262,663	71.1
1985	1,951,384	210,000	2,161,384	90.3
1986	418,863	143,400	562,263	74.5

Table 2. Quality comparison of chum salmon caught in Area 21 and 22 test fisheries, 1981.[11]

	Fish Quality*		
	Semi-bright(%)	Qualla (%)	Canners (%)
Outside (Area 21)	49.3	38.4	12.3
Inside (up to Oct. 15)	0.2	33.5	66.2
Inside (Area 22)	0.3	18.6	81.1

* Qualla fish have darker skin and lighter meat than semi-bright fish; canners are slightly lower in quality than quala due to tissue damage (e.g., scars, net marks).

2.2.3 Chinook and Coho

Area 22 chinook and coho are managed as part of the West Coast Vancouver Island stock aggregate. Directed harvests include the west coast troll and sport fisheries. Most of the catch is taken in the troll fishery, which is managed to treaty-imposed catch ceilings of 375,000 chinook and 1.75 million coho (for the entire west coast of Vancouver Island). The local troll harvest in Area 21 takes place outside Nitinat Lake, while the sport harvest of chinook occurs mainly along Nitinat Bar at the entrance to the lake. Anglers take coho at Nitinat Bar and along the Nitinat River.[12]

The troll fishery is managed to restrict catches within ceiling limits, to remain open as long as possible and to minimize the catch of sub-legal chinook and coho.[12] These objectives are accomplished by comparison of actual catches with anticipated harvests and subsequent implementation of area/time closures based on consultation with the groups affected.[12] In 1985, the first opening for chinook was from 7 May to 24 May. This was followed by an open season beginning on 1 July. The southern portions of Vancouver Island, including Area 21, remained closed until 15 July to protect sub-legal chinook and coho.

2.3 Current Enhancement Activities

2.3.1 Lake Enrichment

Hobiton Lake is one of six important lakes on Vancouver Island that are under intensive study by FRB to determine the effects of lake fertilization on sockeye growth, survival and production. Treatments of inorganic nutrients were systematically applied to the lake from 1977 to 1983. Spawner escapement, within-lake survival of smolts and smolt size were routinely assessed. Treatment of the lake was discontinued in 1984, but annual monitoring has continued. At present, there are plans to continue assessments until the 1990 brood-year returns are complete.[8] Sufficient data will then be available to make reliable comparisons of sockeye growth, survival and production under treated and untreated conditions. Preliminary results indicate that smolt size and within-lake survival is significantly greater under treated lake conditions.[16]

2.3.2 Nitinat Hatchery

Enhancement of Area 22 chum stocks occurs at the Nitinat hatchery (Table 3), which is located at the confluence of the Nitinat and Little Nitinat rivers. The hatchery was completed in 1980 and presently has the capacity to incubate 28 million chum eggs and rear 20 million fry. At capacity, chum returns are estimated to be about 403,000.[17] The first returns from hatchery broods to the facility were observed in 1983. However, stock abundance was not sufficient to stage a commercial fishery until 1984.

On the basis of chum returns to Area 22 since the Nitinat hatchery began operation, there has been no apparent impact of hatchery releases on rearing of wild stocks in Nitinat Lake. Biological studies of Nitinat Lake conducted prior to hatchery construction indicated that the duration of lake co-habitation by hatchery and wild fry was probably short.[6] Assessments of plankton abundance and historic chum escapements also indicated that the rearing capacity of Nitinat Lake was significantly under-utilized.[6]

In 1982, experiments were conducted to determine the optimal timing for fry releases from the Nitinat hatchery. Twenty-one million chum fry were released in three separate batches at ten-day intervals. Results of these experiments will not be available until adult returns from these broods are complete.

Chinook reared at the Nitinat hatchery are used to enhance stocks from the Nitinat and Sarita river systems. Nitinat juveniles are generally reared to the smolt stage, while Sarita chinook are released to their natal streams as pre-smolts. The Nitinat hatchery was originally designed for incubation of 1.5 million chinook eggs. In 1982, egg takes beyond hatchery needs were transplanted to the Sooke River volunteer project.[18] However, more than 2.5 million chinook eggs have been incubated at the hatchery every year since 1983. Estimated chinook returns from the 1985 hatchery brood are expected to be 51,000 adults.[17]

Coho have been raised at the Nitinat hatchery since 1982. Egg takes have varied among years, but have averaged about 80,000 (excluding 1984). Coho are reared to the pre-smolt stage, and estimated returns from the 1985 brood is expected to be 1100 adults.[17] Colonization of barren streams in the Nitinat watershed was completed in 1983. However, the results of this experiment are not yet available.

Table 3. Production capacity of current enhancement facilities in Statistical Area 22 (based on SEP biostandards).[17]

Facility/Project	Target System	Egg Target	Expected Adult Returns
Nitinat Hatchery			
Chum	Nitinat R.	23,000,000	340,000
Chinook	Nitinat R.	4,725,000	56,495

Table 4. Number of significant salmon streams by species in Statistical Area 22.[4]

Species	Total Streams[a]	Significant Streams[b]	Percent MRE[c]
Sockeye	2	1	99
Coho	5	5	99
Pink	-	-	-
Chum	5	2	99
Chinook	1	1	100

[a]Total Streams - the total number of streams that support or have supported the noted salmon species in the past.

[b]Significant Streams - the most important streams in terms of salmon production.

[c]Percent MRE - percentage contribution of the significant streams to the maximum recorded escapement.

2.4 Habitat Status

The Nitinat system produces the vast majority of salmon in Area 22. There are presently no large communities in this area but much of the watershed has been logged. The degree of impact of deforestation on salmon-producing streams is presently unknown. However, vegetative cover is regenerating and some stabilization of basin hydrology is expected to occur.[4]

A summary of the salmon-producing streams in Area 22 and their relative importance to the maximum recorded escapement is provided in Table 4.

2.5 Management Conflicts

2.5.1 Management Uncertainties

Management uncertainties pertaining to Area 22 salmon stocks are most significant for chum, since this species sustains the only local commercial fishery in the area. The major concern is the current inability to predict annual chum returns with confidence, which is largely due to extreme variability in the survival rates and age structure of wild stocks.[11] In addition, there are continuing difficulties in obtaining reliable estimates of spawner escapement due to resource constraints and the adverse environmental conditions which prevail during the fall. As a result, it is difficult to develop fishing plans and to manage the fishery in-season so that surplus chum are harvested but the target escapement is still achieved. Production from the Nitinat hatchery may partially moderate annual variability in chum returns but the inability to harvest hatchery and wild stocks separately may then become a concern.

2.5.2 Mixed-Stock Harvest

Some mixed-stock harvests have occurred in the fisheries directed at Nitinat chum, particularly since the commercial fishery has been held outside the surfline in Area 21. In this outer fishing area, chum from the Fraser River and Puget Sound areas are thought to be intercepted along with Nitinat fish.[6] Although the significance of this by-catch has not been determined, some electrophoretic analyses have been performed to determine the relative contributions of various stocks to the catch.[3] Recovery of tagged chum from the Nitinat hatchery has also provided some information regarding the contribution of Nitinat chum to the total catch.

There is also some incidental harvest of Nitinat coho, chinook and steelhead in the commercial chum fishery.[6] In the past, there has been concern regarding the incidental catch of Nitinat steelhead in the sport fishery and in the Indian food fishery directed at Hobiton sockeye.[5]

Hatchery and wild chum are harvested as one stock group in the commercial fishery. Enhanced and wild fish both contribute to natural spawning along the Nitinat River. At present, there is no means by which the hatchery and wild chum stocks can be harvested discretely. The impact of this mixed-stock harvest on natural production of chum is currently unknown. The Salmonid Enhancement Project (SEP) has undertaken a mark-recovery program to determine the contribution of hatchery chum to naturally-spawning populations.

2.6 Rebuilding Potential

Enrichment of Hobiton Lake has caused sockeye production to increase well above expected levels. During the early 1970s (prior to lake fertilization), the sockeye population was depressed, with total returns conservatively estimated at 2000-10,000 individuals.[19] The escapement target was initially set at 15,000 spawners. However, on the basis of sockeye returns under enriched conditions, the target was increased to 20,000 spawners. In 1982, total returns to Hobiton Lake were over 76,000 sockeye, which exceeded historic returns of 30,000-50,000 fish during the early 1950s. Enrichment of Hobiton Lake was discontinued in 1984. However, monitoring of sockeye populations by FRB has continued to provide comparative data on lake production with and without fertilization. If lake enrichment is as beneficial to sockeye production as suspected, a regular fertilization program may be implemented in the future.

There appears to be potential for rebuilding the wild population of Nitinat chum. However, the degree to which this stock can be rebuilt is highly uncertain at the present time. The rates of return and age composition of this stock are extremely variable, and this makes determination of the optimum escapement very difficult.[11] However, on the basis of historic returns and estimates of habitat capacity, a target of 125,000 spawners has been set. Despite annual variability in return rates, an increasing trend in chum returns has been observed since the 1950s.[11] Evidence of the stock's potential to rebuild was apparent in 1985 when there was an escapement of 225,000 fish from the combined return (hatchery and wild) of 2.1 million chum.

Due to the extremely variable flows typical of the area, the Nitinat chum population will likely continue to demonstrate dramatic changes in production. However, careful management of the outside fishery and continued hatchery production should help to ensure that adequate escapements are achieved. In addition, continued regrowth of forested slopes around Nitinat Lake may reduce variability caused by extreme hydrologic events.

2.7 Management Options for Rebuilding

2.7.1 Management Uncertainties

Knowledge of stock abundance is required to ensure that sufficient escapement is achieved while harvesting the available surplus. The major management uncertainty regarding Nitinat chum stocks is their highly variable return rates. However, this uncertainty can be reduced by stabilizing chum production and improving stock assessment procedures. Some stabilization of Nitinat chum production is expected to occur as a result of hatchery operations and reforestation of the watershed.

Improvements in stock assessment procedures would be required both before and during the fishing season. Pre-season run forecasts are based on escapement, catch and age structure information for the population. The primary means of improving forecasts for Nitinat chum is to increase the accuracy of escapement information. This would require increasing escapement enumeration effort and standardizing enumeration techniques. Although efforts are being made to collect the best possible catch and escapement data, collection of these data is currently limited by personnel and resource constraints.

Despite potential improvements in catch and escapement estimates, pre-season forecasts of run returns will remain speculative. Consequently, it is important to try to gauge actual returns in-season. A test fishery permits run size to be determined under conditions where harvest effort is strictly controlled. To date, there has been limited success in estimating stock abundance on the basis of test fishing results. Nevertheless, by providing at least a rough index of stock abundance, test fisheries can reduce management uncertainty, and thereby reduce the risk of overharvesting when stock size is low. The alternative is to open the commercial fishery for a short period and judge stock size based on catch per unit effort. However, this strategy can threaten stocks when returns are low.

2.7.2 Mixed-Stock Harvest

The commercial chum fishery outside the surfline in Area 21 contributes to the incidental harvest of some passing stocks. An alternative would be to relocate this fishery into Nitinat Lake. However, the quality of the harvested chum would be poor and access to and from the lake by loaded vessels would be extremely difficult.

Among the Nitinat stocks, there is concern over the mixed-stock harvest of wild and enhanced chum. Regardless of the location of the net fishery (within or outside Nitinat Lake), the two stocks cannot be harvested discretely and there is some risk that the wild stock may be lost over time, particularly if harvest rates are set to maximize the catch of hatchery surplus. Unless hatchery stocks are developed with a run timing that does not overlap with wild stocks, this risk appears to be unavoidable.

There is some incidental catch of chinook and steelhead in the native food fishery directed at Hobiton sockeye. However, this does not appear to be a major problem at the present time.

2.8 Potential Enhancement Activities

2.8.1 Nitinat Expansion (Project No. 22-2B)

This project involves the expansion of the current chinook rearing capacity of the Nitinat hatchery. This will include the construction of extra ponds and a new surface water supply from the Little Nitinat River. The production of chinook will be increased by 60,000 adults.

2.8.2 Side Channel Rehabilitation

Rehabilitation of side channel habitats to help stabilize chum production for specific stocks may have application to some West Coast Vancouver Island systems. The technique involves habitat manipulations to formerly active flood channels separated from the mainstem of the river.[20] Channels are excavated to ensure a steady supply of groundwater and are landscaped to provide suitable spawning substrate and water depths for spawning chum. Mainstem currents do not normally pass through these side channel habitats and the problem of scouring is therefore

minimized. Development of side channel spawning areas can help stabilize chum production by reducing the impacts of flood events and thereby increasing freshwater survival in some years.[21] To date, experimental side channels in the lower mainland of British Columbia have shown egg-to-fry survival rates approximately twice those of comparable natural spawning areas.[20] Implementation of this form of enhancement would necessarily be dependent on site location and conditions as well as cost effectiveness.

2.9 Results of Simulation Modelling

A computer simulation model was used to investigate various fisheries management options for Area 22 chum and sockeye. Results of the modelling are intended to indicate only the range of possible outcomes associated with the various management options and some of the merits and shortcomings involved with implementation of these strategies.

2.9.1 Sockeye

The current management scenario for Hobiton sockeye assumed that there was no lake enrichment and that sockeye were harvested in the offshore troll and local native food fisheries. The second scenario was identical to that of current management except that Hobiton Lake was enriched. In the third scenario, Hobiton Lake was fertilized but a commercial net fishery was staged to catch any sockeye surplus to hatchery needs.

Without lake enrichment, sockeye productivity was estimated to be 3.5 recruits per spawner and the target escapement for the Hobiton stock was 15,000 fish.[10,19] With lake enrichment, the productivity was 4.5 recruits per spawner and the target escapement was estimated at 20,000 sockeye.[10,19] A harvest rate of 5% and a premium quality (troll 1) was assumed for the offshore troll fishery. The native food fishery was managed to a quota of 3000 sockeye to fulfil subsistence needs. Although the native fishery usually occurs in Nitinat Lake where sockeye are not in prime condition, premium quality was also used in order to compensate for the additional cultural and ceremonial value of salmon to natives beyond normal market values. The commercial fishery was assumed to operate in Area 21 and a near premium quality (net 1) was assigned to the catch. This fishery was managed to escapement.

Current Management Regime: Results of the modelling indicated that, without lake enrichment, troll catches would stabilize at about 2500 fish by year 5. Native catches were consistent at 3000 sockeye. Escapement of Hobiton sockeye stabilized at an average of about 47,000 in year 5 (Figure 3).

Option 1: With enhancement of Hobiton Lake, troll catches increased to approximately 4500 fish and escapement stabilized at 82,000 spawners in year 6. Native catches remained at 3000 sockeye (Figure 4).

Option 2: Sockeye escapements were limited to a target level of 20,000, but the additional annual catch in the commercial net fisheries was about 60,000 fish. Catches in the troll and native fisheries remained the same as in Option 1 (Figure 5).

2.9.2 Chum

The major problem in the management of Area 22 chum stocks is the high degree of uncertainty regarding adult returns. Therefore, four fishing options were modelled, each having a potentially different level of impact on wild stocks when abundance of chum was low. Wild and hatchery fish were represented as two separate stocks in the model but were considered equally vulnerable to the fisheries. The productivity of hatchery fish was derived from SEP production data. For wild chum stocks, the average productivity based on 12 years of data was used. The average productivity was 4.26 with a variance of 29.27. In Option 4, wild stocks were considered in isolation from hatchery production. It was assumed that commercial fisheries directed at Area 22 chum stocks occurred outside Nitinat Lake, and the quality of the catch was semi-bright.

Option 1: The test fishery option was used to determine the result of intense fishing on returning chum stocks of an unknown size. Under this management scenario, up to 50% of the stocks would be harvested when chum abundance was low. At high abundance levels, the fishery would have little or no impact on the chum population. A second fishery was used in the model to ensure that stocks were adequately harvested during times of high abundance. This fishery harvested chum that were surplus to the combined escapement target for hatchery and wild stocks.

Catch and escapement for both enhanced and wild chum stocks stabilized. The escapement target of 125,000 spawners for wild stocks was achieved by year four and

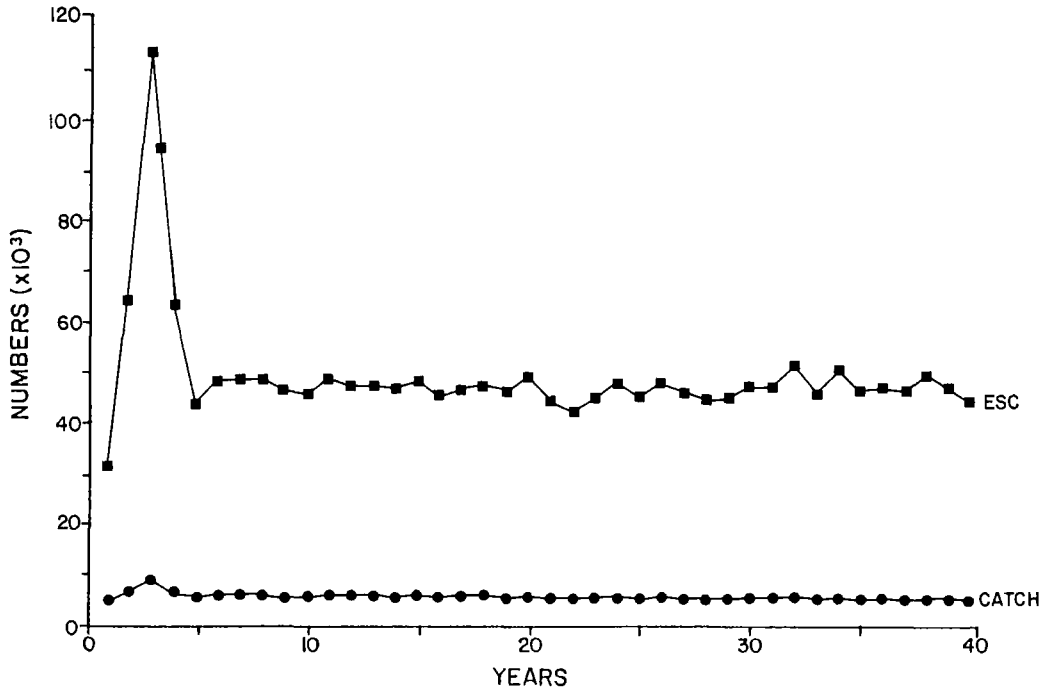

Figure 3. Projected catches and escapements of Area 22 sockeye under the current management regime (no enrichment).

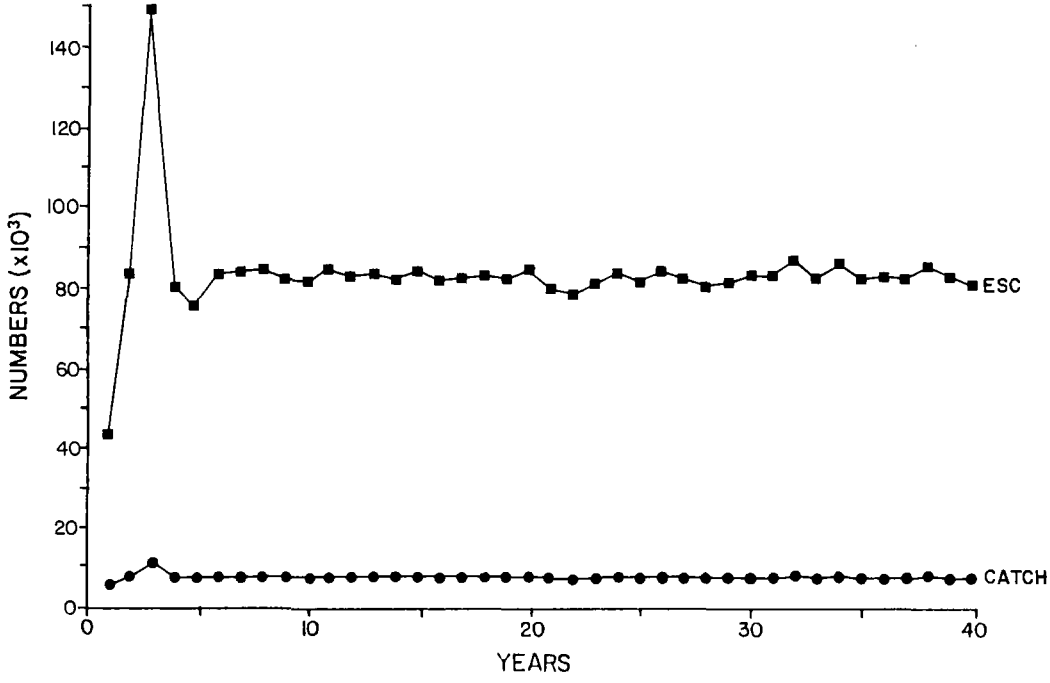

Figure 4. Projected catches and escapements of Area 22 sockeye under Option 1 (lake enrichment).

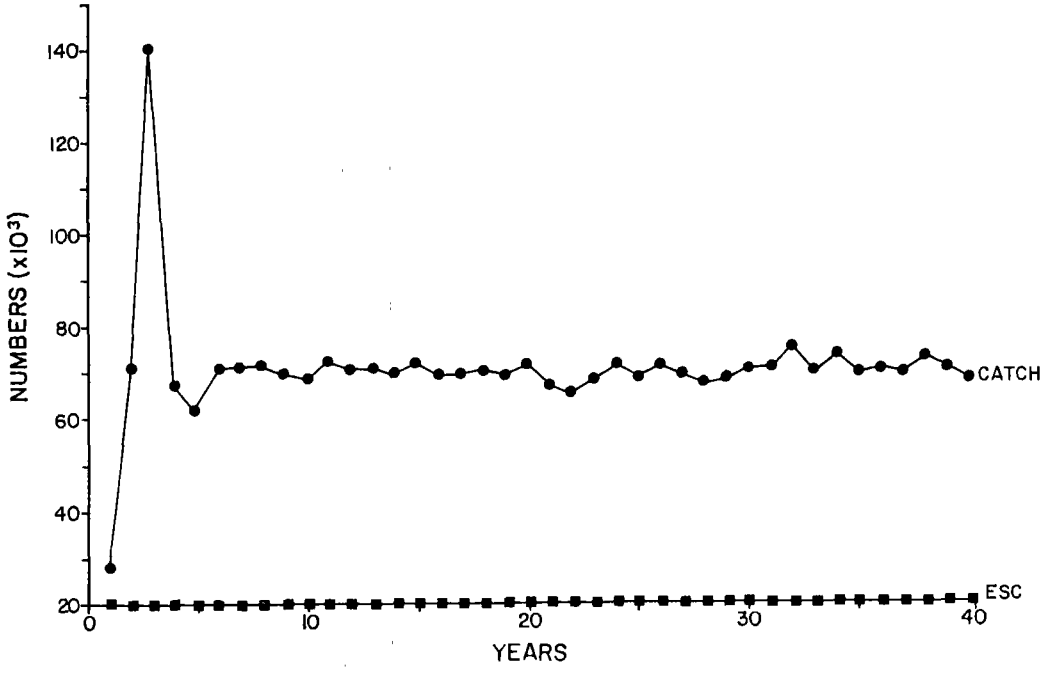

Figure 5. Projected catches and escapements of Area 22 sockeye under Option 2 (increased catch, limited escapement).

was maintained for the remainder of the 40-year period. By the time chum escapements had stabilized, catches averaged approximately 887,000 (Figure 6).

Option 2: This management option is similar to Option 1 except that a maximum of 20% of the stock was harvested when chum abundance was low. Catch and escapement for both enhanced and wild stocks stabilized very quickly, and the spawner target for wild stocks was reached by year 4 (Figure 7). Chum catches averaged approximately 900,000.

Option 3: This option included only one fishery that harvested all chum surplus to escapement needs. Similar to the previous management options, the escapement of wild chum stocks stabilized very quickly by year 4 and catches averaged approximately 900,000 when the average rate of return was used (Figure 8).

Option 4: In this management scenario, hatchery production was excluded from the analysis and two different management approaches were implemented. The first approach was identical to Option 1, where fisheries were staged despite an uncertain number of chum returns and harvest rates approached 50% in years of low chum abundance. The second approach was similar to that of Option 3, where only fish that were surplus to escapement requirements were harvested.

The target escapement of 125,000 spawners was not achieved under either management scenario (Figure 9). In the first case, chum catches averaged above 11,000 and declined gradually over the 40-year period. Average chum escapements varied around about 100,000 spawners (escapement A). Under the second approach, the stock stabilized at an escapement level of approximately 117,000 spawners (escapement B). No fisheries occurred because the stock never exceeded the target escapement.

2.9.3 Summary and Conclusions

Results of the simulation modelling indicated that enrichment of Hobiton Lake could provide significant benefits in terms of additional sockeye catches over current levels. Sockeye production increased substantially with lake enrichment. It was assumed that the Indian food fisheries continued at subsistence levels, and therefore the increased sockeye production had little effect on the harvest. However, significant benefits were accrued to offshore troll fishermen and the total catch by net fishermen targeting on Hobiton sockeye increased significantly.

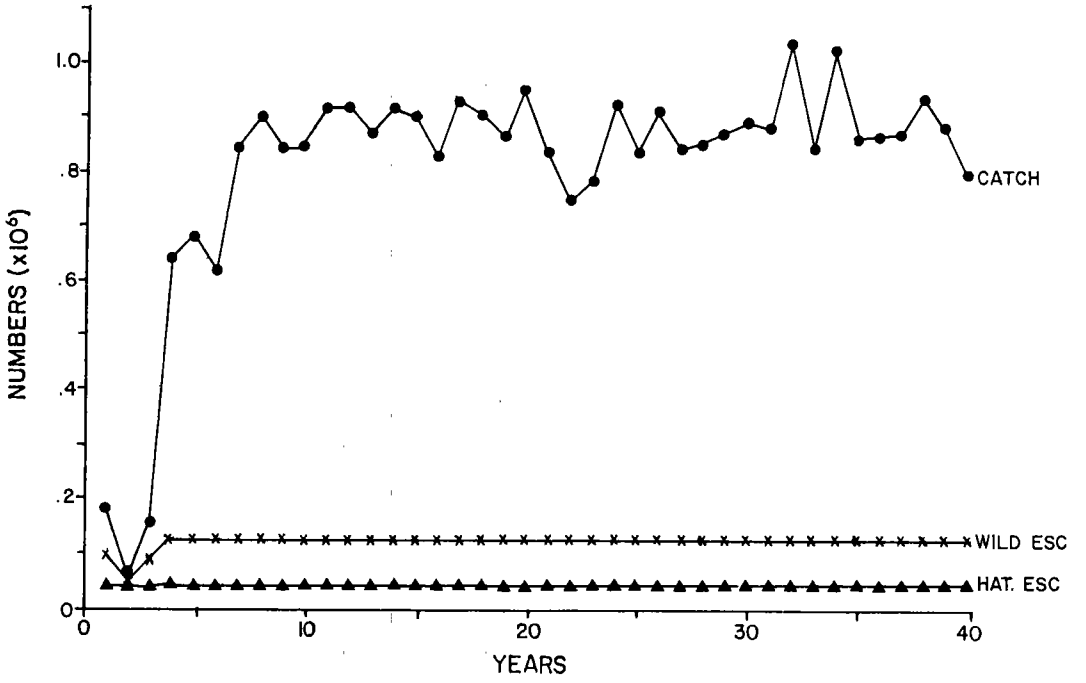

Figure 6. Projected catches and escapements of Area 22 chum under Option 1 (test fishery up to 50% harvest).

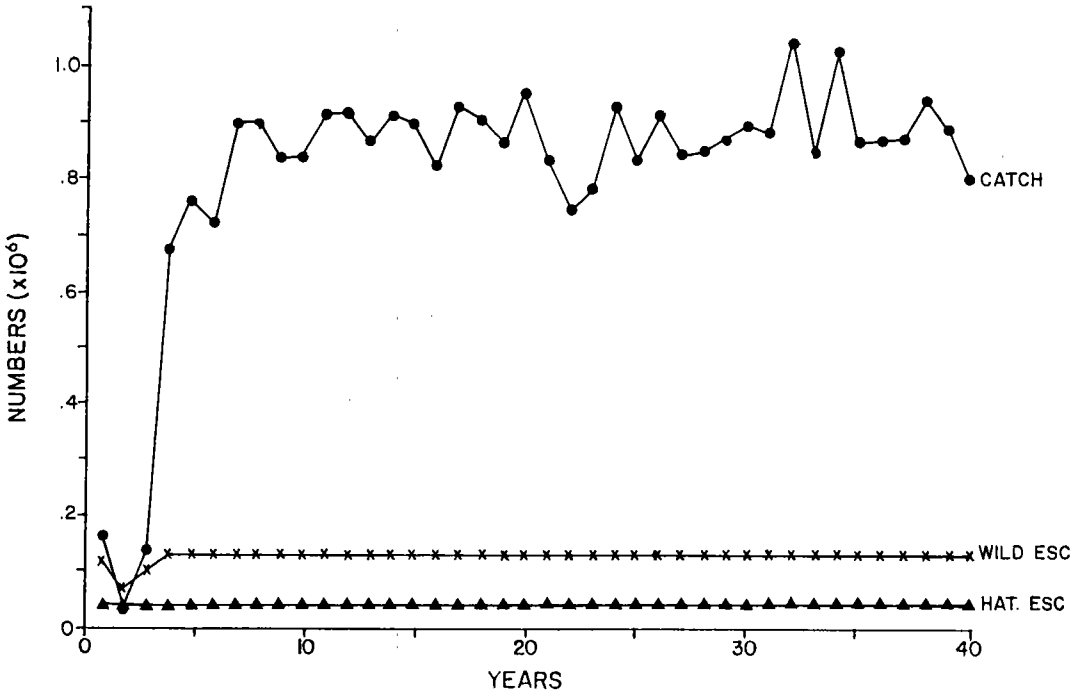

Figure 7. Projected catches and escapements of Area 22 chum under Option 2 (test fishery up to 20% harvest).

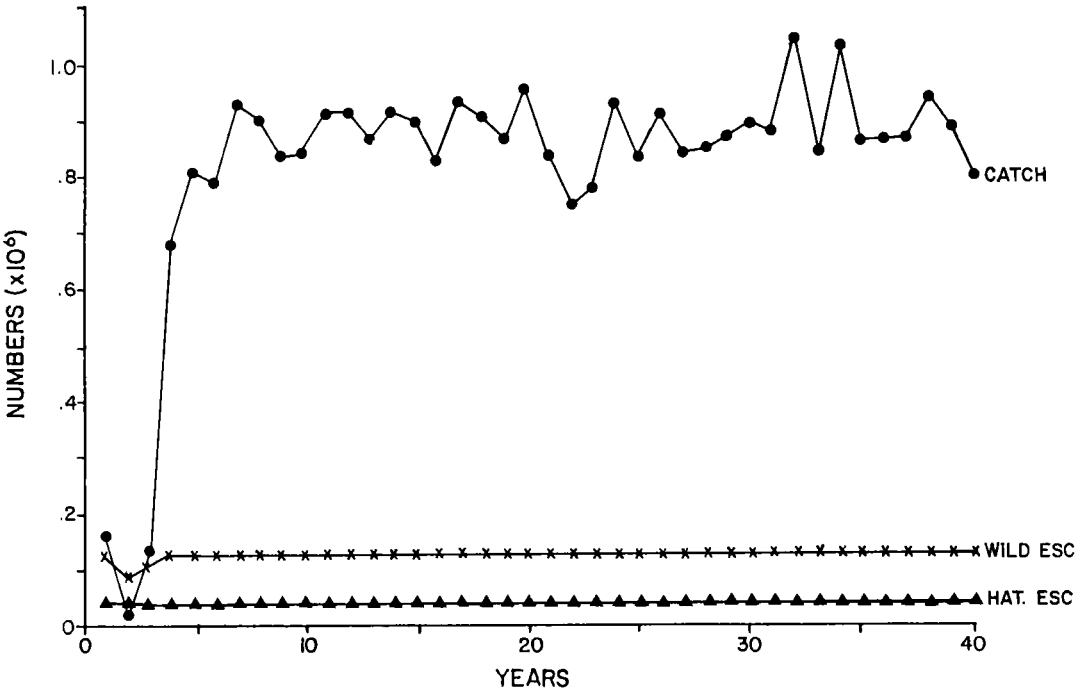

Figure 8. Projected catches and escapements of Area 22 chum under Option 3 (surplus fishery only).

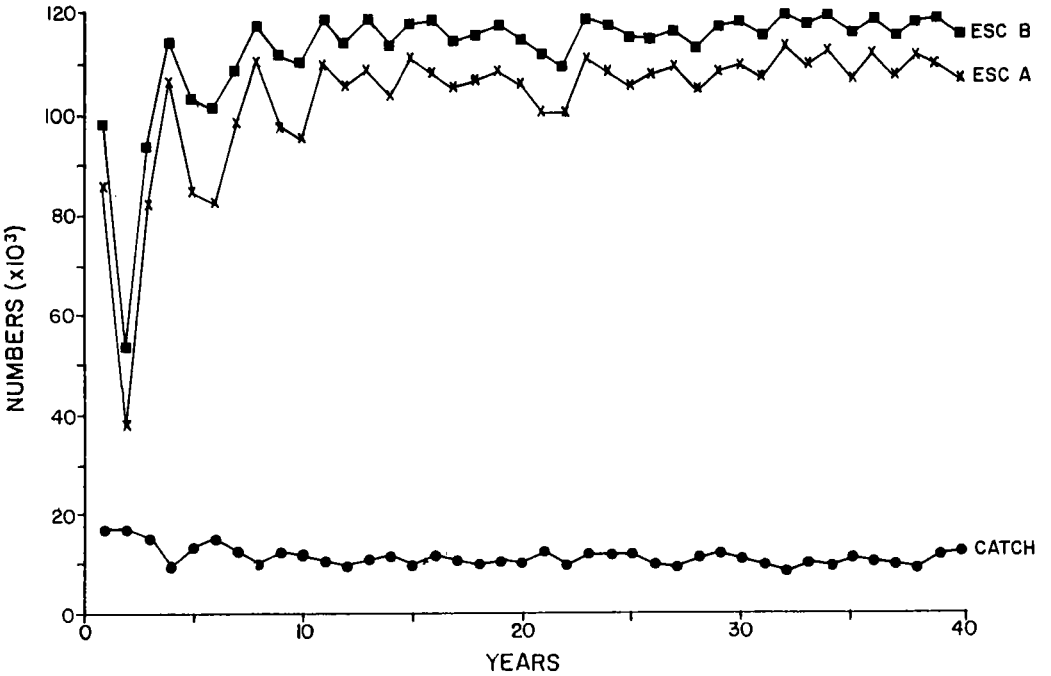

Figure 9. Projected catches and escapements of Area 22 chum under Option 4 (excluding hatchery production, plus Option 1 or 3, giving escapement A and B, respectively).

However, if such a net fishery was to occur, the benefits would have to be weighed against the additional enhancement and management costs as well as the incidental catch of non-target salmon stocks.

Based on the results of the simulation modeling, it is expected that chum stocks would stabilize quickly and catches would remain high as a result of hatchery operations, regardless of which management strategy was employed. The high productivity of hatchery chum is expected to result in large returns, and spawners that are surplus to hatchery needs would contribute to the escapement of wild stocks. Consequently, the natural variability in these escapements would be damped and the overall production of wild stocks would increase. In this situation, hatchery production is the influencing factor in the management of these stocks.

Chum populations stabilized when stock abundance was high; consequently, the potential impacts of the different fishing options were not realized (chum catches remained high under all of the scenarios). However, the stability of chum stocks would be substantially reduced in the absence of a hatchery. Wild stocks are seriously affected by management strategies that result in intense fishing at low stock abundance. Provided that the hatchery is able to maintain a high level of chum production, there would be considerable flexibility in the management of these stocks. However, if hatchery production does not continue at these high levels, long-term economic values would be maximized through adoption of a conservative management strategy and acquisition of improved data to forecast returns.

3. STATISTICAL AREA 23

Statistical Area 23 is located on the central west coast of Vancouver Island (Figure 10 and Table 5). It encompasses all of Barkley Sound and Alberni Inlet.

3.1 Stock Description

Salmon-producing streams in the area support wild populations of chinook, coho, chum, sockeye, and steelhead. In addition, there are several enhancement operations in the area that are directed at producing these species.

3.1.1 Sockeye

There are three major sockeye stocks in Area 23, of which the Great Central and Sproat Lake stocks are the largest.[3] Based on 15 years of data, the combined production from these two lakes accounts for more than 90% of the total sockeye run to the area. Henderson Lake supports a smaller but substantial sockeye run.

The three sockeye stocks can be separated from one another on the basis of parasite analyses. Sockeye from Henderson Lake are host to both brain and flesh parasites, whereas Sproat Lake fish have only the brain parasite and Great Central Lake sockeye have neither. As a result of these natural differences, the migration routes and timing of these stocks can be assessed by analysing the catch from various fisheries.

All three stocks approach Area 23 from the west, often through Trevor Channel[5], and are not subjected to any major harvests prior to reaching the Barkley Sound fisheries. The migration timing of the Henderson stock follows that of the Great Central and Sproat Lake stocks by several weeks (Figure 11). Area 23 stocks are currently the only sockeye populations on the west coast of Vancouver Island with sufficient production to support a commercial fishery.

Techniques used for the determination of sockeye escapements to Great Central and Sproat lakes have changed with time. Prior to 1975, visual counts from a fishway were conducted. In 1975, electronic counters were installed on the Stamp (Great Central Lake) and Sproat rivers, and sockeye were counted using both methods during that year. Since then, electronic counters have been used for sockeye enumeration on the Great Central Lake and Sproat Lake systems. Escapement surveys

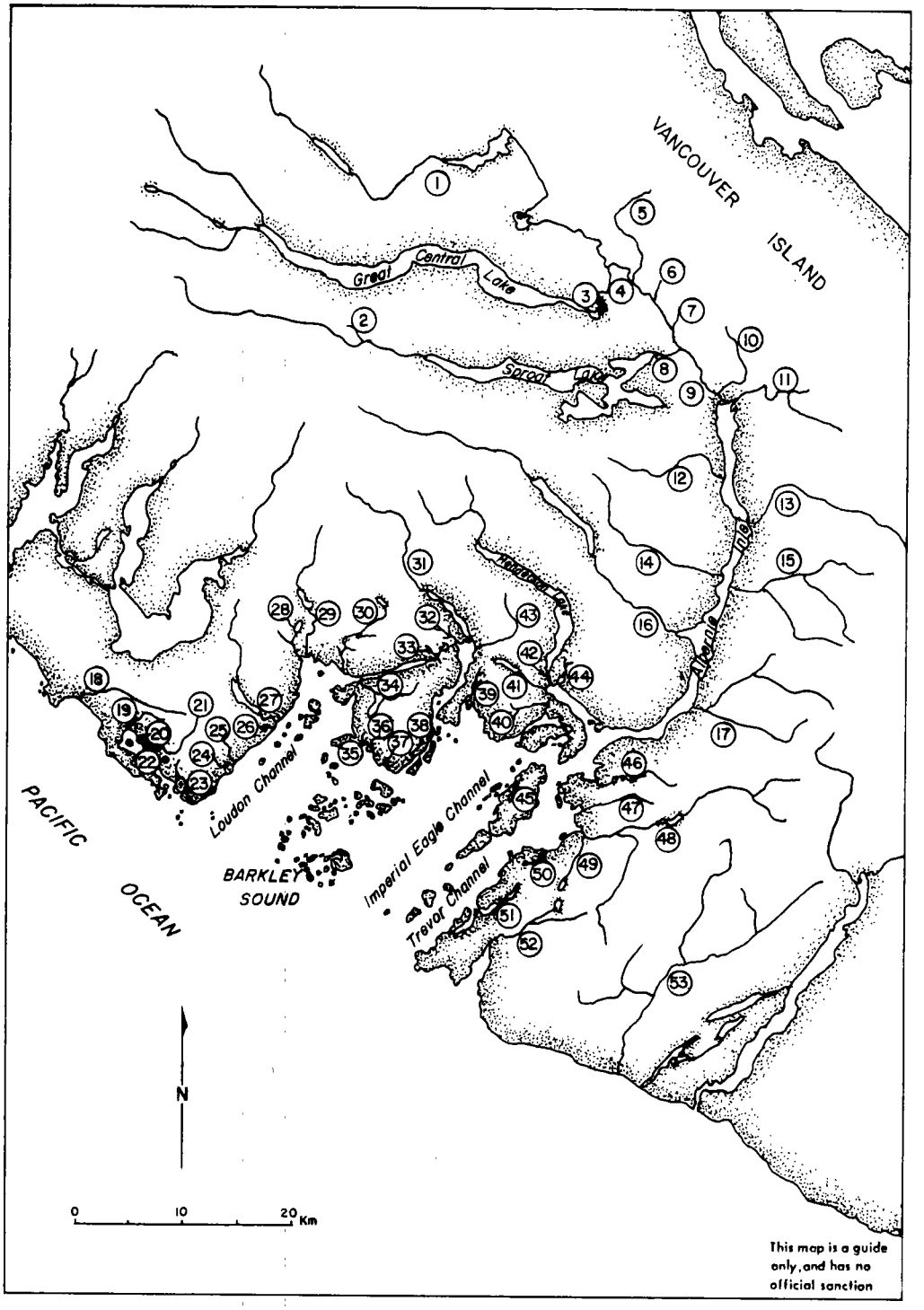

Figure 10. Statistical Area 23, showing location of salmon-producing streams (for key to streams see Table 5).

Table 5. Key to salmon-producing streams in Statistical Area 23 (from Figure 10).

1.	Ash River	21.	Merchantile (Mill) Creek
7.	Beaver Creek	16.	Nahmint River
38.	Canoe Pass Creek	33.	Pipestem Creek
47.	Carnation Creek	52.	Pachena River
34.	Cataract Creek	50.	Poett Nook Creek
13.	China Creek	3.	Robertson Creek Hatchery
17.	Coleman Creek	11.	Roger Creek
46.	Consinka (Wood) Creek	19.	Salmon River
43.	Coeur d'Alena Creek	23.	Sandy Creek
12.	Cous Creek	48.	Sarita River
6.	Deer Creek	37.	Sechart Creek
35.	Dutch Harbour Creek (West)	44.	Snug Basin Creek
36.	Dutch Harbour Creek (East)	9.	Somass River
31.	Effingham River	8.	Sproat River
15.	Franklin River	51.	Sugsaw (Grappler) Creek
49.	Frederick Creek	4.	Stamp River
42.	Henderson (Anderson) River	20.	Thornton Creek Hatchery (Ucluelet Cr.)
22.	Hillier (Mercer) Creek	29.	Toquart River
45.	Holford Creek	28.	Toquart River (left fork)
10.	Kitsuckis Creek	25.	Two Rivers East
53.	Klawana River	24.	Two Rivers West
5.	Jolly (Spaht) Creek	41.	Uchuck (Silver) Creek
26.	Little Maggie Creek	40.	Useless (Useless Inlet) Creek
18.	Lost Shoe Creek	39.	Vernon Bay Creek
30.	Lucky Creek	2.	Weinter Creek
14.	Mactush Creek	32.	West (Wallace) Creek
27.	Maggie River		

of the Henderson system throughout this period have been done by means of "creek walks" (visual counts done by walking along the creek).

Great Central Lake has the largest sockeye run on the west coast of Vancouver Island. Based on escapement data from 1970 to 1985, this stock accounted for 59% of the total Area 23 sockeye. Run reconstruction results indicate that the size of this population has been erratic but generally increasing since 1970[22] (Figure 12). In 1977, returns of Great Central Lake sockeye peaked at 980,000 spawners. From 1970 to 1979, sockeye escapements ranged between 15,000 and 254,000 spawners, with an average of 124,000. For the period 1980-1985, the average escapement was 189,000 and the target escapement of 50,000 spawners was exceeded twice. On the basis of results from lake enrichment, the initial escapement target of 50,000 spawners was increased to 200,000 due to increased rearing capacity of Great Central Lake.[10] Fertilization of the lake was performed annually from 1970 to 1973 and since 1977.

Great Central Lake sockeye first enter Barkley Sound in early May, and their numbers in the fishery peak by early July. By mid-September, most of the stock has already passed through the fishery. The run generally exhibits two peak periods of abundance, one in early July and the other in mid-August. The second peak is usually smaller than the first.

Although Sproat Lake has only been fertilized since 1985, this stock has historically followed a similar trend to the Great Central Lake stock (Figure 13). During the 1970s, escapements varied from 17,000 to 80,000 fish, with an average of 45,000. Since then there has been an average escapement of 153,000 spawners and the original target escapement of 100,000 has been exceeded every year except in 1984. During 1985 and 1986, escapements of Sproat Lake sockeye have exceeded those of the Great Central Lake stock and target escapement was increased to 150,000 spawners. Sproat Lake sockeye pass through the Barkley Sound fishery at the same time as the Great Central Lake stock, but do not show a bi-modal migration pattern.

Henderson Lake has the smallest sockeye population of the three systems, and the population trend has not paralleled that of stocks from the other two lakes (Figure 14). During the 1970s, sockeye returns to Henderson Lake varied between 3000 and 45,000 fish. A definite rebuilding trend was not apparent, and the average escapement was 11,000 spawners, a decline from the previous decade. Henderson sockeye runs have improved over the past 7 years. The average escapement

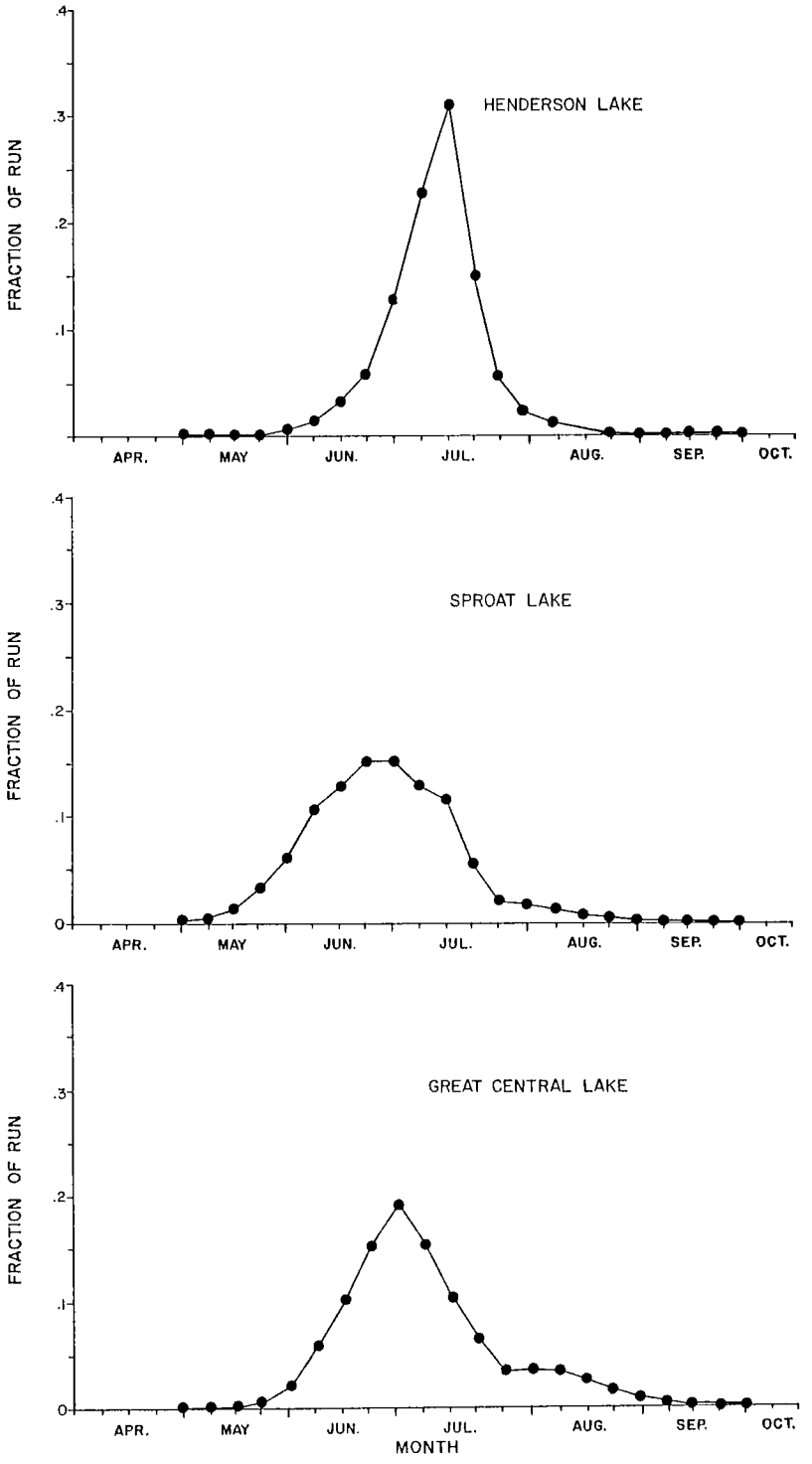

Figure 11. In-migration timing of the three major sockeye stocks in Area 23.[22]

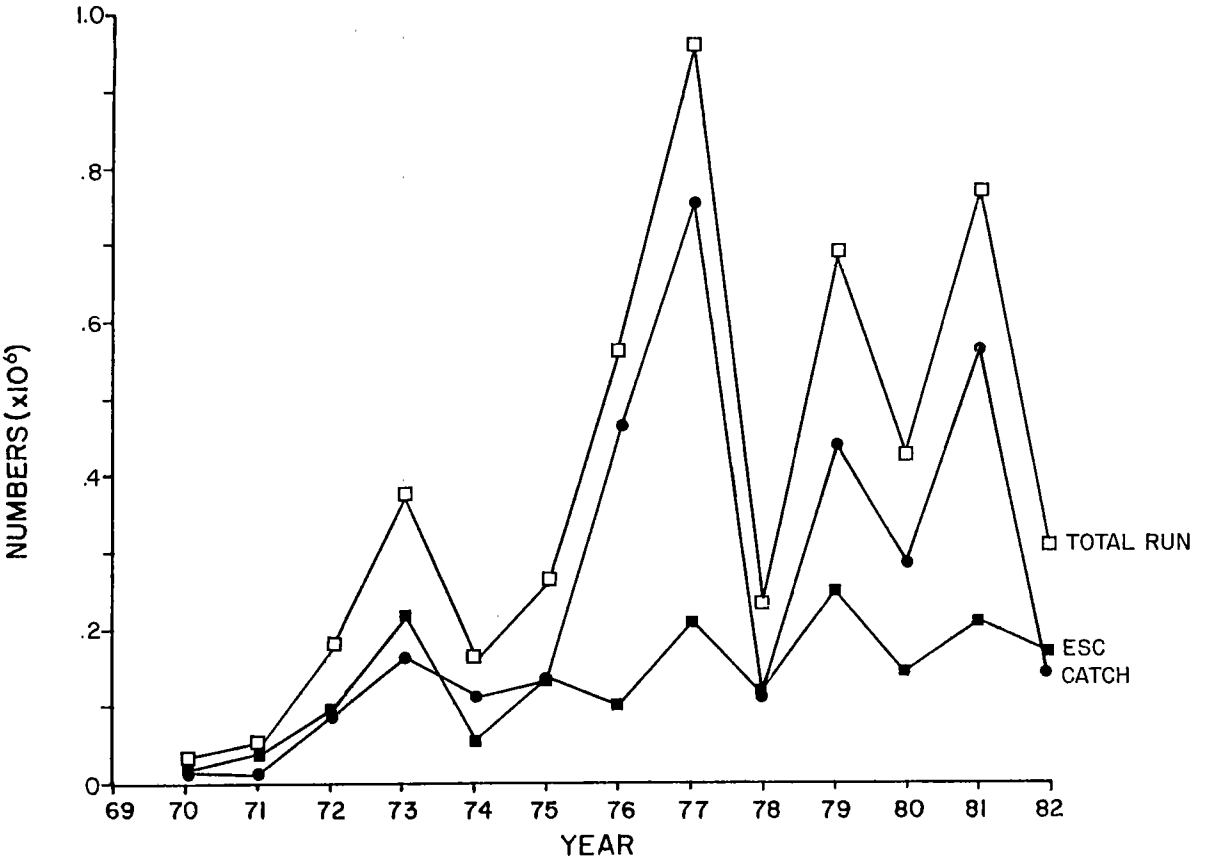

Figure 12. Catch, escapement and total run size of Great Central Lake sockeye, 1970-1982.[22]

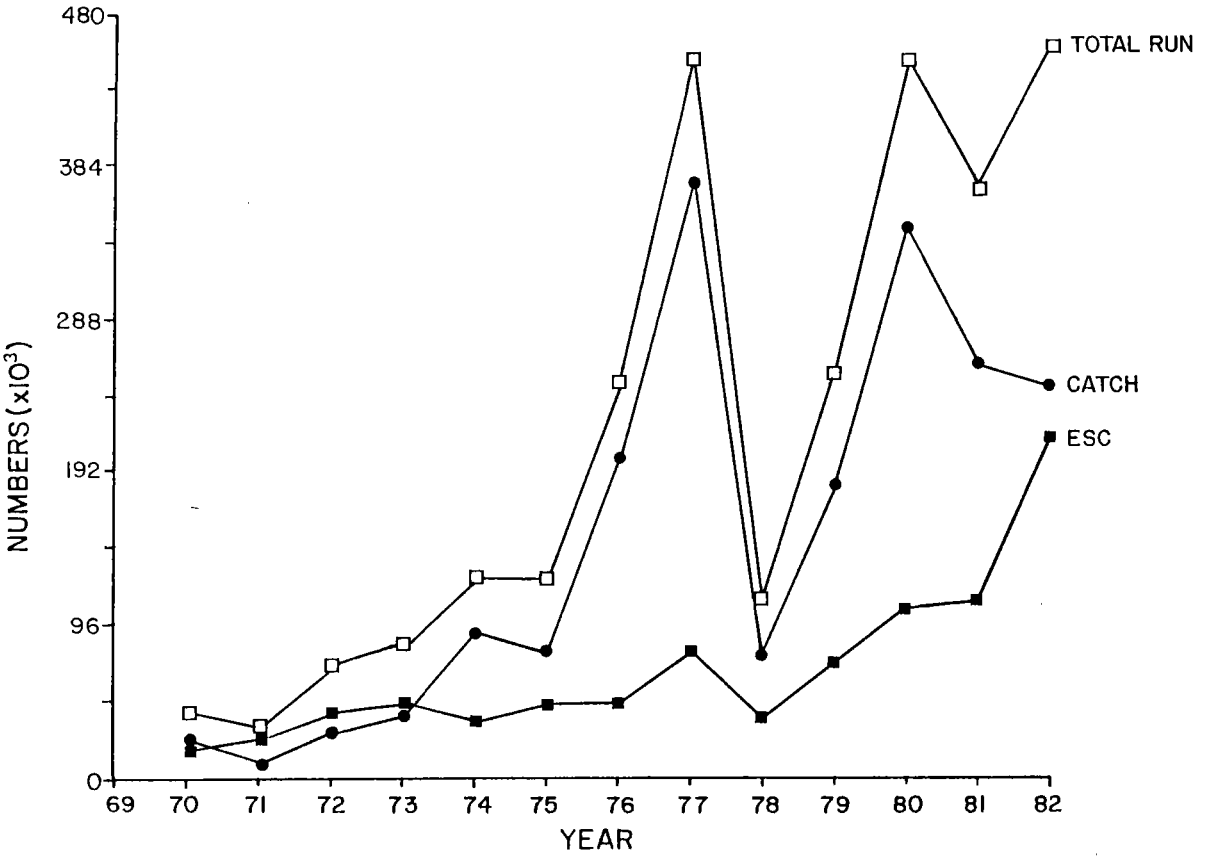

Figure 13. Catch, escapement and total run size of Sproat Lake sockeye, 1970-1982.[22]

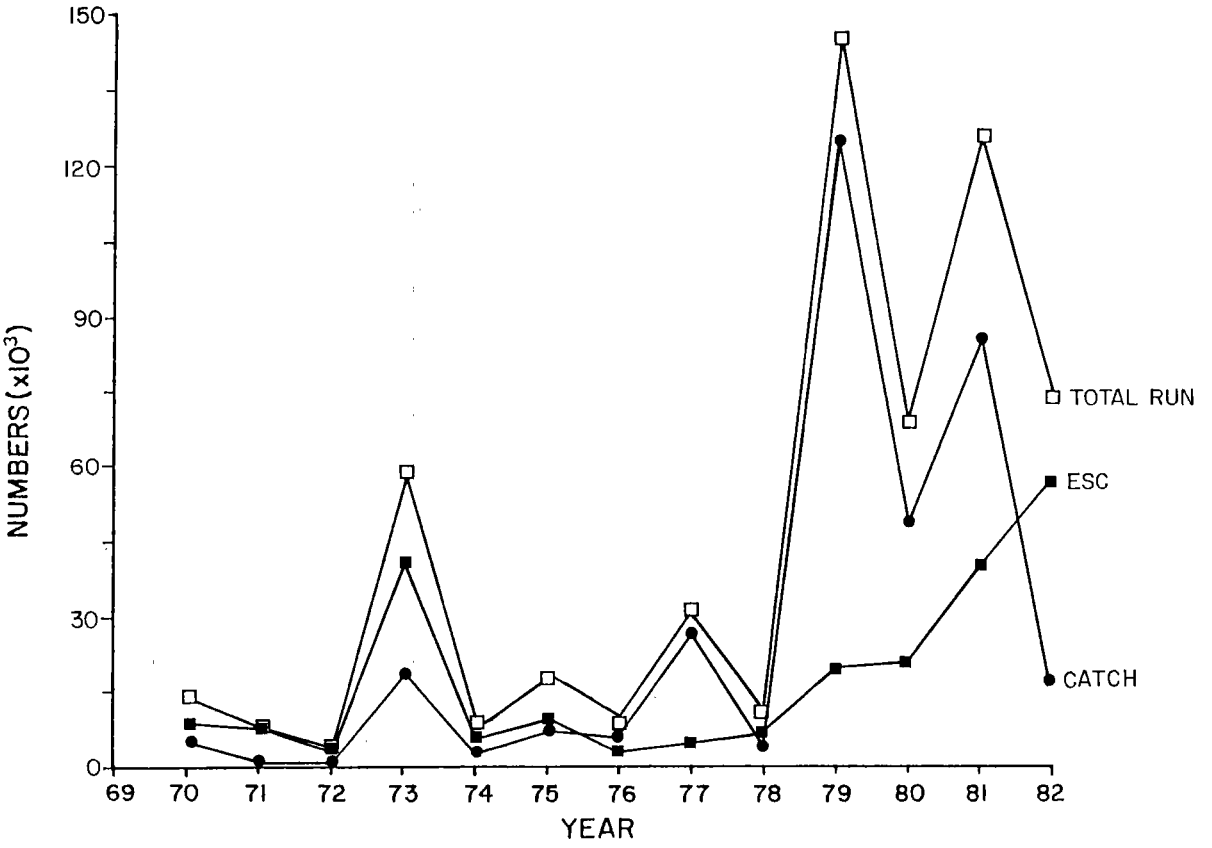

Figure 14. Catch, escapement and total run size of Henderson Lake sockeye, 1970-1982.[22]

for 1980-85 was 39,000 sockeye. Since 1970, the escapement target of 50,000 spawners has been exceeded only once, in 1982.[9] Henderson Lake has been fertilized each year since 1979.

Henderson sockeye have a slightly later migration timing than the other major sockeye stocks in Area 23. The Henderson stock usually enters Barkley Sound during early May. Catches indicate that this stock is most abundant during mid-July and most of the population has passed through the fishing area by late August.

Although lake enrichment appears to have boosted production from Area 23 systems, sockeye returns in 1985 and in 1986 have been well below expected levels. In 1985 the total return was 657,000 compared with an expected level of 1.75 million.[12] In 1986 there were further declines with estimated total stock less than 400,000.

3.1.2 Chum

Chum salmon are known to occur in 42 streams within Area 23. Historic data indicate that the majority of production originates in the Nahmint, Sarita and Toquart rivers; escapements for these three systems (1973-1985) account for more than 60% of the Area 23 total.[5] Other significant chum systems in the area are the Effingham, Henderson and Salmon rivers.

Rates of return for Area 23 chum have been less variable than stocks from Areas 22 and 26.[11] Analyses of 1956-1979 data indicated that the average number of adults returning relative to brood-year escapements was 1.09:1, with high and low values of 1.73:1 and 0.41:1, respectively. The age structure of these populations is approximately 31% 3-year-old, 65% 4-year-old and 4% 5-year-old fish.[11]

The target escapement for Area 23 chum is currently 150,000. However, this target has been achieved only 8 times since 1951.[11] Over the period of record, the highest and lowest escapements were 326,900 in 1954 and 36,100 in 1963, respectively. In 1985, the total escapement of Area 23 chum was estimated to be 120,000, with 40,000 fish returning to the Nahmint River and 53,800 in the Sarita River.[12] Total escapement in 1986 was estimated to have been only about 35,000 fish. Analyses of historic data have indicated that the optimum escapement for Area 23 could be higher than the present target of 150,000 spawners.[11]

Area 23 chum stocks spawn later in the season than other West Coast Vancouver Island runs, with the exception of Nitinat chum. The Nahmint stock first arrives on the spawning grounds in mid-September, while Sarita and Toquart chum do not arrive until early October. Peak spawning for these three major stocks occurs during the first half of November, and spawning activity is complete by the latter part of November.

3.1.3 Chinook

The Somass River is the most significant chinook producer on the west coast of Vancouver Island and has been designated as the indicator system for the region. Although a significant proportion of Area 23 production has come from Robertson Creek hatchery in recent years, the Somass River produces the vast majority of chinook in the area. In 1985, return rates to the hatchery declined from previous levels. There have been concerns that, under the existing catch ceiling, harvest pressure on wild stocks would increase if production of the enhanced stock was reduced. However, it appears that Robertson Creek chinook do not comprise a major portion of the West Coast Vancouver Island troll catch.[3]

Other chinook streams in Area 23 include the Nahmint, Sarita and Toquart rivers. Production from these rivers is currently low, but some enhancement efforts have been undertaken in recent years.[12]

Like most chinook stocks on the west coast of Vancouver Island, Area 23 chinook generally exhibit ocean-type life histories and have fall-run timing. Declines in these populations have occurred and there are significant concerns regarding the status of wild stocks. Escapement estimates averaged 13,000 spawners during the 1950s, 1960s and 1970s and less than 10,000 from 1980 to 1983. In 1980, only about 4500 chinook were counted. By 1985, the estimated escapement for the Somass River was 76,300 chinook spawners, including hatchery fish. However, this was likely due to a change in enumeration technique in 1984, which resulted in more accurate counts. The 1986 escapement was about 45,000 fish. The interim escapement target for the Somass was set by the chinook technical committee at 70,000 natural spawners and 15,000 hatchery brood stock. Allowing for in-river mortality, the desired escapement to the river is 102,500 chinook.[23]

3.1.4 Coho

Over the period of record, coho have been reported in 37 streams in Area 23.[15] The Somass system supports the only large coho population on the west coast of Vancouver Island. In 1985, the reported escapement was about 44,700 coho, including 10,700 hatchery fish.[12] About 40,000 coho were counted in Area 23 streams during 1986.

Historic data indicate that there have been declines in the escapement of Area 23 coho. However, there is considerable uncertainty regarding the reliability of these data. The difficulties in obtaining reliable escapement data for coho are outlined in section 2.1.4.

Of particular concern is the inconsistency in the number of streams surveyed between years. As a result of this inconsistency, escapement trends are not apparent because total population estimates between years cannot be compared. For example, a total of 37 streams in Area 23 were surveyed for coho in 1979 while only 3 were surveyed in 1983.[15]

Recovery of coded wire tags (CWT) indicate that coho from Robertson Creek hatchery are harvested primarily in the West Coast Vancouver Island troll fishery and, to a lesser extent, in the central coast troll fishery. Return rates to the hatchery have recently declined, and a similar situation among wild coho at Carnation Creek has raised concerns that marine survival of west coast coho stocks may be declining.[4] However, record escapements of coho to the west coast of Vancouver Island occurred in 1986.[3]

3.1.5 Pink

There is currently no significant pink salmon production from Area 23.

3.1.6 Steelhead

Several river systems in Area 23 support populations of steelhead. However, most of the wild summer runs are seriously depressed due to interception in the Barkley Sound/Alberni Inlet commercial salmon fisheries.[1] The one exception is the Somass River run. This is the largest summer steelhead run on Vancouver Island[7], partly due to production from the Robertson Creek hatchery.

Systems having important winter and summer steelhead runs include the Stamp, Ash (Somass tributaries), Franklin and Sarita rivers and Cous Creek. The Nahmint River and China Creek have summer runs only. The timing of steelhead runs to the Stamp and Ash rivers is unusual in that there are two periods of peak returns, one in May-June and the other in October.

3.2 Managed Fisheries

The most significant salmon harvest and fishing effort on the west coast of Vancouver Island occurs in Area 23. Sockeye provide the most consistent and economically important fishery in the area. However, chum, chinook and coho are also important in terms of the commercial harvest. In addition to commercial harvests there are various native food fisheries and a growing sport fishery for chinook and coho.

3.2.1 Sockeye

Net fisheries for sockeye occur in Barkley Sound and Alberni Inlet. Although both seiners and gillnetters participate in the fishery, their relative numbers and distribution have changed during the last three decades. Prior to the 1970s, most of the catch and effort was by gillnetters. In the 1970s, catch and total effort increased and the relative proportion of seiners increased dramatically. By 1976, sockeye catches in Area 23 were divided almost equally between the two gear types. Seine catches were greater than gillnet catches in all subsequent years except 1978. Traditionally, seiners and gillnetters have operated together throughout Area 23. Management of this dispersed fleet has been difficult and the incidental catch of juvenile chinook in nursery areas was unacceptably high. Consequently, the fishing areas were separated according to gear type in 1982. Seiners were permitted to fish in Alberni Inlet, and gillnetters were allowed to fish in Barkley Sound.

Sockeye catches in Area 23 have increased over the last 30 years.[24] During the period 1955-1959, the average catch was close to 13,000 sockeye. This increased to about 23,000 in the 1960s and to 360,000 in the 1970s. By the early 1980s (1980-1985), the average catch increased to approximately 644,000 sockeye. Peak harvests occurred in 1977 and 1981, when approximately 1.1 million sockeye were taken in the net fisheries. In 1985, the sockeye catch was 380,000, which was well below the expected catch of 1.2-1.4 million fish.[12] Further declines occurred

in 1986 with the commercial catch amounting to less than 30,000.[12] For the three major sockeye stocks in Area 23, average harvest rates (1970-1984) were calculated to have been 68% for Great Central Lake, 67% for Sproat Lake and 66% for Henderson Lake.

Management of the Area 23 fishery is directed at ensuring that target escapements of the three major stocks are met and the incidental harvest of chinook is minimized. However, it has become increasingly difficult to achieve these objectives as fishing effort has increased. The sockeye net fishery typically opens in the first week of June, and weekly openings continue through the summer, provided that stock abundance appears sufficient to sustain the fishing pressure and still meet the required escapements. Traditionally, the net fishery was open for 4 days per week, but openings have been reduced to 3 and sometimes 2 days per week in recent years. The net fishery generally closes by mid-September to protect chinook stocks. However, in 1985, the season was closed on 11 July when it became apparent that sockeye returns were far less than expected.[12] During the sockeye fishery, there may be minor boundary restrictions implemented to conserve chinook stocks and to minimize pressure on the smaller Henderson sockeye stock.

Management of the net fishery is based on pre-season and in-season stock information. Expected sockeye returns are calculated on the basis of smolt-to-adult survival rates that are applied to the appropriate brood-year escapements. Unfortunately, the variability in return rates and uncertainty in escapement estimates tends to limit the degree of confidence in these forecasts; this was evident from the difference between expected and actual sockeye returns in 1985.

In-season management of the sockeye fishery is based on comparisons between weekly stock abundance estimates and the historic run-timing curve. A computer model operated by the FRB is used to forecast run size based on in-season catch and escapement information. Decisions regarding the timing and duration of the fishery are made in consideration of the model forecasts. In-season information used in the management of the sockeye fishery comes from test fishing results, hail catch data and escapement estimates. The test fishery provides a rough estimate of stock abundance as well as specific data on stock and age composition. Sproat and Great Central Lake stocks can be identified by parasite analysis of the catch within days of sampling. Sonar has been used to assess the abundance of sockeye stocks in Alberni Inlet. However, the effectiveness of this technique has not been proven and therefore the results have not yet been used as an in-season management tool.

3.2.2 Chum

Most of the major net harvests of Area 23 chum occurred prior to 1960. Following this, the fisheries were closed from 1963 to 1969 to allow chum stocks to rebuild.[11] Although fisheries have occurred in most years since that time, there has not been an opening since 1981. The current management approach for Area 23 chum is to harvest only those fish that are surplus to escapement needs. If assessments indicate a return in excess of the escapement target, a commercial fishery may be held.

A gillnet test fishery was conducted in Area 23 from 1977 to 1980 and again in 1982. One of the objectives of the test fishery was to determine the relationship between stock size and catch per unit effort. Various approach routes were examined, but no relationship that would permit reliable in-season forecasting of run size was found.

A small public-involvement project was initiated on Thornton Creek to enhance chum stocks. In 1980 and 1981, surplus returns were harvested and the catches totalled 31,000 and 5100 chum, respectively. Recently, there has been a shift away from enhancement of chum salmon.

3.2.3 Chinook

The only commercial fishery directed at Area 23 chinook is the harvest of surplus hatchery fish by gillnetters. This fishery occurs in August of each year and is managed to harvest chinook that are surplus to escapement needs. Surplus fish that are not taken in the gillnet fishery are harvested at the hatchery in a rack fishery.

In 1985 and 1986 chinook returns were lower than expected. Fishing time was therefore reduced to a single opening each year. In both years total catch amounted to about 1500 chinook.[12]

Historical net catches for Area 23 chinook indicate that there has been a trend toward increasing catches since the early 1970s. Production from the Robertson Creek hatchery has contributed substantially to this increase. However, return rates to the hatchery have declined significantly in the past two years.

3.3 Current Enhancement Activities

Enhancement is a key factor in the current production of salmon in Area 23. Robertson Creek is the only major enhancement facility in the area. However, a CEDP hatchery is located at Thornton Creek and there are various small public-involvement projects throughout the area. In addition, three lakes supporting sockeye are being enriched on an ongoing basis through application of fertilizer.

3.3.1 Lake Enrichment

Great Central Lake, Henderson Lake and more recently, Sproat Lake have been treated with fertilizer to enhance sockeye smolt production. Great Central Lake was treated from 1970-1973 and from 1977 to the present. Henderson Lake has been fertilized since 1979 and Sproat Lake has been fertilized since 1985. Sockeye populations in Great Central Lake have increased significantly over the period of enrichment such that the original escapement target of 50,000 spawners was increased to 200,000 spawners. Although Sproat Lake was not treated until recently, a similar population increase of Sproat Lake sockeye occurred over this time period and the escapement target is currently set at 150,000 spawners. The number of Henderson Lake sockeye has increased since the lake enrichment program was initiated. However, this increase has not been nearly as great as that of Great Central Lake sockeye populations.

3.3.2 Robertson Creek Hatchery

Robertson Creek hatchery is located near the outlet of Great Central Lake. When established in 1959, it consisted of spawning channels for pink salmon. A pilot hatchery was constructed in 1972 and was expanded in 1981. Hatchery production was directed at chinook, coho and steelhead. Returns of chinook were sufficiently high that a terminal gillnet fishery was initiated at the head of Alberni Inlet in 1978. In the past two years, however, chinook returns have declined significantly.

Stocks from Robertson Creek, the Somass and Nahmint rivers are reared at the Robertson Creek facility. Table 6 provides a detailed summary of the target stocks and expected production levels of the enhancement facilities within Area 23.

Table 6. Production capacity of major hatcheries and small enhancement facilities in Statistical Area 23 (based on SEP biostandards).[17]

Facility/Project	Target System	Egg Target	Expected Adult Returns
Robertson Creek			
Chinook	Robertson Cr.	10,300,000	112,000
	Nahmint R.	100,000	1,008
Coho	Robertson Cr.	1,250,000	50,000
Steelhead	Robertson Cr.	98,000	49,000
	Somass R.	248,000	124,000
Thornton Creek (CEDP)			
Chinook	Thornton Cr.	50,000	3,024
	Toquart R.	250,000	
Coho	Thornton Cr.	100,000	5,805
	Upper Kennedy R.	100,000	
Alberni Enhancement Society (PIP)			
Coho	Various Creeks - Somass System	200,000	4,860

3.3.3 Thornton Creek Hatchery

Thornton Creek hatchery is a community-development project located at the mouth of Ucluelet Creek. The hatchery is operated by the Thornton Creek Enhancement Society under contract to SEP. It was established as a Japanese-style chum incubation facility. However, emphasis has shifted to chinook and coho production in recent years. The first chinook and coho returns to the hatchery occurred in 1984. Chinook from Robertson Creek were transplanted to the Ucluelet area after being reared at the Thornton Creek hatchery in attempt to establish a local chinook sport fishery.[18] In addition, coho stocks from the Kennedy watershed (Area 24) are currently being enhanced at the hatchery.

3.4 Habitat Status

Area 23 is one of the most developed areas on the west coast of Vancouver Island. The most apparent impact of development on salmon habitat in the area has resulted from logging operations. Approximately 60% of the watersheds have been influenced by removal of forest cover or road construction.[4] The severity of these impacts on salmon habitat varies significantly among sites, but numerous spawning and rearing areas along Barkley Sound are thought to have been seriously affected as a result of intensive logging.[5] In addition, local effects on salmon habitat have resulted from the various industrial, commercial and residential developments in Port Alberni, which is the largest community on the west coast of the island.

A summary of the salmon-producing streams in Area 23 and their relative contributions to maximum recorded escapement is provided in Table 7. At present, habitat does not appear to be a major constraint to stock rebuilding.

3.5 Management Conflicts

3.5.1 Management Uncertainties

The major uncertainty regarding management of Area 23 sockeye is the estimation of stock abundance. Pre-season estimates of sockeye returns to the area are calculated on the basis of smolt output from nursery lakes. However, forecasts are considered unreliable due to the variability in marine survival of these stocks. A review of sockeye return data for the last 80 years indicated that multi-year intervals of above and below average returns of Barkley Sound stocks have

Table 7. Numbers of significant salmon streams by species in Statistical Area 23.[3,4]

Species	Total Streams[a]	Significant Streams[b]	Percent MRE[c]
Sockeye	2	2	100
Coho	37	9	96
Pink	8	3	97
Chum	42	3	60
Chinook	16	4	94

[a] Total Streams: number of streams that support or have supported the noted salmon species in the past.

[b] Significant Streams: the most important streams in terms of salmon production.

[c] Percent MRE: percentage contribution of the significant streams to the maximum recorded escapement.

occurred.[25] In-season assessments provide a more reliable index of actual returns. In Area 23, in-season indices of sockeye abundance are based on estimates of catch per unit effort (CPUE) and results of a run-timing model operated by the FRB. However, these estimates are not available until the fishery is opened and are limited by the quality of catch and effort information collected during the fisheries.

Although Area 23 chum populations are fairly stable relative to other chum stocks on the west coast of Vancouver Island, returns to the area fluctuate significantly from year to year and, therefore, accurate forecasting of returns is difficult. A test fishery was conducted in Barkley Sound from 1977 to 1980 and again in 1982 to determine the relationship between stock size and CPUE. However, a reliable estimate of stock abundance could not be determined on the basis of the test fishery results. Reliability of test fishery results is conditional upon several sets being made under a variety of conditions, particularly during the early part of the run.[11]

There is also some uncertainty regarding optimum escapement levels for Area 23 chum. Historic data indicate that the optimum level may be significantly higher than the current target of 150,000 spawners.[11]

3.5.2 Mixed-Stock Harvest

The Area 23 sockeye fishery is directed at an actively-managed aggregate stock of Great Central Lake, Sproat Lake and Henderson Lake sockeye. Although the stocks are harvested together in Barkley Sound and Alberni Inlet, their relative strengths and run timing differ. The Henderson sockeye stock is significantly smaller and has a later run timing than the other two stocks. Consequently, fishing in part of Area 23 is generally closed during mid-July to secure adequate escapement of the Henderson run. In addition, the abundance of Sproat Lake sockeye has increased in recent years relative to the Great Central Lake stock. To meet existing escapement targets for the two systems, early closure of the sockeye fishery was implemented in 1986.

In the Area 23 sockeye fishery, there is some incidental harvest of other species, of which steelhead and chinook are of greatest concern. Summer runs of most Area 23 steelhead stocks are depressed. However, the Somass stock appears to be relatively stable, possibly because of hatchery production from Robertson Creek

hatchery.[14] Efforts to minimize the incidental catch of chinook include fishery closures in critical areas such as Nahmint and Sarita bays, in-season boundary changes in areas where by-catch is excessive and partitioning of the net fleet to prevent seine fishing in areas of Barkley Sound where juvenile chinook are abundant.

A small gillnet fishery directed at hatchery chinook is usually held at the head of Alberni Inlet during late August. The impact of this fishery on other stocks is minimal due to its terminal location and relatively short duration.

Although Area 23 chum have not been the target of fisheries in recent years, harvests may be undertaken in the future. Concerns regarding fall chum fisheries include the coincident run timing with Area 23 coho and the inability of the fleet to harvest chum stocks discretely.

3.6 Rebuilding Potential

Major sockeye populations in Area 23 are generally not in need of rebuilding and current management practices appear to be sufficient to maintain these stocks. An increasing trend in the abundance of Great Central Lake sockeye has been apparent since the early 1970s, and lake enrichment has contributed to escapements in excess of original target levels. A similar trend in the abundance of Sproat Lake sockeye has also occurred. Gradual improvements in the production of the Henderson stock has been apparent, but continued protection of this small stock is still required. Run forecasting by the Fisheries Research Branch has improved the in-season management of these stocks. However, more refined methods for assessing stock abundance would further help to minimize the possibility of overharvest in years of low sockeye abundance. Poor sockeye returns to Area 23 in 1985 and 1986 appear to have been a result of periodic oceanographic changes. The size of these stocks and sockeye catches are expected to return to former levels provided that harvests are curtailed to ensure adequate escapements.

Estimates of the size of Area 23 chum stocks indicate that they are currently below levels observed in the 1950s. Furthermore, the relative contribution of the stocks to the total production of West Coast Vancouver Island chum has declined from 30% to 22% over the same time period.[11] The contribution of Area 23 chum to total WCVI catch has declined even more dramatically from 30% to 11%. During the 1980s, escapements averaged less than two thirds of the target level of 150,000

chum. Based on available data for Area 23 chum, there appears to be potential for rebuilding these stocks. However, the variability in the age composition and return rates of the stocks makes it difficult to determine optimum escapement targets.

Chinook populations in the Nahmint, Toquart and Sarita rivers are depressed, but some rebuilding of these stocks is considered possible. Measures to assist rebuilding of chinook stocks along the entire coast have been in place since the signing of the Canada/U.S. Treaty in 1985. However, the success of these measures and the benefit they may have on small local stocks like Area 23 populations has not yet been determined. Within Area 23, the only strategy that would further curtail chinook catches would be to impose additional restrictions on the sockeye net fishery and the Barkley Sound/Alberni Inlet sport fishery. Some enhancement activities have been undertaken in the area to assist the recovery of Area 23 chinook populations. Poor returns to Robertson Creek hatchery in the past two years have caused concern regarding the possible impact to wild chinook stocks due to the reduced availability of hatchery fish.

3.7 Management Options for Rebuilding

3.7.1 Management Uncertainties

To improve the management of Area 23 sockeye stocks, a better understanding of marine survival of sockeye is required. Better information on the mechanisms that affect their survival would generate greater confidence in pre-season forecasts of stock abundance and facilitate more precise planning of fisheries. Current fisheries management depends on in-season monitoring during the fishery to determine run strength.

Variability in the age composition and return rates of West Coast Vancouver Island chum populations currently prevents reliable pre-season forecasting of adult returns. In-season assessment of actual population abundance is the only available method of realistically determining fisheries potential. A test fishery provides some estimate of stock strength and, therefore, is useful when a fishery is planned. Further refinement of test fishing procedures in Area 23 may provide more reliable indices to stock abundance and better information on local migration routes. Additional effort in escapement enumeration and consistency in enumeration techniques would improve baseline data that is necessary for stock assessment.

Resource limitations may require enumeration effort to be focused on a few "key" streams. Continued closure of chum fisheries in Area 23 would be a useful experiment in terms of adaptive management by providing information on the optimal spawning density of Area 23 chum-producing systems. Stock assessment information has indicated that the current escapement target of 150,000 chum may be too low for the area.[11]

An alternative approach to rebuilding Area 23 chum stocks and reducing uncertainty concerning returns of target stocks would be to enhance selected chum populations and direct fishing effort towards these stocks. This approach is currently being taken for the management of stocks in Areas 22 and 25. New enhancement activities are warranted only if a positive cost-benefit ratio is achieved and significant mixed-stock management problems are not created. At the present time, there are no plans to implement major enhancement activities for Area 23 chum. The emphasis of many enhancement activities on the west coast of Vancouver Island has shifted to the production of chinook and coho, which are more of a conservation concern and highly valued as sport fish.

3.7.2 Mixed-Stock Harvest

Among the major sockeye stocks in Area 23, the Henderson Lake stock appears to be suppressed possibly due to the interception of spawners in the mixed-stock sockeye fishery. In order to facilitate rebuilding of the Henderson stock to target levels, further restrictions in the sockeye net fishery would likely be required. This would result in increased escapements of Great Central and Sproat Lake stocks and would be economically feasible only if the additional value of the Henderson production outweighed that of the lost production from the other two systems. Another option would be to move all the fisheries to more terminal locations. However, this would create major management problems in Alberni Inlet unless the number of vessels participating in the fishery could be regulated.

Changes in the strength of the Great Central Lake sockeye stock relative to the Sproat Lake stock will have to be monitored over time. However, with the ability to identify relative stock contributions to catch within a matter of days, it is possible to make in-season adjustments to the fishery to ensure that adequate escapement of the weaker stock is achieved. Re-evaluation of escapement targets for these two systems may be required if return rates of the two stocks, relative to one another, change significantly.

Chinook stocks from Area 23 are intercepted in local and outside fisheries. Declines in Nahmint, Sarita and Toquart populations are most easily offset by continued satellite enhancement from Robertson Creek Hatchery. Reduction of chinook interceptions in Area 23 would require further restriction of sport and net harvests. Reduction of outside interceptions would affect catches and escapements of salmon stocks to other areas. Possible declines in marine survival of chinook similar to those observed in Area 23 sockeye[25] are of concern and would affect future management strategies for chinook harvest on the west coast of Vancouver Island.

3.8 Potential Enhancement Activities

3.8.1 Robertson Creek Hatchery Expansion (Project No. 23-15B)

This proposed project would increase the chinook rearing capacity of the hatchery by 50%. Currently, it has the production capability to release 9 million smolts.

3.8.2 Thornton Creek Facility (Project No. 23-32)

The Thornton Creek facility began as a Japanese-style chum rearing hatchery. However, operations have shifted towards production of local chinook and coho stocks. It is proposed that chum production be curtailed to levels required for maintenance of local stocks and that all of the additional capacity be used to incubate chinook and coho. With existing capacity, the Thornton facility is expected to produce adult returns of 3240 chum, 9925 coho and 2160 chinook. If the proposed changes are implemented, the facility is expected to produce adult returns of 1440 chum, 14,990 coho and 5000 chinook.

3.8.3 Side Channel Rehabilitation

Rehabilitation of side channel habitats to help stabilize chum production for specific stocks may have application to some West Coast Vancouver Island systems. The technique involves habitat manipulation to formerly active flood channels separated from the mainstem of the river.[20] Channels are excavated to ensure a steady supply of groundwater and are landscaped to provide suitable spawning substrate and water depths for spawning chum. Mainstem currents do not normally pass through these side channel habitats and the problem of scouring is therefore

minimized. Development of side channel spawning areas can help stabilize chum production by reducing the impacts of flood events and thereby increasing freshwater survival in some years.[21] To date, experimental side channels in the lower mainland of British Columbia have shown egg-to-fry survival rates approximately twice those of comparable natural spawning areas.[20] Implementation of this form of enhancement would necessarily be dependent on site location and conditions as well as cost effectiveness.

3.9 Results of Simulation Modelling

A computer model was used to investigate various fisheries management options for Area 23 sockeye and chum stocks. Results of the modelling are intended to indicate only the range of possible outcomes associated with the various management options and the merits and shortcomings involved with implementation of these strategies.

3.9.1 Sockeye

Two management scenarios were modelled for Area 23 sockeye stocks. In Option 1, it was assumed that the Great Central Lake, Sproat Lake and Henderson Lake stocks were managed as one large aggregate. Option 2 was a management strategy intended to facilitate rebuilding of the Henderson stock to target escapement. Productivity values for each of the stocks were based on their return rates over the past 10 years. For Great Central Lake and Sproat Lake stocks, a rate of 4.5 recruits per spawner was used. Although Henderson Lake has been enriched, a return rate of only 3.5 was used for the simulation. A variance of 1.0 was assigned to the return rate of each stock. The target escapements used for Great Central, Sproat and Henderson Lake stocks were 150,000, 150,000 and 50,000 spawners, respectively.

The offshore troll, Barkley Sound gillnet and Alberni Inlet seine fisheries were included in the model. It was assumed that the troll fishery harvested 5% of Area 23 sockeye, while the gillnet fishery harvested 30%. The seine fishery operated to harvest sockeye that were surplus to escapement needs. An escapement requirement of 350,000 sockeye was used in Option 1, which is the combined total of all three systems. In Option 2, harvesting was delayed until escapement requirements of the depressed Henderson stock were met. All three stocks were considered to be equally vulnerable to the troll and gillnet fisheries. However, the

Henderson stock was considered to be slightly less vulnerable than the other stocks to the seine fishery because of existing boundary restrictions and the later run timing of this stock.

Option 1: When sockeye stocks were managed to achieve a total escapement of 350,000, the Henderson stock did not rebuild. Both Great Central and Sproat Lake stocks stabilized at escapement levels slightly over the target level, while the Henderson Lake stock declined to about 30,000 sockeye (Figure 15). Catches in all of the fisheries declined slightly over time, with an average aggregate catch of about 1.3 million (Figure 15).

Option 2: Results of this simulation indicated that the Henderson sockeye stock could rebuild to the target level of 50,000 spawners, but there would be an associated reduction in overall catch. Rebuilding the Henderson stock resulted in a reduction in overall fishing effort, which contributed to overescapement of the Great Central and Sproat Lake stocks and a reduction in catch to a level of about 1.25 million. The Henderson stock rebuilt to the target level in year 1 under this management strategy (Figure 16).

3.9.2 Chum

Three management scenarios were modelled for Area 23 stocks. In Options 1 and 2, the effects of management uncertainty were investigated by implementing fisheries that harvested chum stocks at different intensities when abundance was low. The third option allowed for maximum rebuilding of these stocks by restricting harvest to chum that were surplus to escapement needs. Based on 19 years of data, the average rate of return for wild stocks was 1.09 returns per spawner with a variance of 0.18. Chum stocks were managed as one large stock aggregate due to a lack of information on specific stock groups.

Option 1: This simulation involved a test fishery to determine the result of intense fishing on returning stocks of unknown abundance. At very low abundance, as many as 50% of the chum were harvested. Results indicated that chum stocks could not sustain this form of management and serious declines in these stocks would occur (Figure 17).

Option 2: The management approach used in Option 2 was similar to that used in Option 1, except that a maximum of 20% of the chum stocks were harvested when

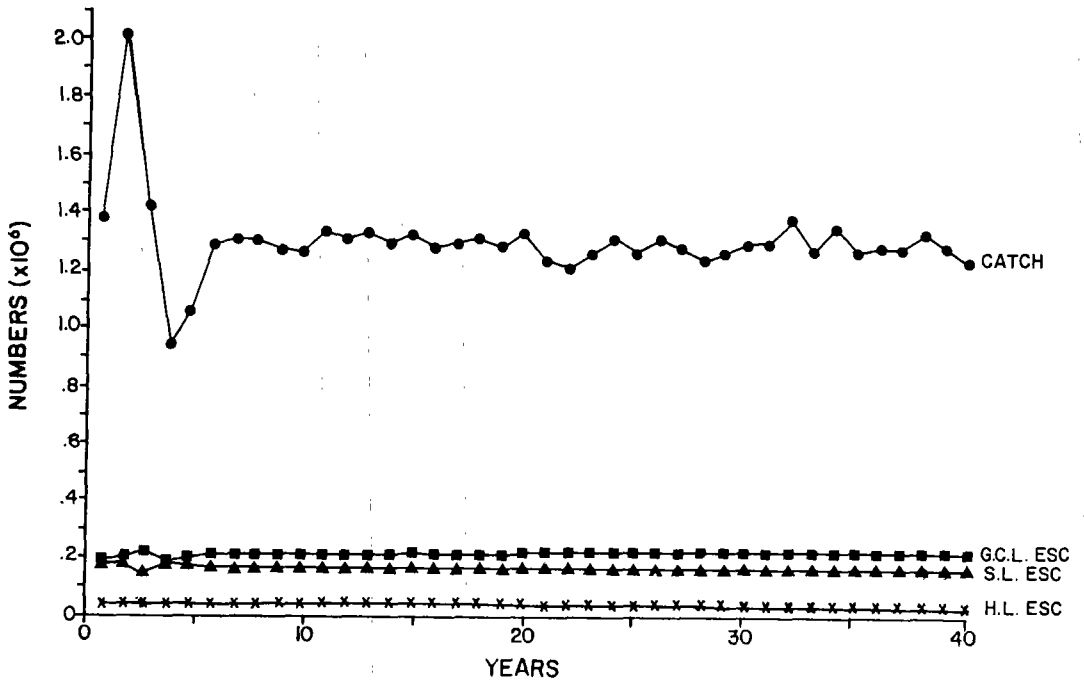

Figure 15. Projected catches and escapements of Area 23 sockeye under Option 1 (management of three stocks as aggregate).

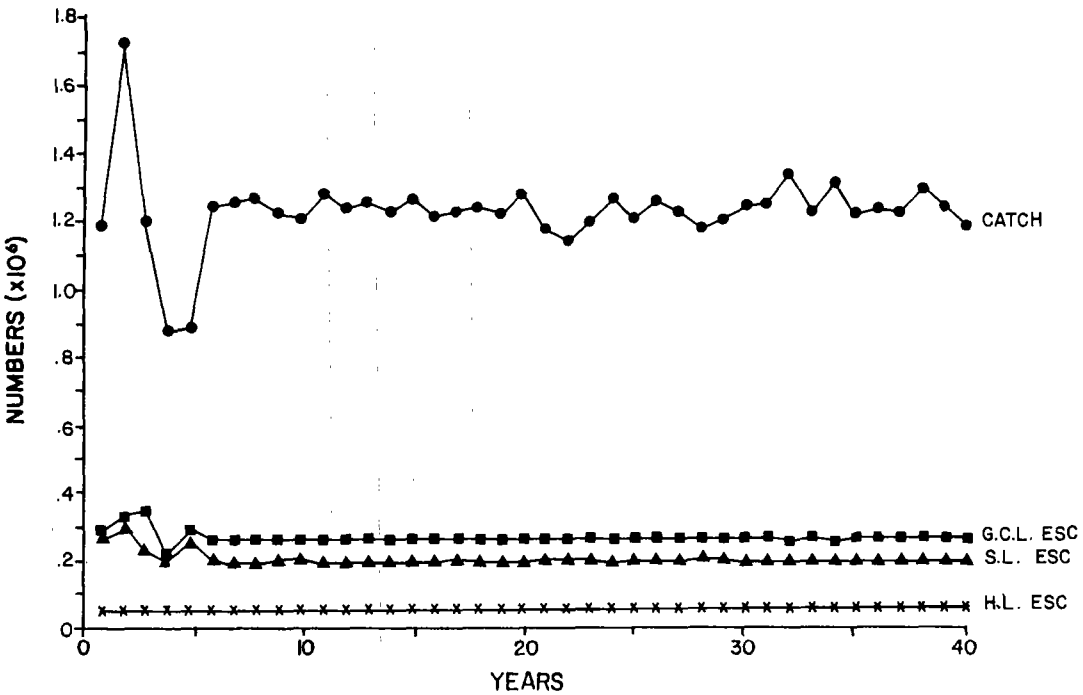

Figure 16. Projected catches and escapements of Area 23 sockeye under Option 2 (rebuild Henderson stocks).

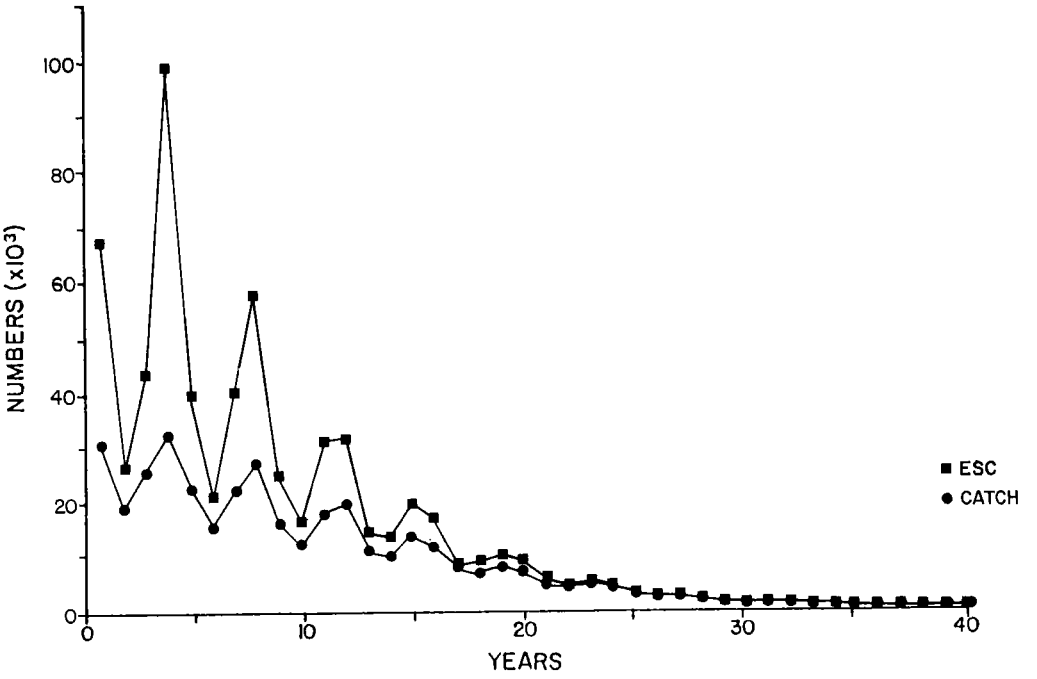

Figure 17. Projected catches and escapements of Area 23 chum under Option 1 (test fishery up to 50%).

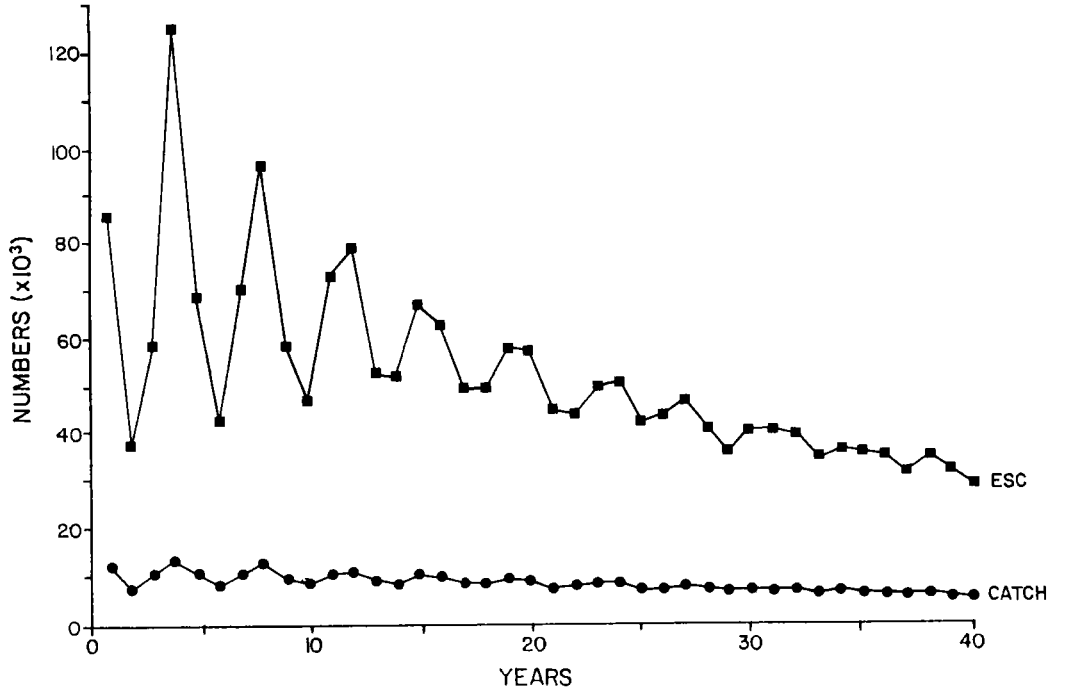

Figure 18. Projected catches and escapements of Area 23 chum under Option 2 (test fishery up to 20%).

abundance was low. Chum stocks never reached the target escapement and escapements declined over time. Catches averaged about 10,000 fish over the first 15 years, but declined slightly over the simulation period (Figure 18).

Option 3: This option represented the most conservative management approach. Fisheries were staged only when target escapements had been achieved. At an average return rate of 1.09 recruits per spawner, the chum population fluctuated around 95,000 spawners, well below the target escapement level (Figure 19). Harvestable surpluses were not available.

3.9.3 Summary and Conclusions

Although the Henderson stock remains below target levels, the current approach to managing Area 23 sockeye stocks maximizes long-term economic benefits. Rebuilding the Henderson stock to the target escapement level would require a reduction in fishing effort and reduced harvest of Great Central and Sproat Lake stocks. Movement of the entire net fleet into Alberni Inlet may allow some rebuilding of the Henderson stock, but congestion of the fishing fleet would create an unmanageable situation. Although Henderson Lake is currently being fertilized to increase sockeye production, productivity has not yet reached that of the Great Central Lake stock. Major changes to the current management approach may not be required if productivity of the Henderson stock is increased sufficiently through lake fertilization.

Results of the simulation modelling of management options for Area 23 chum indicate that at current estimates of productivity these stocks would not rebuild to target levels even under the most conservative management regime. However, due to the variability of West Coast Vancouver Island chum returns, run size could exceed target escapement levels in any given year and, therefore, permit fisheries to operate in some years. When chum harvests occur, benefits are maximized by adopting a conservative management approach. This entails in-season estimation of stock abundance to reduce the risk of overharvesting. With more data on Area 23 chum returns, the estimate of productivity may be revised. To avoid problems associated with mixed-stock fisheries, additional information on the productivity and migration patterns of these stocks is also necessary.

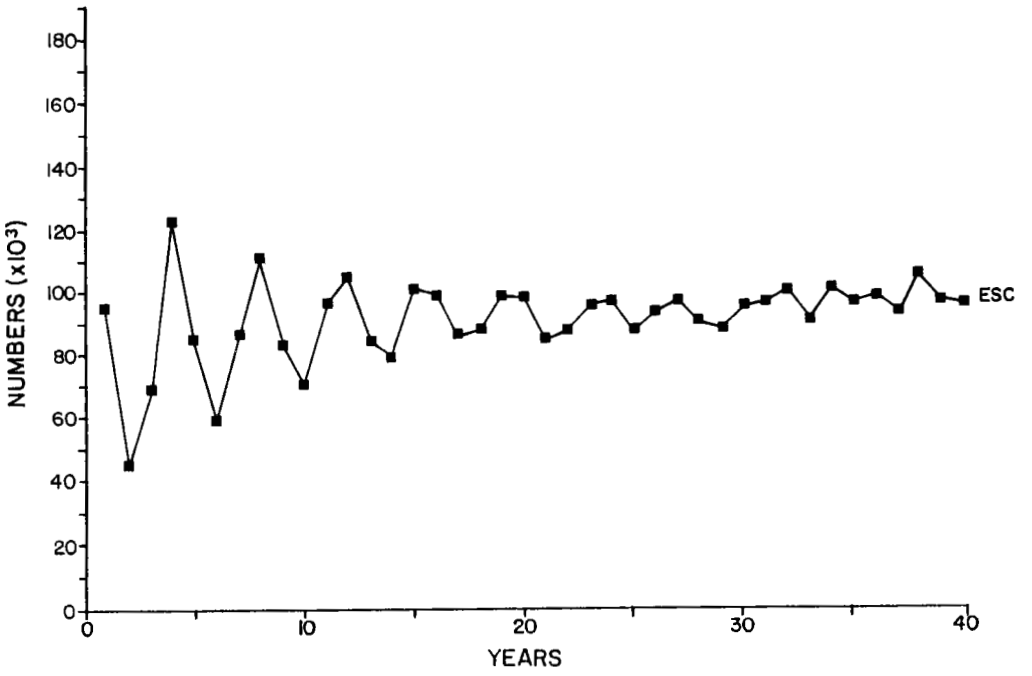

Figure 19. Projected escapements of Area 23 chum under Option 3 (surplus harvest only).

4. STATISTICAL AREA 24

Statistical Area 24 (Clayoquot Sound) is located on the central portion of the west coast of Vancouver Island (Figure 20). This area includes the coastline and associated streams from Florencia Bay to Estevan Point. The Kennedy system is the largest salmon-producing system in the area. Other important watercourses are the Megin and Moyeha rivers and Atleo,Tranquil and Bawden Bay creeks.

4.1 Stock Description

Streams in Area 24 support sockeye, chum, chinook, coho and steelhead. Pink salmon have not been observed in Area 24 for the past 12 years.[26] Sockeye and chum stocks are actively managed in local fisheries, while chinook and coho stocks are managed on a coast-wide basis.

4.1.1 Sockeye

Kennedy Lake sockeye account for 95% of the total sockeye returns to Area 24. There are two distinct sockeye stocks within Kennedy Lake, one from Clayoquot Arm and the other from Main Arm. The biophysical conditions of these two basins differ and although both of these sockeye stocks are beach spawners, they are essentially distinct from one another.[26] Clayoquot Arm encompasses only about one third of Kennedy Lake's volume, but this stock accounts for about two thirds of the total production. Although fry recruitment of Clayoquot sockeye has been relatively high, there appears to be significant competition with limnetic sticklebacks that are found in this part of the system.[26] Sockeye from the Main Arm appear to have poor survival from the egg to fry stage.

Historically, there were large runs of sockeye to the Kennedy system. Prior to the 1960s, catches in the terminal area ranged between 200,000 and 400,000 fish.[26] Most of these sockeye are believed to have been Kennedy fish. The total run size of these stocks is therefore estimated to have been in the order of 300,000 to 500,000 fish during this time. Despite the termination of commercial fisheries directed at Kennedy sockeye, the run has not yet recovered to this former level.

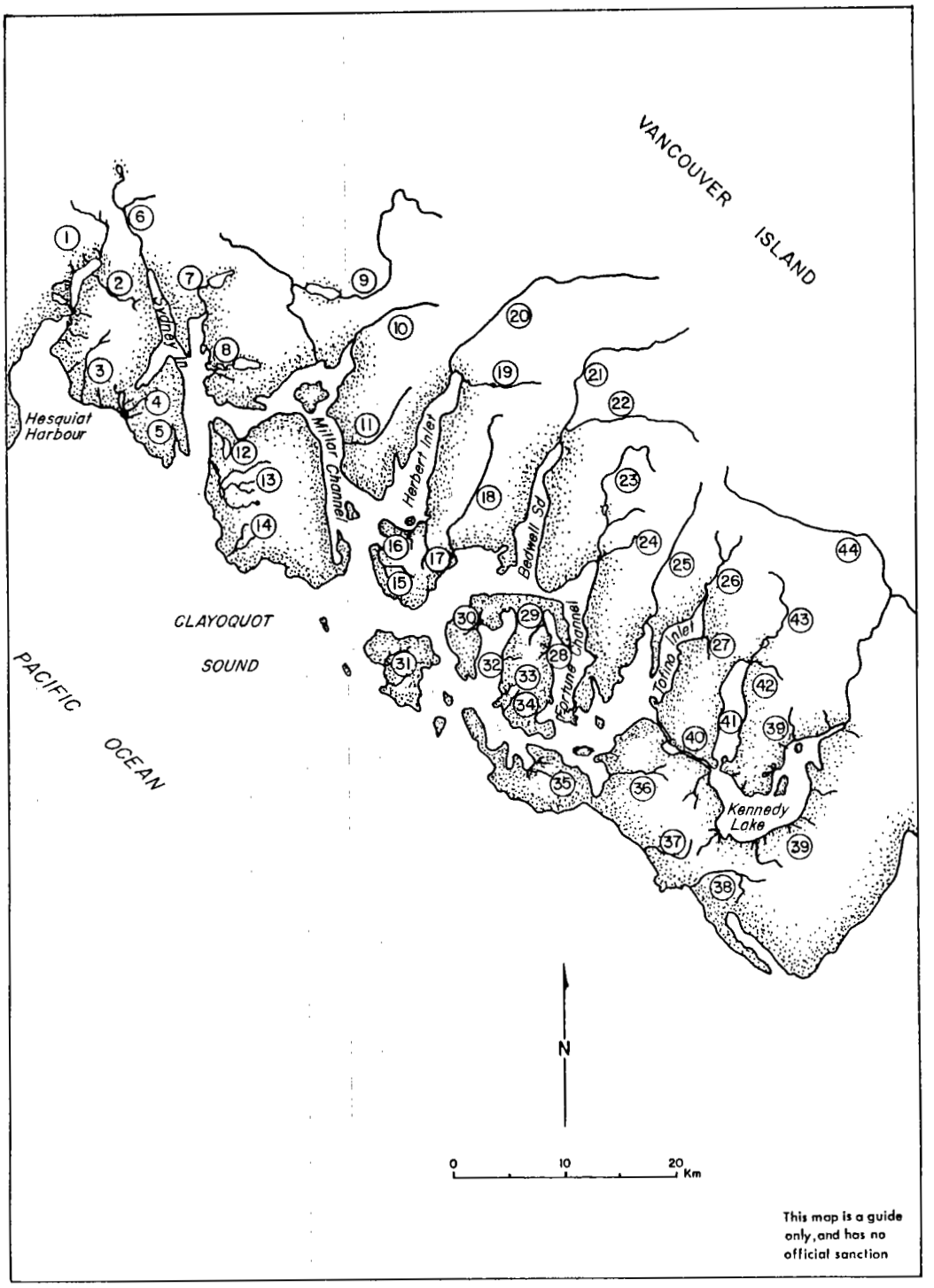

Figure 20. Statistical Area 24, showing location of salmon-producing streams (for key to streams, see Table 8).

Table 8. Key to salmon-producing streams in Statistical Area 24 (from Figure 20).

11.	Atleo Creek	44.	Kennedy River (Upper)
15.	Bawden Bay Creek	16.	Little Whitepine Cove Creek
21.	Bedwell River	38.	Lost Shoe Creek
23.	Bulson Creek	34.	Meares Creek
8.	Cecilia Creek	9.	Megin River
41.	Clayoquot Arm	20.	Moyeha River
43.	Clayoquot River	14.	Rafael Point Creeks
33.	Close Creeks	12.	Riley's Cove Creek
42.	Cold Creek	37.	Sandhill Creek
30.	Cone Creeks	2.	Satchie Creek
19.	Cotter Creek	32.	Sharp Creek
18.	Cypre River	35.	South Bay Creeks
3.	Hesquiat Harbour Creeks	29.	Sutton's Mill Creek
1.	Hesquiat Lake Creeks	26.	Tofino Creek
13.	Hootla Kootla Creek	25.	Tranquil Creek
5.	Hotsprings Cove Creek	22.	Ursus Creek
7.	Ice River	31.	Vargas Island Creek
36.	Indian River (Kootowis Creek)	24.	Warn Bay Creek
6.	Irving River (Sydney River)	10.	Watta River
4.	Kanim Creek	17.	Whitepine Cove Creek
39.	Kennedy Lake feeder streams	27.	Woman Island Creek
40.	Kennedy River (Lower)	28.	Wood Islet Creeks

Average escapements of Area 24 sockeye have ranged from about 48,000 in the 1950s to 22,000 in the 1960s. During the 1970s the average escapement increased slightly to about 27,000 sockeye. In the early 1980s, the trend in increasing escapements continued, with an average escapement of over 30,000 spawners. However, escapement in 1985 was estimated to be about 25,000 sockeye and in 1986 it was about 16,000 sockeye.[12] At least 90% of the sockeye are from the Kennedy system. The escapement target is currently 120,000 sockeye, but this has not been achieved since escapement enumerations were initiated in 1950.

4.1.2 Chum

There are more than 20 streams in Area 24 that support chum populations. The Megin and Moyeha rivers and Atleo, Tranquil and Bawden Bay creeks are the major producers. Based on data from 1973 to 1982, these streams accounted for 70% of the total chum escapement to the area. Escapements to the area averaged 69,800 during the 1950s, 39,500 during the 1960s, and 58,900 during the 1970s. From 1980 to 1985, the average escapement was 76,200. In 1986, chum escapement to the area was 72,300.[12] There has been a generally increasing trend in Area 24 chum escapement since the early 1970s, but considerable fluctuations have occurred among years.

Area 24 chum stocks are managed as an aggregate stock. The target escapement for this stock is 100,000 spawners, but this level has only been met three times since 1950.

Migration routes and timing through the fishing area are not well documented. The arrival of chum on the spawning grounds usually occurs in late September or early October. Spawning proceeds through October and is normally complete in November. Run timing of Area 24 chum is over a longer time of period than many other stocks from the west coast of Vancouver Island.

4.1.3 Chinook

Escapement records for Area 24 chinook indicate that stock levels have declined substantially since the 1950s. Average escapement during the 1950s was 5200 compared to less than 100 spawners in the late 1970s and early 1980s. Historically, the Bedwell, Cypre, Megin, Moyeha, Sydney, Tofino and Tranquil systems all supported populations of chinook salmon. However, the lower Kennedy

River is currently the only major chinook producer in the area. Estimated escapement during 1986 was 260 adults.

4.1.4 Coho

Coho escapements to Area 24 streams have apparently declined in recent decades. During the 1950s, average escapement of coho was about 18,000. There were over 7,000 coho spawners in 1986 but average escapement since 1980 has been about 5,000 fish. However, the actual status of coho stocks in Area 24 is unclear due to uncertainties regarding the quality of historic data. The difficulties in obtaining reliable escapement data for coho are outlined in section 2.1.4.

4.1.5 Steelhead

All of the larger river systems in Area 24 support steelhead populations. The largest producers are the Megin and Cypre rivers. Although stock assessment information is limited, both summer and winter runs are known to occur. Data regarding the migration of these two runs timing through the fishing area are currently lacking.

4.2 Managed Fisheries

4.2.1 Chum

Historically, the commercial net fishery in Area 24 targeted almost exclusively on chum stocks. Catches averaged over 60,000 during the period 1930 to 1949, then declined to an average of just over 32,000 chum from 1951 to 1963. This was followed by an extended closure of the fishery until 1976, when it was re-opened each year (except 1977 and 1979) until 1982. The total catch averaged almost 42,000 chum over this period.

The current approach to managing Area 24 chum salmon stocks is to only harvest fish that are surplus to escapement needs. The aggregate target escapement for Area 24 chum is 100,000. If there is an indication that returns will exceed the target, a commercial net fishery is held. In years when a harvestable surplus of chum is available, the commercial net fishery occurs during the first two weeks of October and generally lasts one to two days.

4.2.2 Sockeye

Traditionally, there was a fishery directed at Kennedy Lake sockeye and catches were reported to be as high as 400,000.[26] However, there has not been a commercial fishery for Kennedy sockeye stocks since 1971 due to population declines. Despite an ongoing lake enrichment program in the Clayoquot Arm of Kennedy Lake, the sockeye stock has not rebuilt sufficiently to permit a commercial fishery. The target escapement is currently 120,000 sockeye. However, there is little documentation of run timing and migration routes for this stock. There is intensive monitoring of juvenile abundance but numbers of returning adults are not rigorously assessed.

4.3 Current Enhancement Activities

Enhancement activities in Area 24 include a lake enrichment project and three small incubation projects (Table 9). In the past, there has also been some outplanting of coho and chinook from the Thornton Creek facility (Area 23) to systems in Area 24.

The Main Arm of Kennedy Lake was fertilized in 1979 and 1980, and Clayoquot Arm has been fertilized annually since 1978. However, the effect of this enrichment on the Kennedy Lake sockeye population has not yet been determined. The first spawners from broods raised under enriched conditions returned to the area in 1981, but increases in adult production associated with lake fertilization are not yet apparent. To date, fry recruitment of sockeye Clayoquot Arm has been relatively high. However, there may be serious competition with resident sticklebacks, which is limiting growth rates of juvenile sockeye and, therefore, their marine survival.[26] Fry recruitment of sockeye in the Main Arm of Kennedy Lake is currently low. There are plans to fertilize the Main Arm in 1987 in an attempt to improve fry recruitment. Fertilization of Clayoquot Arm will not occur in 1987 so that data can be collected on sockeye populations in an untreated lake condition.[26]

Small enhancement activities in Area 24 include a CEDP project and two PIP projects. The CEDP project is managed by the Clayoquot Band and is located on the lower Kennedy River. This involves the use of a cassette-incubator system, which was first established in 1984 to raise both coho and chinook salmon. However, there may be increased emphasis on chinook production in the future. The Ahousaht Band has a small SEP project that involves incubating 100,000 chum eggs from Wilson

Table 9. Production capacity of current enhancement facilities in Statistical Area 24 (based on SEP biostandards).[27,17]

Facility/Project	Target System	Egg Target	Expected Adult Returns
Kennedy (Clayoquot Band) (CEDP)			
Chinook	Lower Kennedy R.	15,000	151
Coho	Kootowis R.	100,000	2,430
Ahousaht Band (PIP)			
Chum	Flores Island	100,000	1,200
Coho	Streams	6,000	145
Tofino Enhancement Society			
Coho	Cypre R.	165,000	2,600

Creek and 6000 coho eggs from Cow Creek. In addition, the Tofino Enhancement Society has a hatchery facility in Tofino. Over 100,000 coho eggs are taken from the Cypre River stock and backplanted as fry. Some chinook stocks may also be enhanced at this facility.

4.4 Habitat Status

The physical terrain throughout Statistical Area 24 is rugged. Most streams in the area have extremely variable flows, particularly during winter when storms are common. Tofino and Ahousaht are the only major settlements in the area and they have little direct impact on salmon habitat in the area.

Logging has been the dominant industrial activity in Area 24, and few watersheds in the area remained undisturbed. Some salmon stocks have likely been influenced by changes in stream habitats that have resulted from logging operations. However, it is not certain to what extent these activities have contributed to declines of specific stocks in the area. A summary of the salmon-producing streams in Area 24 is presented in Table 10.

4.5 Management Conflicts

4.5.1 Management Uncertainties

The major concern regarding management of Kennedy sockeye stocks is the apparent lack of rebuilding, despite enrichment of the lake and the absence of commercial fisheries directed at these stocks. The FRB is continuing its investigation into the performance of these populations as part of the lake enrichment program. Although smolt production is regularly monitored, there is uncertainty regarding the marine survival (smolt to adult) of these stocks because escapement data for Kennedy sockeye are limited to visual estimates. Significant improvements in the accuracy of escapement enumeration for sockeye as well as other salmon stocks from the Kennedy system would be possible if a counting fence was installed on the lower Kennedy River.

The major concern regarding management of Area 24 chum stocks is the variability in return rates among wild stocks, which makes pre-season forecasting very difficult. In-season stock assessments provide a better indication of actual stock abundance, but there is still considerable uncertainty regarding the accuracy of

Table 10. Numbers of significant salmon streams by species in Statistical Area 24.26,27

Species	Total Streams[a]	Significant Streams[b]	Percent MRE[c]
Sockeye	8	6	96
Coho	26	11	80
Pink	9	4	94
Chum	24	9	83
Chinook	10	6	99

[a] Total Streams - number of streams that support or have supported the noted salmon species in the past.

[b] Significant Streams - the most important streams in terms of salmon production.

[c] Percent MRE - percentage contribution of the significant streams to the maximum recorded escapement.

this information. Without reasonable confidence in return estimates, fisheries cannot be adequately managed and, therefore, there is a significant risk of harvesting into escapement requirements.

The escapement target for the Area 24 chum stock complex is 100,000 spawners. However, information on the productivity of the stocks over a wide range of escapements is limited, particularly at high levels of escapement. Consequently, the validity of this target as well as specific escapement targets for each of the contributing river systems are uncertain.

4.5.2 Mixed-Stock Harvest

During years when chum fisheries take place in Area 24, conflicts regarding mixed-stock harvests will occur. Traditionally, chum fisheries have taken place near the surfline to maximize the quality of the catch. Fisheries located in this area intercept passing chum stocks from other areas along the west coast. In addition, local chum populations are mixed and management to an aggregate escapement for all of the Area 24 region may cause declines in some populations due to stock-specific differences in productivity and vulnerability to fisheries. Catch quality must therefore be considered in relation to the importance of preserving groups of viable chum stocks. An additional concern is the incidental catch of Kennedy River chinook and fall-run steelhead in fisheries directed at Area 24 chum stocks.

4.6 Rebuilding Potential

4.6.1 Sockeye

Historic information indicates that Kennedy Lake sockeye may have numbered 300,000 to 500,000 fish prior to the 1960s.[26] In the absence of an Area 24 commercial harvest, recent escapements averaged about 35,000 spawners. Allowing for underestimation of adult escapement, the size of the Kennedy sockeye population may have been ten times larger than it is at the present time. Therefore, there may be great potential for rebuilding this stock if the reason for this apparent stabilization of the population at the current low level of abundance can be identified.

4.6.2 Chum

There appears to be some potential to rebuild Area 24 wild chum stocks to the target escapement, although verification of this target may be required. The escapement target for Area 24 chum is currently set at 100,000 spawners. However, recent escapements to the area have averaged approximately 75,000. The escapement target has been achieved only three times since 1950, but total stock abundance has exceeded 100,000 fish ten times during this period. On two occasions, the total stock exceeded 200,000 chum. The extended closure of the commercial harvest of Area 24 chum between 1964 and 1971 appeared to allow limited recovery of these stocks. However, variability in chum returns to the area makes it difficult to identify trends in stock abundance. Additional information on stock productivity over a wide range of escapement levels is required. Due to past fishing pressure on these stocks, chum escapements have rarely exceeded 70,000 spawners. Evaluation of chum production at escapements above this level would help to establish a realistic escapement target for Area 24 stocks.

4.7 Management Options for Rebuilding

4.7.1 Management Uncertainties

Improvements to the management of Area 24 chum fisheries and refinement of escapement goals could promote rebuilding of Area 24 chum stocks. It is important to determine whether the current target reflects the production potential for the Clayoquot stock complex. Uncertainty regarding potential production for chum will be reduced as additional information on returns from escapements near the target level becomes available.

Closure of commercial harvests of Clayoquot chum since 1982 and the current management approach of fishing only those fish that are surplus to the escapement requirement should permit limited recovery of these stocks. If the stocks do not rebuild under these conditions, tagging studies to identify possible outside interceptions should be considered.

The effectiveness of the current management strategy depends on strict control of the harvest to ensure that only fish that are surplus to escapement are taken. However, because the accuracy of pre-season forecasts are uncertain, it is necessary to implement a test fishery to obtain reliable estimates of in-season stock

abundance. A gillnet test fishery was conducted in Area 24 from 1977 to 1980, and significant correlations between mean catch per hour and total stock abundance were established.[11] Accurate escapement enumerations are also necessary since they provide the basis for monitoring of rebuilding trends and pre-season estimates of returns.

An alternative approach to rebuilding wild chum stocks and reducing uncertainty regarding returns of target stocks would be to enhance selected chum populations and direct the fishing effort towards these stocks. This approach is currently being taken for the management of Area 22 and 25 stocks. New enhancement activities are warranted only if a positive benefit-cost ratio is achieved and significant mixed-stock management problems are not created. At the present time there are no plans to implement major enhancement activities for Area 24 chum. The emphasis of many enhancement activities on the west coast of Vancouver Island has shifted to the production of chinook and coho salmon, which are more of a conservation concern and highly valued as sport fish.

No major changes to the current management strategy for Area 24 sockeye would permit rebuilding of these stocks. There is presently no commercial fishery in the Clayoquot area, and the Fisheries Research Branch continues to investigate factors that may be limiting the production of Kennedy Lake sockeye. Installation of a fence in the Lower Kennedy River would be beneficial for assessing adult returns to the area.

4.7.2 Mixed-Stock Harvest

There have been no changes to the current management regime in Area 24 since there is little information to indicate that mixed-stock harvests are limiting the recovery of local stocks. With additional information of the vulnerability of chum to commercial harvest and the productivity of these stocks, it may be possible that some conservation measures can be taken when fisheries are conducted. Although there may be a decline in the quality of the catch, the simplest approach would be to move the net fishery to a more terminal location.

4.8 Potential Enhancement Activities

4.8.1 Kennedy River/Clayoquot CEDP Expansion (Project No. 24-10B)

Kennedy River chinook are currently being incubated and reared at the Thornton Creek facility, and then back-planted to the Kennedy River as 5 gram smolts. The Clayoquot Band has recently initiated an incubation and net-pen rearing operation, with a current production capacity of 50,000 coho eggs. It is proposed that when the Clayoquot facility and staff are prepared, the production of Kennedy River chinook will be transferred from the Thornton Creek facility to the Clayoquot site. The Clayoquot facility will have a production capacity of 100,000 coho and 100,000 chinook eggs, which will yield 7500 coho and 3000 chinook adults.

4.8.2 Side Channel Rehabilitation

Rehabilitation of side channel habitats to help stabilize chum production for specific stocks may have application to some West Coast Vancouver Island systems. The technique involves habitat manipulations to formerly active flood channels separated from the mainstem of the river.[20] Channels are excavated to ensure a steady supply of groundwater and are landscaped to provide suitable spawning substrate and water depths for spawning chum. Mainstem currents do not normally pass through these side channel habitats and the problem of scouring is therefore minimized. Development of side channel spawning areas can help stabilize chum production by reducing the impacts of flood events and thereby increasing freshwater survival in some years.[21] To date, experimental side channels in the lower mainland of British Columbia have shown egg-to-fry survival rates approximately twice those of comparable natural spawning areas.[20] Implementation of this form of enhancement would necessarily be dependent on site location and conditions as well as cost effectiveness.

4.9 Results of Simulation Modelling

A computer model was used to investigate various fisheries management options for Area 24 sockeye and chum stocks. Results of the modelling are intended to indicate only the range of possible outcomes associated with the various management options and the merits and shortcomings involved with implementation of these strategies.

4.9.1 Sockeye

Because current estimates of return rates of Kennedy Lake sockeye stocks are considered uncertain, different productivity rates were used in the simulation modelling to identify the possible range of economic benefits which may be accrued from Kennedy Lake sockeye at current and target population levels. The two populations were considered as an aggregate stock. It was assumed that there was a 5% harvest rate due to outside interception of these stocks and that only fish surplus to escapement requirements were harvested in the Area 24 fishery. The quality of the catch from the outside fisheries were considered to be Troll 1 and Net 1, respectively. The escapement target was 120,000 sockeye and the age structure of the population was 80% 4-year-old and 20% 5-year-old fish.

Option 1: The current status of the Kennedy Lake stock was simulated by running the model with a return rate of 1.5 recruits per spawner. Based on similarities between the run size observed in the first 5 years of the simulation period and actual returns in recent years, this rate of return was considered a good representation of the current productivity of this stock. Under this scenario, rebuilding of the Kennedy Lake stock occurred. However, the target escapement of 120,000 was never achieved. Consequently, sockeye were harvested only in the outside troll fishery and catches stabilized at about 5000 per year (Figure 21).

Option 2: With a return rate of 3.5 recruits per spawner, the Kennedy sockeye population reached the target level within ten years. A fishery targeting on surplus sockeye was held in Area 24, and catches stabilized over a 35-year period. Results of this simulation are illustrated in Figure 22.

4.9.2 Chum

Three management scenarios were modelled for Area 24 chum stocks. Options 1 and 2 involved staging a fishery that harvested chum at different intensities when abundance was low. The third option allowed for rebuilding of these stocks by staging a fishery only when when a harvestable surplus was available. Based on 10 years of data, the average rate of return was 1.79 recruits per spawner and the variance was 0.53. The average age structure of the population was 33% 3-year-old, 64% 4-year-old and 3% 5-year-old fish. The escapement target was 100,000 chum, and the quality of the catch was assumed to be semi-bright.

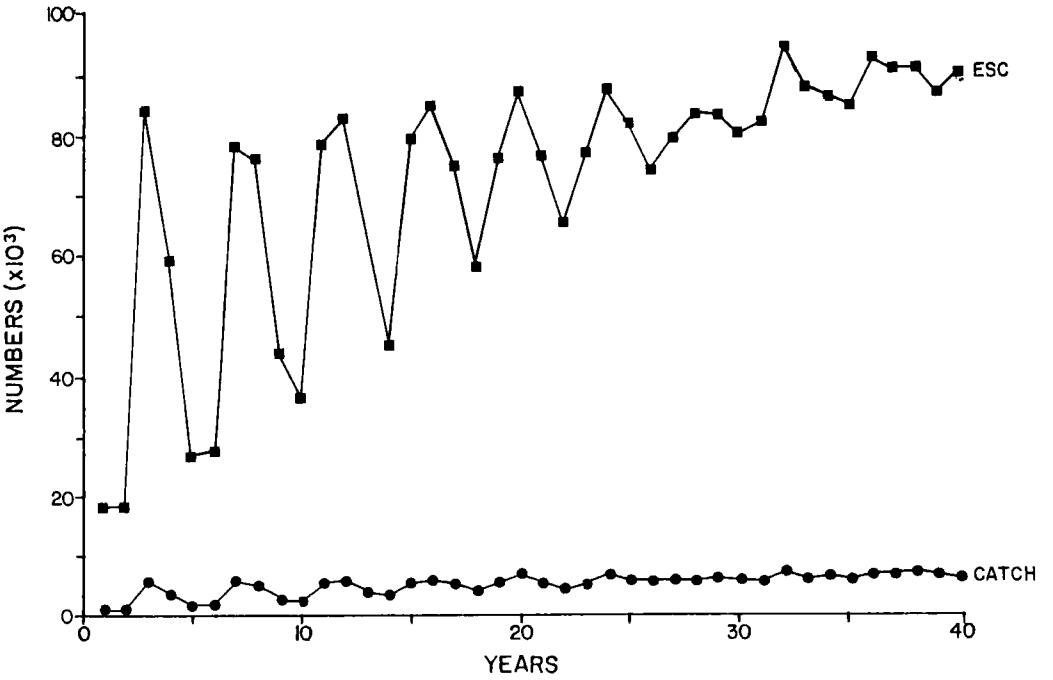

Figure 21. Projected catches and escapements of Area 24 sockeye under Option 1 (1.5 recruits per spawner).

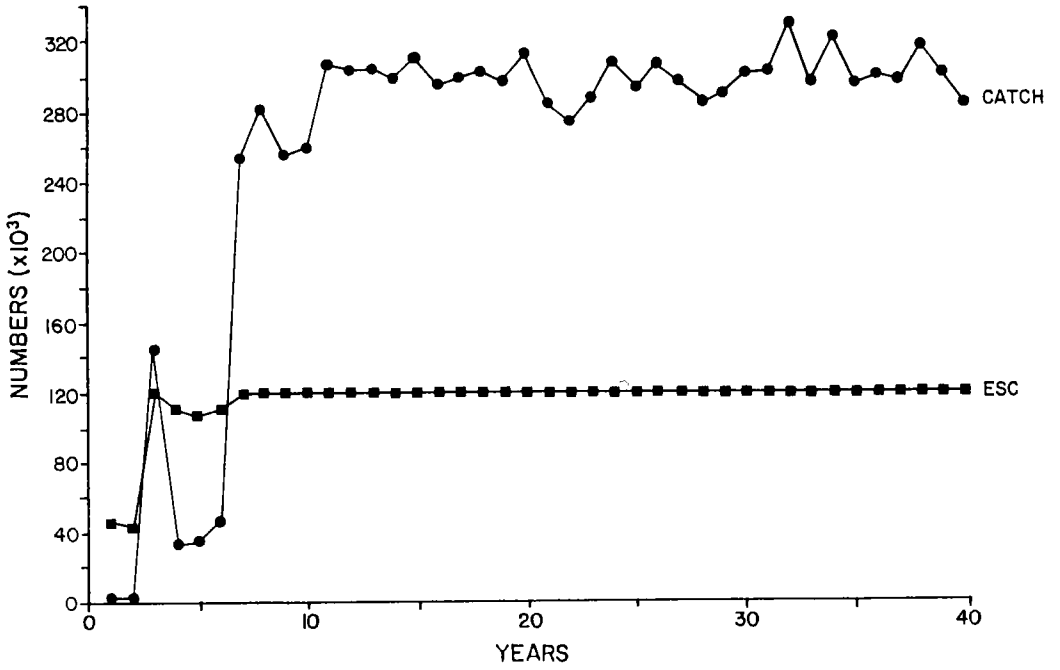

Figure 22. Projected catches and escapements of Area 24 sockeye under Option 2 (3.5 recruits per spawner).

Option 1: This simulation involved the use of a test fishery to determine the result of intense fishing on stocks of unknown abundance. Under this option, as much as 50% of the stock was harvested when returns were low. Any chum that were surplus to escapement requirements were taken in a second fishery to ensure that overescapements did not occur. Results of this simulation indicated that chum stocks stabilized below the escapement target, and catch averaged approximately 15,000 fish (Figure 23).

Option 2: The management approach used in Option 2 was similar to that used in Option 1, except that chum stocks were harvested to a maximum of 20% (in the first fishery) when abundance was low. Rebuilding occurred and stocks stabilized at an escapement level just below the target of 100,000. Catches stabilized at about 5500 fish (Figure 24).

Option 3: Option 3 represented a conservative approach to the management of Area 24 chum stocks. Fisheries were staged only when escapement requirements were achieved. Under this management scenario, stocks stabilized very near the target escapement level (Figure 25); however, no harvestable surpluses were available.

4.9.3 Summary and Conclusions

Results of modelling indicated that there would be significant economic benefits if Kennedy Lake sockeye stocks are rebuilt to target levels. However, the reasons for continued depression of these stocks are unclear at the present time. Competition between juvenile sockeye and sticklebacks is suspected as the factor limiting rebuilding of the Clayoquot Arm sockeye stock. Investigations by the Enhancement Assessment Unit to identify the cause of the stock depression are being continued. Installation of a counting device on the lower Kennedy River would allow a more accurate assessment of adult returns, which would provide better understanding of the population mechanisms that currently affect production of Kennedy Lake sockeye.

Results of the simulation modelling indicated that there is potential to rebuild Area 24 chum stocks to the target escapement. A conservative approach to managing Area 24 chum fisheries would maximize the rate at which these stocks are rebuilt by preventing harvest in years of low return. Due to the variability in return rates, there may be some years when returns are sufficient to stage a fishery on wild stocks.

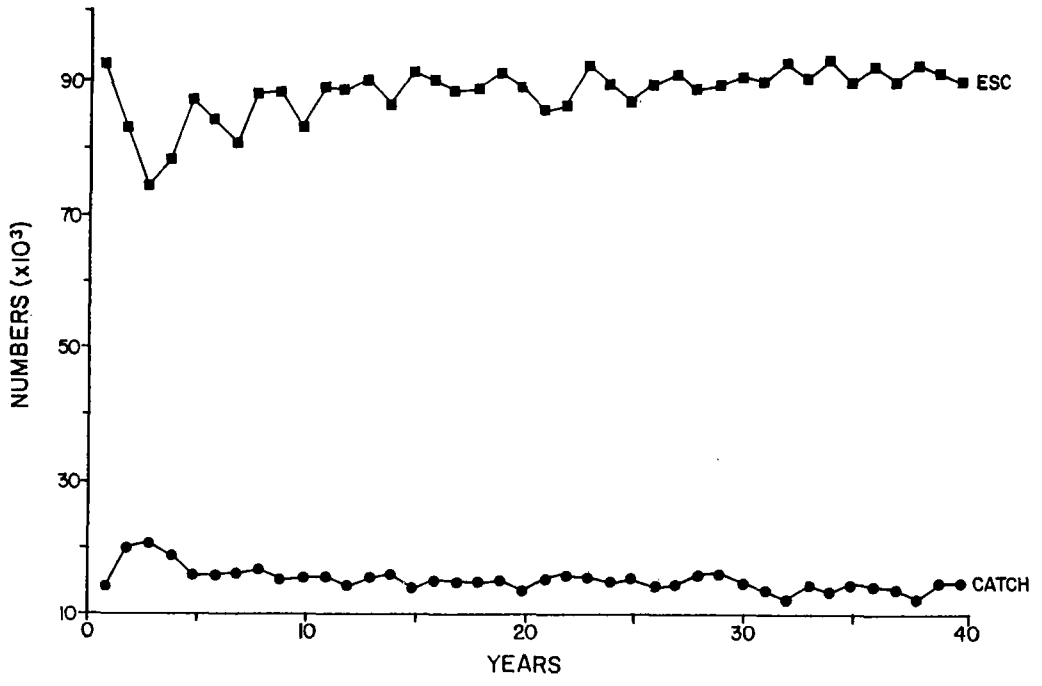

Figure 23. Projected catches and escapements of Area 24 chum under Option 1 (test fishery up to 50% harvest).

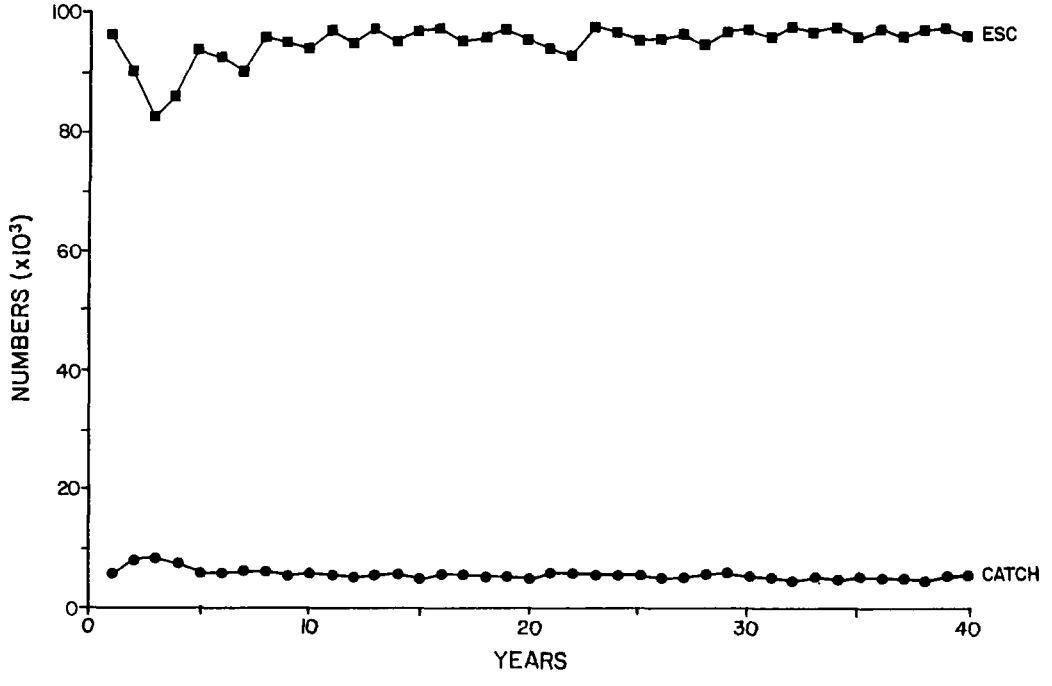

Figure 24. Projected catches and escapements of Area 24 chum under Option 2 (test fishery up to 20% harvest).

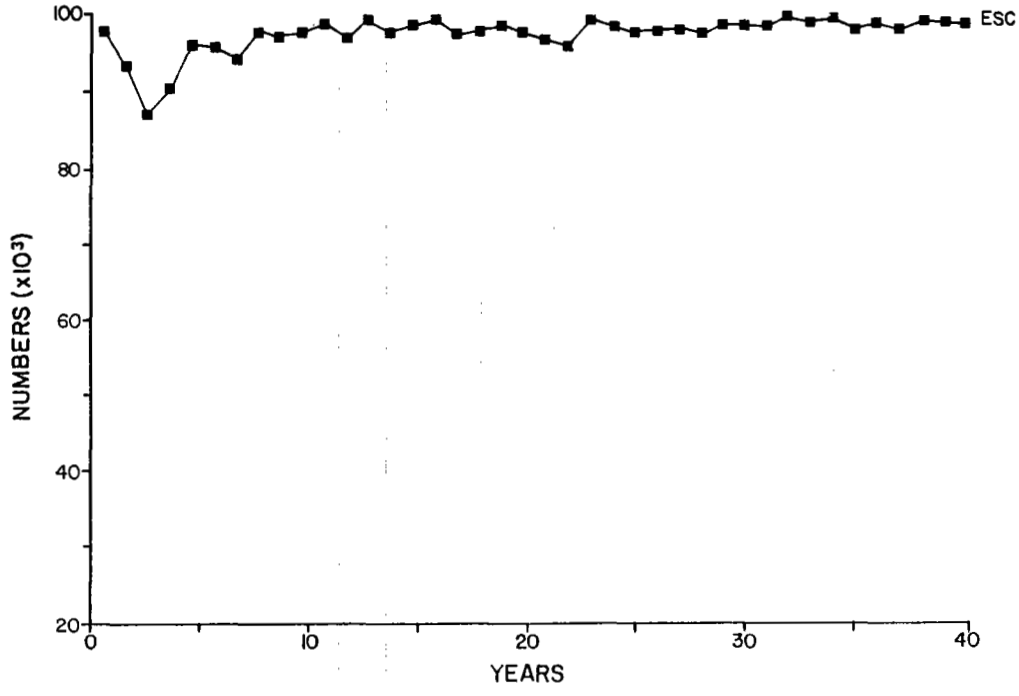

Figure 25. Projected escapements of Area 24 chum under Option 3 (surplus harvest only).

The difficulty in managing Area 24 chum fisheries is largely due to the variability return rates of these stocks. At present, the most realistic means of addressing this problem is to implement an in-season test fishery to assess actual stock strength prior to staging a fishery. In conjunction with the collection of accurate and consistent catch and escapement data, this would help to minimize the risk of overharvesting chum stocks and provide a reliable time series of data necessary for stock assessment and run forecasting.

5. STATISTICAL AREA 25

Statistical Area 25 is located on the central west coast of Vancouver Island. Area 25 is subdivided into two major sub-areas: Esperanza Inlet which includes Eliza, Nuchatlitz and Zeballos inlets; and Nootka Sound which includes Tahsis, Tlupana and Muchalat inlets (Figure 26 and Table 11).

5.1 Stock Description

All five salmon species are produced in Area 25[28], although chum are the most abundant and currently, the most important commercial species. Steelhead trout are also common in Area 25.

5.1.1 Sockeye

The major sockeye-producing systems in Area 25 are the Oktwanch River and Muchalat Lake, tributaries of the Gold River, which drains into Muchalat Inlet. Sockeye escapement data for these systems are limited. However, the aggregate population has been estimated at approximately 7000 for the last 30 years, with escapements of 10,000-17,000 fish on six occasions since the early 1970s.[29] Recorded escapement for 1986 was 17,855 spawners.[12]

5.1.2 Chum

Chum stocks originate in 40 streams within Area 25.[28] Stream escapement data indicate that spawning is generally distributed evenly over all of the systems. On average, the most productive systems are Conuma, Inner Basin, Tahsis and Zeballos rivers. However, the systems with the most consistent production are the Burman, Leiner, Park, Sucwoa, Tlupana and Tsowwin rivers, as well as Canton, Chum and Deserted creeks. The average escapement for each of these systems is about 15,000 chum, with a range from 1500 to 75,000 spawners.[11]

Over the past 35 years, total chum escapement to Area 25 has ranged from 32,000 in 1955 to 294,000 in 1960.[6] Escapements to the area have been variable, but a generally increasing trend has been apparent since 1976. Chum escapements to the area have averaged around 140,000 in recent years and 1986 escapement was 150,800 with another 15,000 used for hatchery broodstock.[12] Target escapement for the aggregate Area 25 chum stock is currently 150,000, which includes 15,000 for

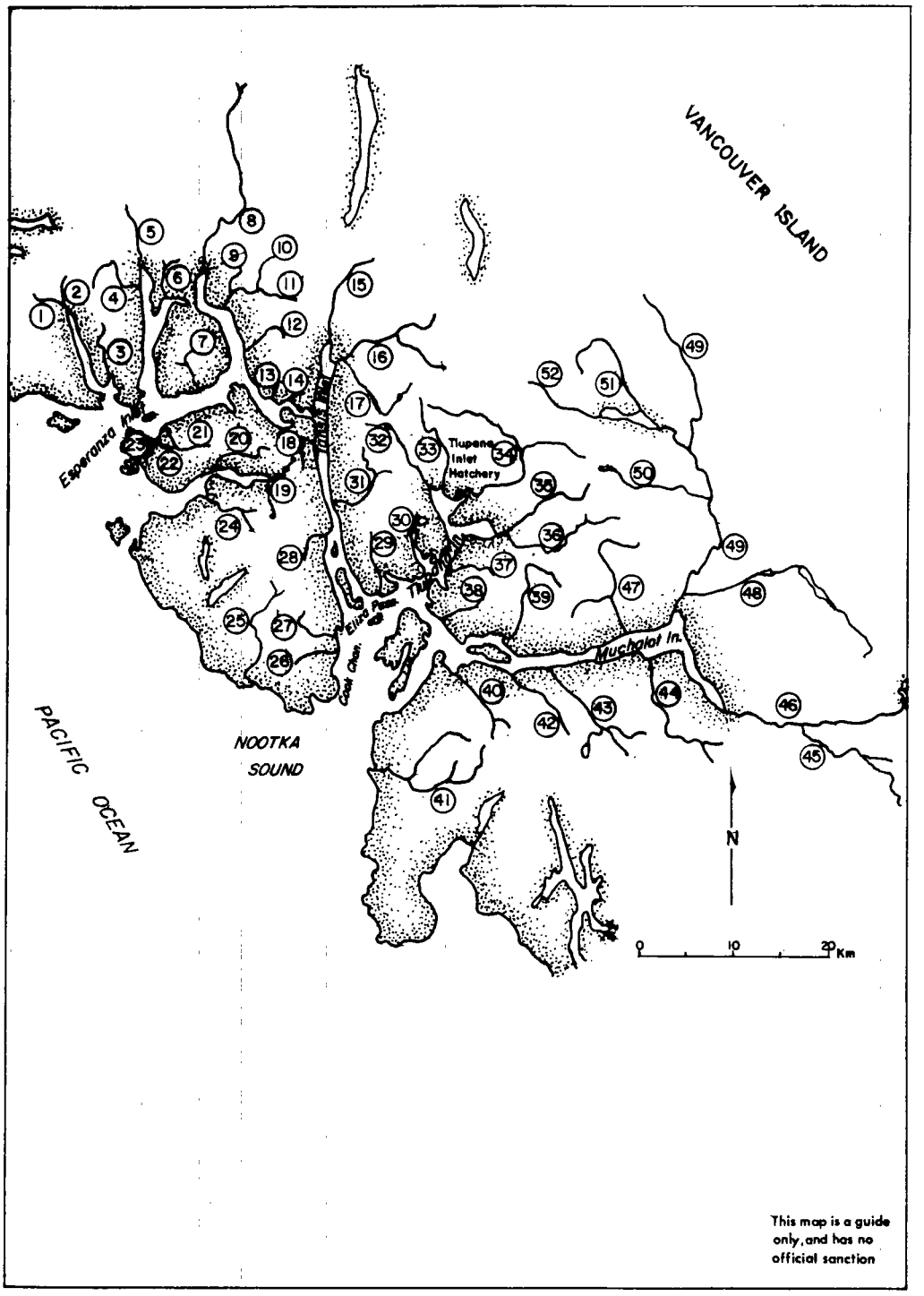

Figure 26. Statistical Area 25, showing location of salmon-producing streams (for key to streams, see Table 11).

Table 11. Key to salmon-producing streams in Statistical Area 25 (from Figure 26).

2.	Apple Creek	44.	Jacklah River
45.	Bancroft Creek	28.	Kendrick Creek (Kendrick River)
12.	Barr Creek	39.	Kleeptee Creek (Tooter Creek)
25.	Beano Creek	24.	Laurie Creek
9.	Bingo Creek	16.	Leiner River (Russian River)
18.	Blowhole Creek	11.	Little Zeballos River (Zeballos River Little)
21.	Brodick Creek (Garden Pnt. Cr; Garden Cr)	14.	Lord Creek (Ceepeecee Creek)
46.	Burman River	6.	Mamat Creek (Little Espinosa Creek)
33.	Canton Creek (Canton Gorge Creek)	27.	(Marvinas Creek; Marvinas Bay Creek)
4.	(Chum Creek)	47.	McCurdy Creek
34.	Conuma River	40.	Mooyah River (Mooyah Bay Cr; Camp Bay Creek)
37.	Cougar Creek	52.	Muchalat River (Muchalat River System)
26.	(Demikosse River)	36.	Nesook River
30.	(Deserted Creek; (Hisnit Creek)	51.	Okhwanch River
7.	Ehatisaht Creek (Ehatisat Creek)	23.	Owossita Creek (Owossita River)
1.	Eliza Creek (Port Eliza #1; Port Eliza West)	3.	Park River (Queen Cove Creek)
41.	Escalante River	17.	Perry River
13.	Esperanza Creek	2.	(Port Eliza #2; (Hammond Creek: East)
5.	Espinosa Creek (Big Espinosa River)	42.	Silverado Creek
10.	Friend Creek (Friendly Cr)	32.	Sucwoa River (Bear River)
49.	Gold River	15.	Tahsis River
20.	Gulse Creek	35.	Tlupana River
38.	Hanna Creek	31.	Tsowwin River (Sandpoint Creek; Sou-End River)
29.	Holss Creek (Canal Creek)	48.	Ucona River
43.	Houston River	50.	Upana River
19.	(Inner Basin Creeks (2); Inner Basin Rivers)	8.	Zeballos River (Big Zeballos River)

hatchery broodstock. Target escapement for the Nootka and Esperanza populations is 90,000 and 60,000 spawners, respectively.

The average age structure of Area 25 chum populations is 38% 3-year-old, 58% 4-year-old and 4% 5-year-old fish; however, like most West Coast Vancouver Island stocks, the age composition is variable.[11] Since the 1956 brood year, return ratios have averaged 2.67:1 and have ranged from 0.22:1 (in 1973) to 10.35:1 (in 1957).[11] With the exception of the 1972, 1973 and 1975 broods, Area 25 chum stocks have generally shown good return rates. Chum salmon stocks in Tlupana Inlet have been enhanced since 1978 at the Tlupana Inlet hatchery, which is located at the mouth of the Conuma River.

Most West Coast Vancouver Island chum stocks arrive on the spawning grounds and commence spawning from late September to mid-October. However, Area 25 stocks arrive approximately two weeks earlier (early to mid-September) and begin spawning in mid- to late September.[30] The peak and end of spawning are similar to other West Coast Vancouver Island chum stocks and occur in mid- and late October, respectively. The early chum runs originate primarily from the Conuma and Tlupana River systems.

5.1.3 Chinook

The major chinook-producing systems in Area 25 are the Gold, Burman, Conuma and Liener rivers. Historically, the Deserted, Tahsis, Tsowwin, Sucwoa and Mooyah rivers produced chinook. However, escapement estimates are currently fewer than 100 fish for each of these systems. Enhancement activities have been initiated on the Tahsis, Liener, Sucwoa, Gold, Burman and Conuma rivers.

In general, Area 25 chinook stocks are depressed. The historic escapement average is approximately 5000 spawners (1947-1983). Since 1980, chinook escapements (including hatchery fish) have been less than the historical average, but an increasing trend is apparent. Recent escapements for Area 25 are as follows:[9,12]

Year	Escapement
1980	2,545
1981	1,550
1982	1,855
1983	2,487
1984	3,308
1985	3,110
1986	4,329

Intensive monitoring of chinook streams has occurred since 1983. Although there is limited confidence in the accuracy of escapement data collected prior to 1983, data collected since this time are believed to be consistent among years.[28] Area 25 streams are difficult to monitor due to their remoteness and serious limitations related to resources available for such activities. The current escapement target for chinook is 5000 to 6000 spawners, although there may be capacity for up to 21,000 spawners.[30]

Information on the age structure of Area 25 chinook stocks is currently limited. Based on coded wire tag (CWT) data from the Tlupana hatchery, most chinook return as 4- or 5-year-old fish. These stocks generally have a fall-run, ocean-type life history.

5.1.4 Coho

Escapement records indicate that the major coho-producing streams in Area 25 are the Burman, Conuma, Gold, Leiner, Tahsis, Tlupana, Zeballos and Perry rivers. Based on observations of habitat availability and fry and spawner abundance, the following streams are also considered to be significant coho producers: Canton and Deserted creeks, and Escalante, Inner Basin, Little Zeballos, Mooyah, Muchalat, Oktwanch and Tsowwin rivers.[28] Average escapements of the aggregate coho stock were estimated to be approximately 30,000 in the mid-1960s, but decreased to less than 10,000 in recent years.[29] Estimated escapament for 1986 was 11,900 adults.[12] However, the reported declines in escapement over the past decade may not reflect an actual trend because there is considerable uncertainty regarding the accuracy of

the escapement data. The difficulties in obtaining reliable escapement data for coho are outlined in section 2.1.4.

5.1.5 Pink

Pink salmon are not abundant in Area 25. No large runs are known to have occurred in recent years, and a brief survey of the major systems in the area indicate that there was a total of about 700 pink salmon in 1986.[12] The most significant producers of pink salmon are the Burman, Leiner and Zeballos rivers. As recently as 1972, there were 240,000 spawners in Area 25 streams.

5.1.6 Steelhead

The Gold and Zeballos rivers are the most important steelhead-producing systems in Area 25. The Gold River population is believed to have the largest natural (wild stock) steelhead run on Vancouver Island.[14]

Both summer and winter steelhead runs occur in Area 25. The winter steelhead run supports an intensive sport fishery at Gold River and, to a lesser extent, at Zeballos and Tahsis rivers. The incidental catch of steelhead in the commercial chum fisheries in this area is presently a concern.[14]

5.2 Managed Fisheries

5.2.1 Chum

Historically, net fisheries directed at West Coast Vancouver Island chum stocks have operated in the inlets (inside the surfline) in years when abundance of chum was high.[5] Area 25 stocks have consistently supported a fishery from 1951 to 1985.[11,12] Based on the occurrence of past fisheries, it appears that Area 25 is the most consistent chum producer of all the statistical areas on the west coast of Vancouver Island.[11] Catches averaged 105,000 in the 1950s, 33,000 in the 1960s, 66,500 in the 1970s and 153,700 from 1980 to 1985.[11,12] The largest catch was 260,000 chum in 1982. Harvest rates have ranged from 3% to 67% in years when the fishery has been open. The harvest rate averaged 49% during recent years (1980-85). Since 1983, the fishery in Area 25 has largely been directed at chum produced by the Tlupana hatchery.

In the past, the entire area would be opened to fishing and effort would be distributed throughout the region. In 1985, Area 25 was managed on a sub-unit basis and only Cook Channel and Eliza Pass (sub-Areas 25-7 and 25-6) were open to commercial fishing. The Area 25 chum fishery generally opens in early October.

From 1977 to 1980, gillnet test fisheries were conducted in the area to provide an index of the abundance of incoming chum salmon. No statistically significant correlation between the total stock size and the test fishery catches was found.[11] However, this analysis was based on only 3 years of complete data. Additional data and increased fishing effort would be required to establish a relationship between test catches and total stock size.[11]

From 1982 to 1986, seine test fisheries were undertaken to determine both stock abundance and fish quality at the time of harvest. A subjective estimate of chum abundance in both Nootka Sound and Tlupana Inlet was provided.[11]

Chum salmon generally move into Nootka Sound in semi-bright condition. However, stocks bound for the Tlupana Inlet region often remain in the area for a period of time prior to moving to their natal streams. During this time, the quality of these fish declines. Quality is highest during the last two weeks of September and gradually decreases in October.

5.3 Current Enhancement Activities

Table 12 summarizes the production targets for chum, coho and chinook broods for each of the enhancement facilities in Area 25.

5.3.1 Conuma River/Tlupana Inlet Hatchery

The Tlupana facility is a Japanese-style hatchery located near the mouth of the Conuma River. Like the Nitinat hatchery (Statistical Area 22), it was designed to stabilize and increase chum catches in inlets along the west coast. The Tlupana hatchery has the capacity to incubate 23 million eggs, which are expected to result in returns of about 280,000 adults. The hatchery is operated as a satellite facility to enhance chum stocks from the Canton, Conuma, Deserted, Sucwoa and Tlupana systems. This strategy was developed in anticipation of a fishery that would harvest all of these stocks in Tlupana Inlet. By enhancing these populations at a level proportional to their natural abundance (within the Tlupana chum stock

Table 12. Production capacity of major hatcheries and small enhancement facilities in Statistical Area 25 (based on SEP biostandards).[17]

Facility/Project	Target System	Egg Target	Expected Adult Returns
Tlupana			
Chum	Sucwoa R. Canton Cr. Tlupana R. Conuma R. Deserted Cr.	23,000,000	281,520
Chinook	Conuma R. Tlupana R. Sucwoa R.	3,500,000	20,160
Coho	Conuma R. Sucwoa R. Canton Cr. Deserted Cr. Tlupana R.	120,000	5,700
Gold River Rod & Gun Club			
Chinook	Gold R.	300,000	3,240
	Burman R.	200,000	2,160
Coho	Gold R.	200,000	2,160
Tahsis Village Association			
Chinook	Tahsis R. Leiner R.	200,000	2,160
Coho	Tahsis R. Leiner R.	50,000	540

complex), all stocks should remain viable despite the fact that they are harvested in a mixed-stock fishery.

The Tlupana Hatchery is also designed to increase coho and chinook production to account for potential interceptions of these fish in the chum fishery. Chinook and coho brood stocks were initially taken from the Conuma River. However, brood stocks were also taken from Tlupana and Sucwoa rivers in 1984 in an attempt to balance production of chinook and coho from these systems. Chinook and coho stocks also contribute to the sport fishery that operates in the inlets.

Maximum chum production was reached in 1983, when approximately 19 million chum fry were released from the Tlupana hatchery. The first significant harvestable surplus of hatchery fish occurred in the fall of 1985. However, enhanced returns also contributed, to a lesser extent, to the 1983 and 1984 fisheries.

5.3.2 Gold River Rod & Gun Club

In 1986, the Gold River Community Chinook Enhancement Program incubated a total of 281,000 Gold River and 152,000 Burman River chinook eggs. The target is 500,000 eggs for both of these rivers.

5.3.3 Tahsis Village Association

The Tahsis Village Association incubated 135,000 chinook eggs from the Liener River in 1986. Due to low returns (50-60 chinook) to the Tahsis River in the same year, no brood stock was taken from this system.

5.4 Habitat Status

Salmon-producing watercourses in Area 25 are typical of other West Coast Vancouver Island systems in that they are subjected to widely fluctuating stream flows. The topography is generally rugged and the region is dominated by forest cover. Although some pristine areas still exist, logging has occurred in most watersheds in the region.[4] In addition, there are pulp mill operations in Muchalat Inlet and sawmill operations in Tahsis Inlet that may have caused localized impacts on stream and estuarine habitats in these areas. Gold River and Tahsis are the major towns in the area, while other small settlements include Zeballos and Nootka. A summary of the salmon-producing streams in Area 25 is provided in Table 13.

Table 13. Numbers of significant salmon streams by species in Statistical Area 25.[28]

Species	Total Streams[a]	Significant Streams[b]	Percent MRE[c]
Sockeye	10	5	98
Coho	31	17	99
Pink	33	18	97
Chum	40	26	95
Chinook	29	11	95

[a] Total Streams = number of streams that support or have supported the noted salmon species in the past.

[b] Significant Streams = most important in terms of salmon production.

[c] Percent MRE = percentage contribution of the significant streams to the maximum recorded escapement.

5.5 Management Conflicts

5.5.1 Management Uncertainties

The major uncertainty in the management of Area 25 chum stocks is the abundance of returning chum stocks. Variability in return rates and lack of confidence in historic catch and escapement data for wild chum stocks limits the ability of fisheries managers to forecast returns. The forecast of enhanced chum salmon to Area 25 is more reliable because natural variability in the production of these stocks has been reduced through rearing of eggs in a controlled environment. Nevertheless, the number of returns from hatchery stocks has not yet reached forecasted levels.[28]

Forecasts of run returns depend on accurate catch and escapement records. Traditionally, catch data for Area 25 chum stocks were collected for the area as a whole, and this masked differences between stocks from the two sub-areas, Nootka Sound and Esperanza Inlet. However, a fishery has not occurred in Esperanza Inlet since 1982 and, therefore, catch data collected since this year are available only for the Nootka Sound stock complex.[17]

The reliability of escapement data depends on the resources available to field personnel and local weather conditions during the spawning season. Escapement data collected in recent years are considered more reliable because of consistency in enumeration effort and field personnel. Historic data are less dependable. Results of a 1978 mark-recapture study in Tlupana Inlet indicated that there were significant inconsistencies between visual and mark-recapture estimates of chum escapements.[30]

Due to the uncertainties associated with run forecasts, in-season assessment of stock abundance must be completed in a manner that reduces the risk of overharvest. Although test fisheries were conducted in Area 25 in the past, data are presently considered insufficient to estimate stock abundance accurately.

Another factor that contributes to management uncertainty is the limited information available regarding the migration patterns of Area 25 chum stocks. Although the area can be separated into Nootka Sound and Esperanza Inlet, fish from one sub-area may migrate through the other area en route to their spawning streams. Limited data from marked returns indicate that only minor interceptions

of Tlupana fish occur in Esperanza Inlet. If stocks in each sub-area generally avoid the other area the two groups could be managed separately. It would be necessary to determine the approach of each stock to determine which groups should be managed together. Tahsis Inlet stocks could be part of either the Nootka or Esperanza group.

Sub-areas could be further divided to represent specific stock groups. For example, Nootka Sound stocks could be separated into Tahsis, Tlupana and Muchalat Inlet stocks. Little is known about the migration timing and patterns of these smaller stock groups. However, some information on arrival times into the inlets is available from test fishery results and records taken by Fishery Officers. The arrival of stocks to the area tends to be fairly consistent, although the timing of subsequent migration to natal streams varies significantly and appears to be related to weather conditions that influence river flow.[28]

5.5.2 Mixed-Stock Harvest

The Area 25 chum fishery in Cook Channel and Eliza Pass is a mixed-stock fishery that targets on enhanced chum stocks from the Tlupana hatchery. This fishery likely intercepts less productive chum stocks from Muchalat Inlet (particularly Burman River and Kleeptee Creek stocks) and the Tsowwin River, but may also intercept Tahsis and Leiner River stocks depending on their migration routes. The fishery has been confined to the Cook Channel and Eliza Pass areas to minimize interception of Muchalat Inlet stocks, which likely migrate primarily through King Passage. However, no mark-recapture studies have been conducted to determine the interception rate on wild chum stocks.

Some coho are taken incidentally in the chum fishery. However, the vulnerability of coho to this harvest is probably not high due to the extended period of their migration to spawning habitats within the region. During 1986, 7000-10,000 coho returned to Tlupana hatchery. Most of these hatchery fish were well inside Tlupana Inlet prior to the opening of the chum harvest, which indicates that the incidental catch of coho in Area 25 is composed primarily of wild stocks.[28] Opening the chum fishery earlier (early September) might help to reduce interceptions of wild coho; however, the by-catch of chinook and steelhead could increase.

5.6 Rebuilding Potential

Area 25 chum stocks have sustained a relatively consistent fishery over the past 35 years. Chum catches in the order of 300,000 fish are expected in the future as a result of hatchery production. If fisheries directed at enhanced chum continue to be restricted to the Nootka Sound area, this may allow wild chum stocks that are least affected by the fishery to rebuild. Stocks with the greatest rebuilding potential are those from Esperanza Inlet, which probably escape the fishery. There is less opportunity for rebuilding of wild chum stocks from Muchalat Inlet and the Tsowwin River, becaus they are intercepted in the mixed-stock fishery that targets on enhanced stocks. Rebuilding of Tahsis and Leiner River wild stocks would depend on their susceptibility to this fishery as determined by their migration patterns. There may be more opportunity for rebuilding when additional information on migration timing and patterns becomes available and alternative management strategies to reduce interceptions of these wild stocks are developed.

Rebuilding of several Area 25 wild stocks will depend on the maintenance or rehabilitation of stream habitat. Many watersheds in the area have been logged, and salmon production may be limited by the high variability in survival caused by the cyclic nature of flood events.

During the 1960s and early 1970s, escapements of even-year pink salmon to Area 25 were approximately 150,000. However, escapements have declined markedly since this time. There have not been any Area 25 fisheries directed at these stocks since 1973; hence the reasons for the lack of rebuilding are unclear. These fish may be intercepted in the West Coast Vancouver Island troll fishery, but there is no information available to confirm this. It is unlikely that restrictions would be imposed on the troll fishery to rebuild Area 25 pink stocks. Rebuilding of these stocks has not received high priority in the past because it has been difficult to attract a portion of the fleet due to the concurrent sockeye fishery in Johnstone Strait.

5.7 Management Options for Rebuilding

5.7.1 Management Uncertainties

The Area 25 fishery currently harvests a mixture of enhanced and wild chum stocks. Production from the Tlupana Inlet hatchery has provided some stabilization to production of the Tlupana stock complex. However, there is still considerable variability in return rates of these stocks. Therefore, the best approach to rebuilding Area 25 chum stocks would be to improve the in-season estimates of stock abundance. With better in-season estimates, the risks of overharvest would be minimized and escapements would be more consistently near target levels.

An annual test fishery is required to assess in-season abundance of chum stocks. Test fishery results would provide at least a rough index of stock abundance. Valuable time series data regarding stock abundance, timing and migration patterns could also be collected if the test fisheries were conducted in a standardized and representative manner.

Management uncertainty could also be minimized by improving run forecasts through rigorous and consistent collection of escapement data and reporting of commercial catches by sub-area, where this is possible.

To understand the migration timing and approach routes of Area 25 chum stocks to the sub-areas, each of the various stocks must be identified. Hatchery fish from the Tlupana facility are already marked with coded wire tags. However, identification of specific wild stocks would require implementation of a tagging program. In particular, tagging of stocks from the Nootka complex would help to identify the migration characteristics of the various substocks that originate from Tahsis, Tlupana and Muchalat Inlets. In combination with test fisheries in Nootka Sound and Esperanza Inlet, the tagging program may help to determine the vulnerability of the Tahsis and Leiner chum stocks to the existing fishery.

5.7.2 Mixed-Stock Harvest

Esperanza Inlet chum stocks are currently managed as a separate stock complex from Nootka Sound. If Esperanza stocks are harvested, it would be in a mixed-stock fishery directed at wild chum stocks. The impact of this fishery is uncertain

since information regarding the productivity and migration patterns of these stocks is presently limited.

Enhanced chum stocks from the Tlupana hatchery and wild chum stocks are taken in the mixed-stock fishery in Nootka Sound. The less productive wild stocks have been overharvested in recent years because they cannot withstand the harvest rates on enhanced stocks.[12] Additional information regarding the movement of these stocks through Nootka Sound may indicate specific areas where fishery restrictions could minimize the interception of these stocks.

Alternatively, the fishery for enhanced stocks could be moved to terminal areas in Tlupana Inlet. The geographic configuration of Tlupana Inlet lends itself to this management approach. Unfortunately such a strategy would cause a decrease in the quality of harvested chum, since fish entering Nootka Sound are in silver bright or semi-bright condition but deteriorate after a short period of time.[11]

Another option for harvesting enhanced chum stocks is to open the fishery for a longer period of time. The fishery currently targets on the main run during October. Early runs of the enhanced Conuma and Tlupana stocks arrive in Area 25 streams in early September and, therefore, are not harvested. By distributing the fishing effort over this period, harvest rates on the main run could be reduced, which would, thereby, reduce interception of wild chum stocks. Total enhanced fish may increase because the earlier portions of the run could be harvested at a higher rate. The quality of the chum would also be higher earlier in the fishery. This earlier fishery would likely result in the interception of chinook salmon and steelhead trout. There is presently some enhancement of the main chinook stocks at the Tlupana hatchery and through Public Involvement Projects. However, it is not known if local stocks would be able to withstand the additional harvest pressure. Monitoring of the fleet would be necessary to ensure that the incidental catch of chinook was not excessive. Concerns regarding interception of steelhead would have to be addressed through consultation with the Provincial government and other interested groups.

5.8 Potential Enhancement Activities

5.8.1 Tlupana, Gold/Burman Expansion (Project No. 25-8B)

This proposal involves the expansion of the Tlupana hatchery to enhance Gold and Burman River coho and chinook salmon. These fish would be incubated and reared for a short period of time at the Tlupana facility, then backplanted to their natal systems. This expansion would include extra ponds, wells and surface water supply and would result in the production of approximately 50,000 adult chinook and 50,000 adult coho.

The Tlupana expansion project is not being actively pursued at the present time. However, the Gold River Community Chinook Program involves enhancement of the Gold and Burman River chinook stocks at the CIP Inc. pulp mill site.[28] In 1986, this group incubated approximately 300,000 chinook eggs, and they plan to incubate 500,000 chinook eggs in 1987. It is hoped that enhancement of these chinook stocks will contribute to the local sport fishery.

5.8.2 Side Channel Rehabilitation

Rehabilitation of side channel habitats to help stabilize chum production for specific stocks may have application to some West Coast Vancouver Island systems. The technique involves habitat manipulations to formerly active flood channels separated from the mainstem of the river.[20] Channels are excavated to ensure a steady supply of groundwater and are landscaped to provide suitable spawning substrate and water depths for spawning chum. Mainstem currents do not normally pass through these side channel habitats and the problem of scouring is therefore minimized. Development of side channel spawning areas can help stabilize chum production by reducing the impacts of flood events and, thereby, increasing freshwater survival in some years.[21] To date, experimental side channels in the lower mainland of British Columbia have shown egg-to-fry survival rates approximately twice those of comparable natural spawning areas.[20] Implementation of this form of enhancement would necessarily be dependent on site location and conditions as well as cost effectiveness.

5.9 Results of Simulation Modelling

A computer model was used to investigate various fisheries management options for Area 25 chum stocks. Results of the modelling are intended to indicate only the range of possible outcomes associated with the various management options and the merits and shortcomings involved with the implementation of these strategies.

5.9.1 Chum

Four management scenarios were modelled for Area 25 chum stocks. The average rate of return was used for all simulations. Based on 21 years of data, the average rate of return was 2.67 recruits per spawner with a variance of 6.92.

Option 1: In the first option, chum stocks in Area 25 were managed as an aggregate to an escapement target of 150,000 spawners. Only fish that were surplus to escapement were harvested. It was assumed that Esperanza and Nootka chum stocks were harvested in the same fishery. The average chum catch was about 250,000 (Figure 27). Escapement of wild chum remained well below target levels and declined to approximately 35,000 fish. Escapement of enhanced chum increased to about 110,000 fish since fisheries were managed to achieve an aggregate escapement of both wild and enhanced stocks. Wild stocks were replaced by hatchery stocks over time. The rates at which wild stocks declined and the degree of success of the fisheries depended on the rate of return for wild stocks.

Option 2: Option 2 involved managing chum stocks by two sub-areas, Esperanza Inlet and Nootka Sound. A major assumption was that the two major stock groups are relatively discrete and do not mix in these two fishing areas. The Esperanza fishery was managed to allow an escapement of 60,000 chum, while the Nootka Sound fishery was managed to an escapement target of 90,000.

The simulation modelling indicated that the total chum salmon catch would average about 300,000 (Figure 28). The model projected almost 100,000 fish would be taken in the Esperanza fishery and more than 200,000 would be harvested in Nootka Sound.

Esperanza stocks consistently approached the target of 60,000 under this management strategy. The combined escapement of Nootka wild and enhanced chum stocks remained stable at the target of 90,000 fish. However, the wild stock was

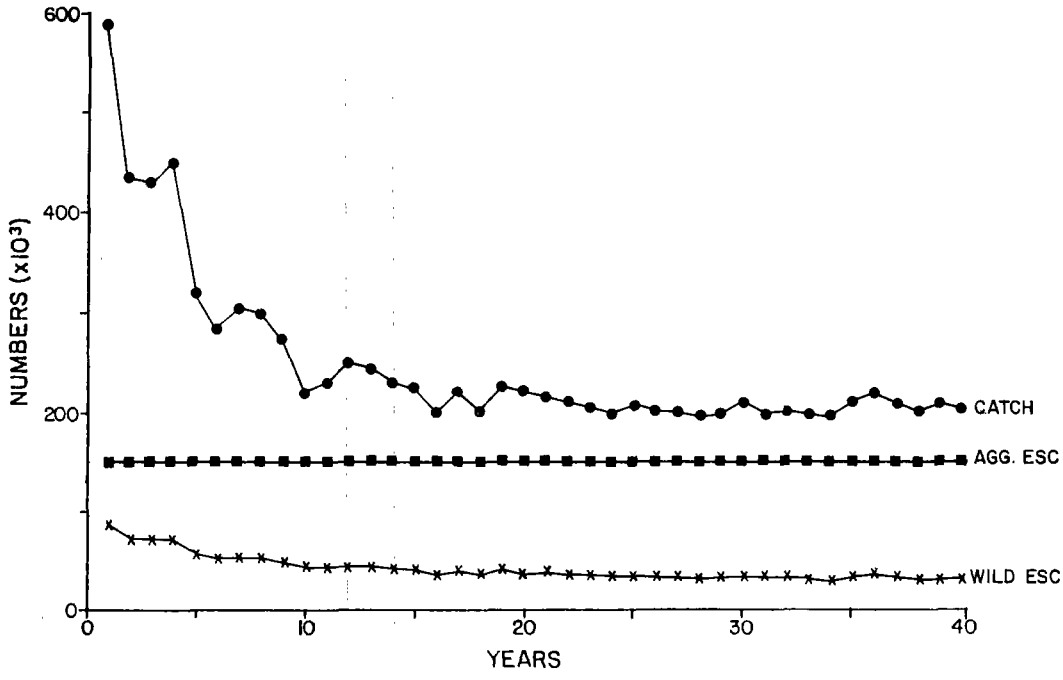

Figure 27. Projected catches and escapements of Area 25 chum under Option 1 (aggregate stock; surplus harvest only).

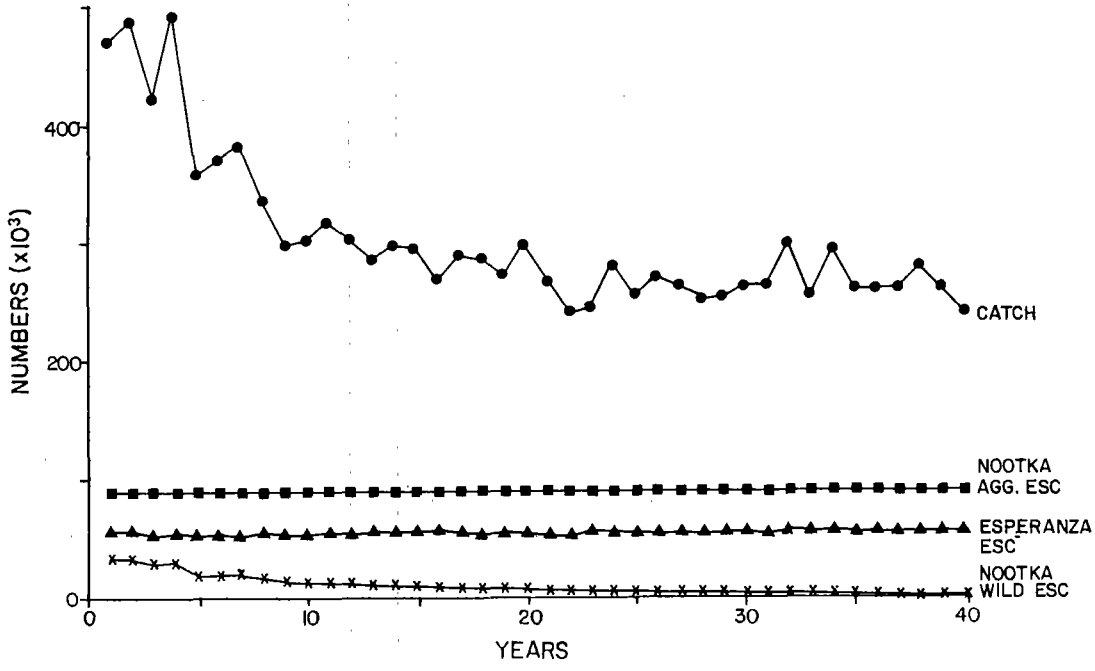

Figure 28. Projected catches and escapements of Area 25 chum under Option 2 (two stocks managed to escapement).

replaced by the more productive hatchery stock over time as a result of high harvest rates on the enhanced stocks. There are indications that this may be occurring at the present time.[28]

Option 3: Option 3 involved the operation of a terminal fishery directed at enhanced stocks in Tlupana Inlet. Esperanza stocks were managed separately to an escapement target of 60,000. The Tlupana Inlet fishery was managed to an escapement target of 60,000 fish, assuming a hatchery brood stock requirement of 20,000 and a capacity in local streams for an additional 40,000 spawners. It was assumed that the terminal fishery in Tlupana Inlet would harvest 25% of the wild Nootka Sound stocks. Another terminal fishery directed at Muchalat Inlet wild stocks was assumed to open in years when the abundance of wild chum exceeded the target of 30,000 fish. Quality of the catch was assumed to be semi-bright in the Esperanza fishery and dark red in the terminal fisheries.

Under Option 3, total chum catch in Area 25 averaged 450,000 (Figure 29). The average catches in the Esperanza fishery, the Tlupana terminal fishery and the Muchalat Inlet fishery were 100,000, 300,000 and 50,000 chum, respectively. Escapements of all wild chum stocks were slightly below their respective target levels. Total wild escapement averaged more than 100,000, which was higher than that projected under any of the other options. Esperanza and Nootka chum salmon stocks achieved approximately the same escapements.

Option 4: Option 4 involved staging a fishery in Tlupana Inlet that was directed at early runs of enhanced Conuma and Tlupana stocks. A quota of 5000 was set for this fishery, because the early run size has recently averaged about 8000 fish and the hatchery brood stock requirements are currently about 4000 fish. The quality of chum taken in this fishery was assumed to be silver bright. Management of the later fishery in Nootka Sound was based on a total escapement target of 90,000 fish. Chum harvested in the Nootka Sound fishery were considered to be of semi-bright quality. The Esperanza fishery was managed to an escapement target of 60,000 and quality of the catch was semi-bright.

Modelling results indicated that the average chum catch would be in the order of 300,000 (Figure 30). Escapements of wild Esperanza chum stabilized at about 55,000 spawners, while wild stocks in Nootka Sound were predicted to decline due to the high harvest rates on enhanced stocks. A major concern regarding this management strategy would be by-catch of Tsowwin River chum stocks and chinook. However,

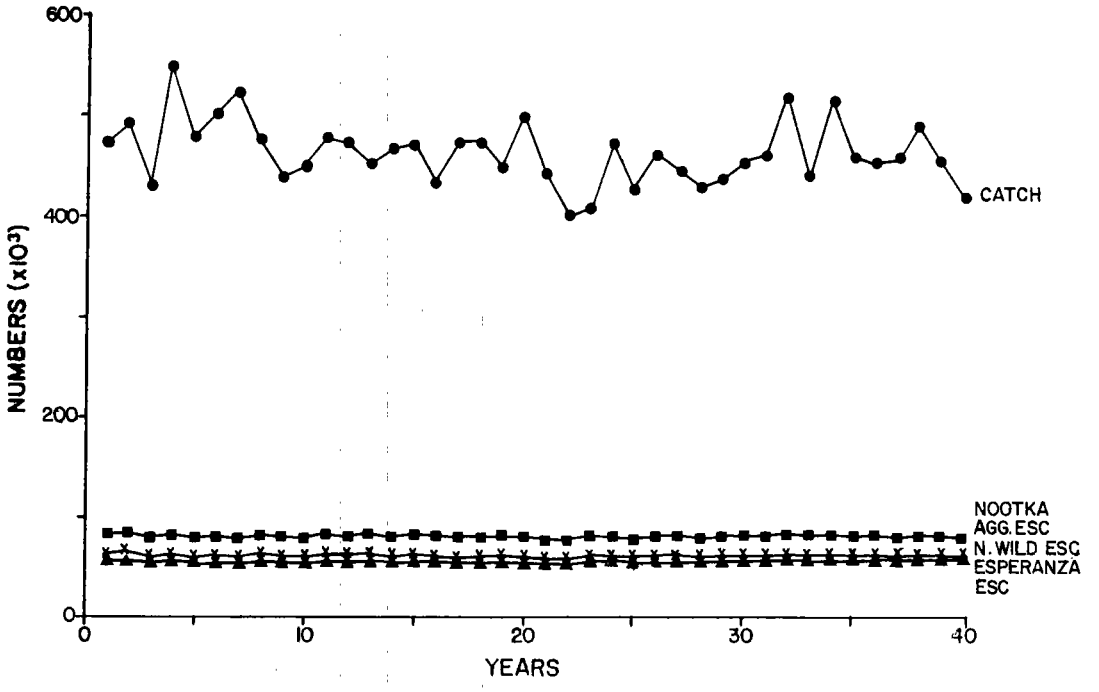

Figure 29. Projected catches and escapements of Area 25 chum under Option 3 (terminal fishery in Tlupana Inlet).

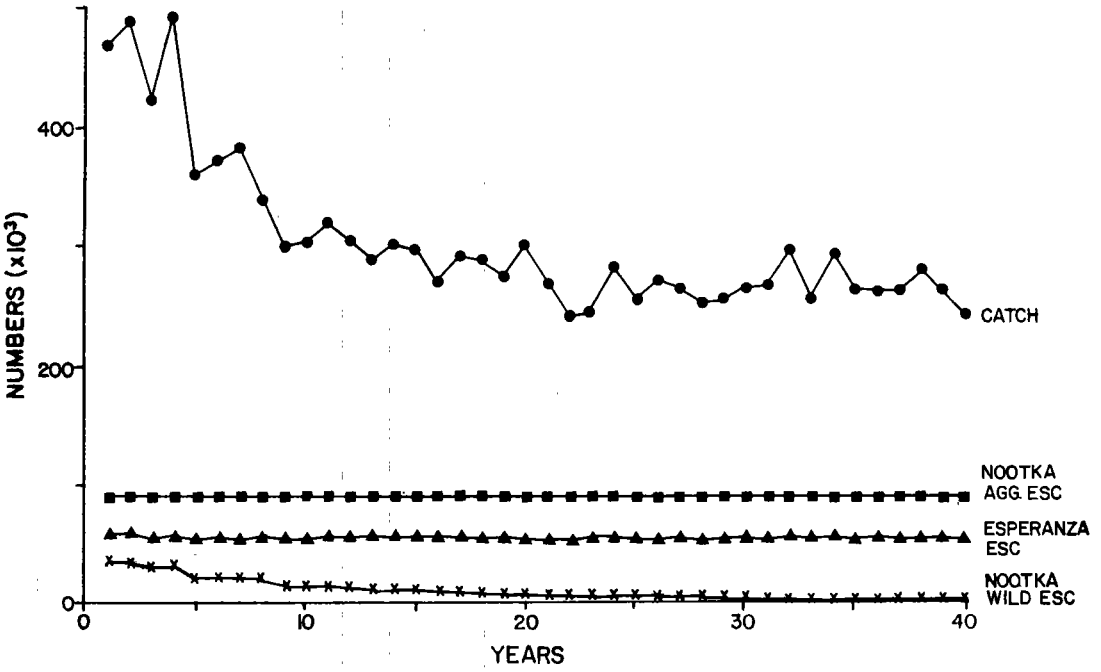

Figure 30. Projected catches and escapements of Area 25 chum under Option (early fishery).

these interceptions could be minimized through in-season catch monitoring and minor regulatory changes to the fishery.[28]

5.9.2 Summary and Conclusions

Based on the results of model simulations, it is apparent that rebuilding of wild chum stocks would be maximized by managing the Esperanza Inlet and Nootka Sound stocks separately. When Area 25 chum stocks were managed as one large stock aggregate, there were significant declines in many wild stocks. Escapement levels and economic value of the harvests was well below those predicted for all of the other scenarios. When Esperanza and Nootka stocks were managed separately, Esperanza stocks rebuilt. However, declines in the number of Nootka Sound wild chum still occurred as a result of interceptions in the fishery directed at hatchery fish. Minor adjustments to the fishery are possible, and any rebuilding of Nootka Sound wild chum stocks would increase the total economic benefits of the fishery. Quality of the catch was improved by taking a portion of the Nootka Sound catch earlier in the season. Although chum catches are maximized by harvesting enhanced chum in a terminal fishery, reduction in the quality of the catch would reduce its economic value.

There are several different strategies for managing Area 25 chum stocks. However, better information on the migration timing and productivity of these stocks is necessary to determine the best possible approach. Uncertainty in the management of Area 25 chum stocks will continue due to natural variability in the return rates of these stocks. However, the potential risks of overharvest can be minimized by implementing a program to assess in-season stock abundance, which may allow more reliable forecasts of returns.

6.0 STATISTICAL AREA 26

Statistical Area 26 is located on the northwest coast of Vancouver Island between Tatchu Point and Cape Cook. It includes Kyuquot Sound (Kashutl and Tahsish inlets) and Checleset Bay (Nasparti and Ououkinsh inlets) (Figure 31).

6.1 Stock Description

All five salmon species are produced in Area 26. Steelhead trout are also common in the area. Escapement records have been maintained for 23 streams in the area but there are many other streams for which escapements have not been consistently recorded.

6.1.1 Sockeye

Two streams in Area 26, Power River and Jansen Lake Creek, support significant sockeye salmon populations.[12] Escapements have averaged about 3000 spawners and have ranged as high as 7000 in 1968 and 1982.[9] Estimated escapement in 1985 was 1500 spawners.[12] Escapement estimates for 1986 were unavailable. The majority of these sockeye are lake spawners.

6.1.2 Chum

Chum stocks are found in 23 streams in Area 26. The major streams that support chum populations include the Chamiss, Clanninick, Kauwinch, Malksope and Tahsish rivers. Based on data from 1973 to 1982, these systems accounted for more than 50% of the total escapement for Area 26.[11]

Between 1951 and 1985, total chum escapements to Area 26 have ranged from 110,000 in 1958 to 11,000 in 1963.[11] During this period, average escapement was 72,000 in the 1950s, 39,000 in the 1960s, 60,000 in the 1970s and 76,000 in the early 1980s.[9] The target escapement of 120,000 chum was not reached during the period of record until 1985, when total chum escapement to the area was estimated at 125,000 spawners. In 1986 chum salmon escapement to Area 26 was about 78,600.[12]

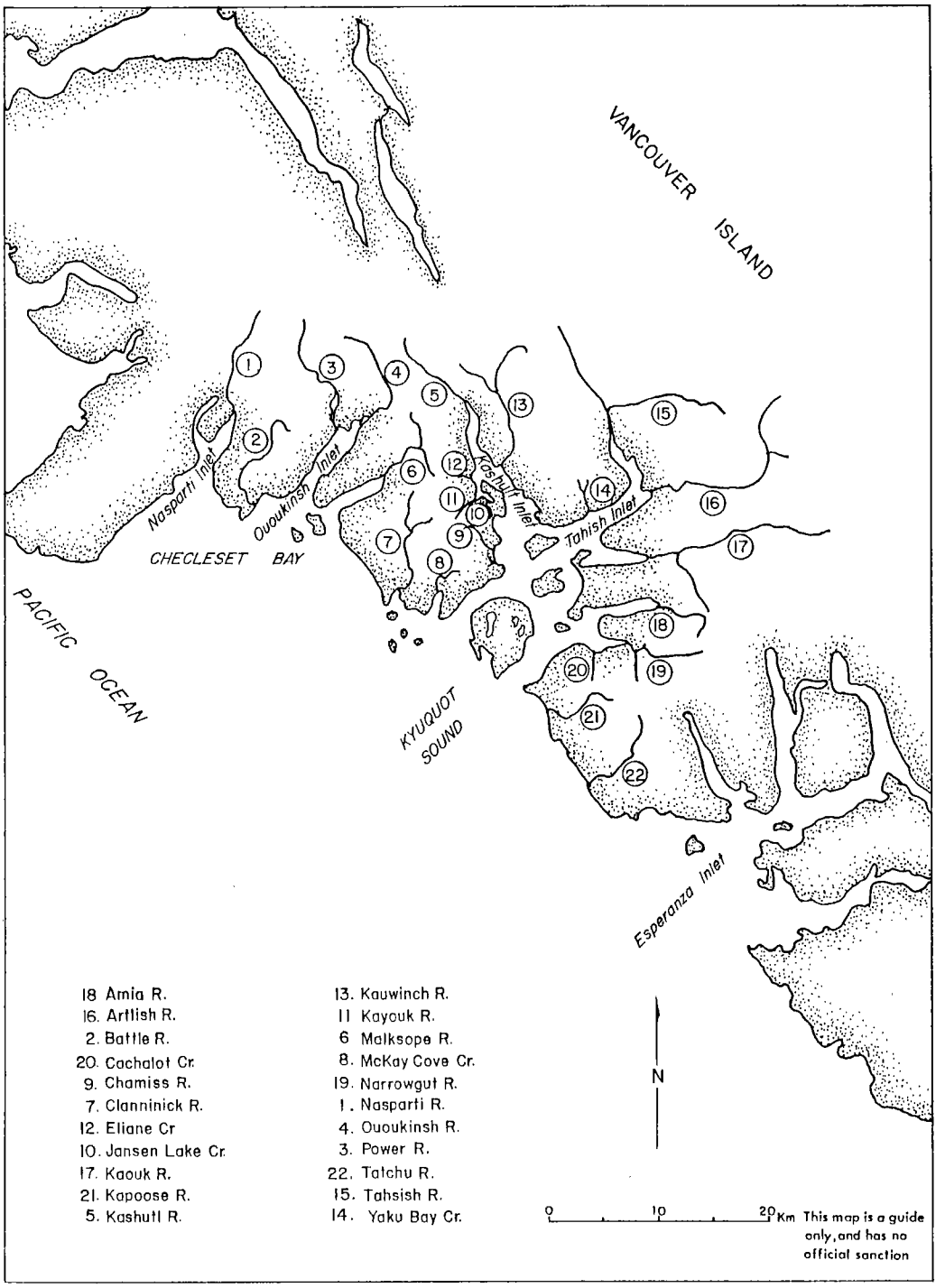

Figure 31. Statistical Area 26, showing location of salmon-producing streams.

Based on an analysis of 13 years of data (commercial catch, stream survey, test fisheries), the proportions of chum stocks that return as three-, four- and five-year olds have averaged 37%, 59.6% and 3.4%, respectively.[11] Annual variability in the age structure of these stocks is illustrated by the results of the 1986 test fishery; there were 6.8% 3-year-old, 85% 4-year-old and 8.2% 5-year-old Kyuquot chum.[31] Since the 1956 brood year, return ratios have averaged 3.38:1 and have ranged from 0.08:1 in 1973 to 17.02:1 in 1977.[11] However, the accuracy of these estimates is uncertain, because they are based on escapement and catch data, which are often incomplete and unreliable.

Area 26 chum stocks are present in the streams during late September and spawning commences in early October. Peak spawning activity generally occurs in late October/early November, and is complete by mid-November.[23] As with coho, peak chum spawning is generally associated with the first significant rise in the river water level.[7] The run timing of Area 26 chum stocks is believed to be intermediate in comparison to other West Coast Vancouver Island chum stocks.

6.1.3 Chinook

Area 26 chinook stocks are typical of most other West Coast Vancouver Island stocks in that they are primarily fall-run, ocean-type stocks that mature as three- and four-year old fish. Some stocks such as Tahsish enter the inlet in mid-July but hold outside their natal rivers until fall.[31] Although the chinook-producing streams in Area 26 are remote and poorly enumerated, these stocks are considered to be severely depressed. Recent escapement data indicate that there are significant populations of chinook (100 individuals or more) in the Tahsish and Power rivers. Historically, the Kayouk River also supported populations of chinook salmon. Total chinook salmon escapement to Area 26 averaged about 6100 prior to the 1960s but has consistently declined since this time. There were average escapements of 3200 chinook in the 1960s, 1600 in the 1970s and 1580 in the 1980s.[9] In 1986, chinook escapement was estimated at 1500 spawners.[12] Local area closures on sport, commercial and native fisheries are implemented during the fall to reduce the harvest of returning chinook spawners.

6.1.4 Coho

Spawning populations of coho salmon are found in all 23 streams that are monitored on a regular basis. Recent escapements of 100 coho or more have been

recorded in 15 of these systems.[31] Coho spawning occurs between mid-September and late November, with peak spawning occurring from early to mid-October.[23] Peak spawning usually coincides with the first freshet of the fall.[31] Escapement estimates indicate that coho stocks are declining; escapements averaged 16,600 in the 1950s, 4300 in the 1960s, 4800 in the 1970s and 1750 from 1980 to 1985.[9] In 1986 estimated coho escapement was 6350, a significant increase in abundance. However, there are serious difficulties in obtaining reliable escapement data for coho as outlined in section 2.1.4; hence, historic trends in escapement must be viewed with caution.

The apparent decline in coho escapements is at least partly due to inconsistencies in the level of effort expended on spawner enumeration. Up to 19 streams were monitored during the 1950s, as compared with only 1 system in 1983. The 1985 escapement estimate of 4000 coho was based largely on test fishery results.[12]

6.1.5 Pink

Many systems in Area 26 support small even-year pink populations. However, Area 26 pink stocks are not actively managed at the present time. The major pink producers are Tatchu Creek, and Kayouk, Kauwinch, Battle and Artlish rivers. Prior to 1966, escapement of even-year pinks was relatively low, ranging between 1000 and 32,000 spawners.[9] Escapements increased substantially in the late 1960s and 1970s and ranged from 20,000 to 157,000 spawners. However, pink escapements have declined during the 1980s, with a record low of 200 spawners in 1984.[9] There were approximately 1300 pink salmon counted in 1986.[12] Pink spawning usually peaks between early September and mid-October.[23]

6.1.6 Steelhead

As is typical of other areas on the west coast of Vancouver Island, there are numerous small steelhead runs in Area 26 that exhibit a wide range of life histories and migration timings. Summer and winter populations have been reported in the Tahsish, Kayouk, Kashutl and Nasparti rivers.[23] However, no major steelhead runs occur in the area and the overall production is considered low.[14]

6.2 Managed Fisheries

6.2.1 Chum

At present, the only actively-managed commercial fishery in Area 26 is the chum fishery. This fishery is directed at wild stocks and is opened only when harvestable surpluses are expected. Kyuquot chum were harvested commercially for 23 years from 1951 to 1985, with an extended closure during the 1960s.[11,12] Total catch in these fisheries averaged 10,000 for gillnetters and 49,000 for seiners. Catch and escapement data indicate that Area 26 chum stocks have been overharvested on several occasions. To date, the target escapement for the area has not been achieved, although total stock abundance has exceeded the target level on 10 occasions.

The management strategy for Area 26 chum fisheries was changed substantially in 1985 when it was decided that escapement requirements should be met before a fishery is opened, and once opened, the fishery should continue until all of the surplus is harvested.[12] In addition, fishing boundaries were placed within Area 26 to ensure that escapement needs were met. In 1985, the target escapement of 120,000 chum was achieved.[12]

During the period from 1977 to 1980, gillnet test fisheries were conducted each fall in Area 26. However, the catch data did not provide a reliable correlation with total stock abundance.[11] In 1982, a seine test fishery was implemented. Although the fishing method allowed a subjective estimate of fish abundance, use of the catch data to predict actual stock size is speculative. In 1985 and 1986, the seine test fishery was conducted again and the catch information was found to be useful for in-season management (determination of openings and setting of boundaries).[31] A more consistent and regular test fishery in the future may provide a useful index for estimating in-season stock abundance.

6.2.2 Pink

Pink salmon stocks have not been actively managed in Area 26 despite relatively high returns during the late 1960s and 1970s. During the 1980s, escapements to the area have been low, which may be due to interception of pinks in net fisheries directed at chum or in troll fisheries, or they may simply be a reflection of

poor assessment information. Analysis of past catch and escapement data might show if there is the potential for rebuilding these stocks.

6.3 Current Enhancement Activities

A small SEP project through the Community Economic Development Program was attempted by the Kyuquot Indian Band but was unsuccessful.[31] Although the facilities are not presently being used, operations may be resumed in the future.

6.4 Habitat Status

Area 26 is the most inaccessible area on the west coast of Vancouver Island. Ground access is limited to a small network of logging roads, and there are no large communities within the region. The terrain is rugged and coniferous forest is the dominant plant community. Annual precipitation is high, particularly during the fall and winter months.

Logging operations have affected up to 50% of the river systems in Area 26.[4] With the exception of the Nasparti and Ououkinsh rivers, all of the major watersheds in the area have been logged to some degree.[23] Recently, most of the logging activities have occurred in headwater and tributary areas and have not had a major impact on fish habitat. However, logging operations in Chamiss River, Malksope River and Kayouk River have resulted in significant impacts on stream habitats.[23] Despite the effects of logging on Chamiss River, chum escapements to the stream have remained stable. A summary of the salmon-producing streams in Area 26 is provided in Table 14.

6.5 Management Conflicts

6.5.1 Management Uncertainties

The most significant uncertainty regarding management of Area 26 chum stocks is the variability in return rates and age composition of these stocks. This is compounded by the fact that the accuracy of escapement estimates in past years is uncertain. Consequently, forecasting returns and managing fisheries in the area are both extremely difficult. To reduce uncertainty regarding actual run size, stock abundance is assessed in-season. The seine test fishery has proven useful

Table 14. Numbers of significant salmon streams by species in Statistical Area 26.[31]

Species	Total Streams[a]	Significant[b] Streams	Percent[c] MRE
Sockeye	11	2	96
Coho	23	12	98
Pink	19	9	95
Chum	23	12	94
Chinook	18	5	97

[a] Total Streams - number of streams that support or have supported the noted salmon species in the past

[b] Significant Streams - most important in terms of salmon production

[c] Percent MRE - percentage contribution of the significant streams to the maximum recorded escapement.

for in-season assessment of Area 26 chum stocks, although it provides only a rough index of stock abundance.

Another factor that affects the management of Area 26 chum stocks is uncertainty regarding escapement targets. Although targets have been set, the validity of these targets is uncertain. This has been due largely to a lack of reliable escapement data, stock separation data, and information regarding rates of return over a wide range of escapement levels. Due to intense fishing over many years, there are sufficient data on these stocks at low escapement levels, but very few data at high escapement levels.

6.5.2 Mixed-Stock Harvest

In 1985, the Area 26 fishery operated in Kyuquot Sound.[12] Chum stocks in this area are managed as an aggregate and, therefore, are harvested in a mixed-stock fishery. The effects of this mixed-stock fishery are presently unknown because there is a lack of information on the productivity of specific stocks. Stock-specific information is necessary to identify any problems associated with this fishery.

Area 26 was previously managed as a single unit. The entire area was open to fishing in years when fisheries were permitted. With this approach, it was impossible to manage the various chum stock groups separately. In recent years, Checleset Bay (Ououkinsh and Nasparti inlets) and Kyuquot Sound stock aggregates have been managed separately which has reduced problems associated with the mixed-stock harvests.[31]

6.6 Rebuilding Potential

Based on 1985 escapement and estimates of historic returns, Area 26 chum stocks appear to have the potential to rebuild to target levels. Whether the stocks can be maintained at target levels depends on the management approach, natural variability and the validity of the current escapement target. The current management approach of delaying the commercial fishery until escapement needs are met is an appropriate strategy to facilitate stock rebuilding. The validity of the escapement target will become apparent as better stock data become available, particularly data on chum returns from very high escapement levels. Most historic data were collected in years when escapements were well below target levels.

Although some of the variability that has been apparent in chum returns is undoubtedly due to incomplete data, natural fluctuations are characteristic of West Coast Vancouver Island chum populations and will ultimately determine whether the escapement target can be achieved and maintained.

6.7 Management Options for Rebuilding

6.7.1 Management Uncertainties

Variability in returns will remain a concern as long as Area 26 is managed for wild chum stocks. The best approach to reducing management uncertainty and thereby facilitating stock rebuilding is to manage the fishery to prevent harvesting into escapement needs. Although the current approach to managing Area 26 chum stocks is directed towards this goal, it is limited by the reliability of stock data on which pre-season forecasts are based, and the ability to determine in-season stock abundance accurately.

Continuation of test fisheries and collection of reliable and consistent escapement data are necessary to minimize management uncertainty regarding stock abundance. The test fishery program implemented in recent years has proven useful in determining whether stock size is sufficient to stage a fishery. Continuation of this program is essential for the management of Area 26 fisheries. Pre-season forecasts of returns are based on brood year-spawner estimates and age composition data for the population. Efforts have been made to improve spawner enumerations, but they are limited by resource and manpower constraints. It may be necessary to limit enumeration efforts to a thorough survey of a selected number of streams that are considered representative of an area.

An alternative approach to rebuilding wild chum stocks and reducing uncertainty regarding returns of target stocks would be to enhance selected chum populations and direct fishing effort towards these stocks. This approach is currently being taken for the management of stocks in Areas 22 and 25. New enhancement activities are warranted only if a positive benefit-cost ratio is achieved and significant mixed-stock fishery management problems are not created. At the present time, there are no plans to implement major enhancement facilities for Area 26 chum. The emphasis of many enhancement activities on the west coast of Vancouver Island has shifted to the production of chinook and coho, which are more of a conservation concern and are highly valued as sport fish.

6.7.2 Mixed-Stock Harvest

There is no indication that rebuilding of Area 26 chum stocks is limited by mixed-stock harvests. However, stock-specific data are generally unavailable. In an attempt to address this concern, the management strategy for Area 26 was changed in 1985. The new approach has been to manage the area for two major stock complexes, Kyoquot and Checleset Bay, rather than Area 26 as a whole. Each stock complex is managed to a separate escapement target.[31] This approach is expected to facilitate the rebuilding of Area 26 chum stocks. Although a commitment of more resources to Area 26 would be required, this approach should be directed at more specific groups to allow the performance of key stocks from individual inlets (Nasparti, Ououkinsh, Kashutl, Tahsish) to be assessed. If the current approach of managing chum stocks to escapement fails to rebuild the two stock complexes, there will be a need for the implementation of tagging studies to identify migration patterns and possible outside interceptions. It may also be necessary to re-examine escapement targets.

6.8 Potential Enhancement Activities

In 1977, streams in Areas 26 and 27 were surveyed to provide baseline physical data and an assessment of enhancement opportunities.[23] The inaccessibility of the area and limited brood stock restricts any major enhancement opportunities in Area 26, although some small-scale projects (stream improvement and colonization) were identified.[23] It is not possible to determine whether these projects are compatible with current management strategies because of the limited data on individual chum stocks.

6.8.1 McKay Cove Creek Pilot (Kyuquot Creek) (Project No. 26-2A)

This proposal involves building a small facility on McKay Cove Creek to produce small numbers of chum, chinook and coho salmon. The facility would be developed in conjunction with the Department of Indian Affairs hydroelectric power project for Kyuquot Village and would incorporate the incubation project previously undertaken by the Kyuquot Band. Proposed production is for the incubation of 100,000 chinook eggs, 100,000 coho eggs and 350,000 chum eggs, which is expected to yield 1080 chinook, 2160 coho and 5040 chum adults. This proposed facility is expected to provide incremental increases in the harvest for offshore troll and the

local Area 26 fisheries, and would also contribute to increased escapement of chum to the area.

6.8.2 Side Channel Rehabilitation

Rehabilitation of side channel habitats to help stabilize chum production for specific stocks may have application to some West Coast Vancouver Island systems. The technique involves habitat manipulations to formerly active flood channels separated from the mainstem of the river.[20] Channels are excavated to ensure a steady supply of groundwater and are landscaped to provide suitable spawning substrate and water depths for spawning chum. Mainstem currents do not normally pass through these side channel habitats and the problem of scouring is therefore minimized. Development of side channel spawning areas can help stabilize chum production by reducing the impacts of flood events and thereby increasing freshwater survival in some years.[21] To date, experimental side channels in the lower mainland of British Columbia have shown egg-to-fry survival rates approximately twice those of comparable natural spawning areas.[20] Implementation of this form of enhancement would necessarily be dependent on site location and conditions as well as cost effectiveness.

6.9 Results of Simulation Modelling

A computer model was used to investigate various fisheries management options for Area 26 chum stocks. Results of the modelling are intended to indicate only the range of possible outcomes associated with the various management options and the merits and shortcomings involved with implementation of these strategies.

6.9.1 Chum

Four management scenarios were modelled for Area 26 chum. The average rate of return was used for all simulations. Based on 8 years of data, the average rate of return was 1.68 recruits per spawner with a variance of 25.4. All catches were assumed to be of semi-bright quality.

Option 1: Option 1 represented a management approach where there is high uncertainty in estimates of stock abundance. Openings of commercial fisheries are based on limited stock abundance information and overharvesting of chum may occur when returns are low. This option involved a variable test fishery that harvested up to

50% of the stock when chum abundance was low and a second "clean-up" fishery to harvest fish that were surplus to escapement in years when returns were high. Under this scenario, Area 26 chum were managed as one large stock aggregate, with all stocks assumed to be equally vulnerable to harvest.

Results of the simulation modelling indicated that there were generally poor returns and harvests (Figure 32). Chum escapements steadily declined over the 40-year simulation period and catches declined from more than 40,000 to fewer than 1000 fish.

Option 2: Option 2 represented a more conservative management approach, where the risks of overharvesting were reduced by delaying the fishery until there was an indication that target escapements would be achieved. This involved a variable test fishery that harvested a maximum of 20% of the stock when chum abundance was low. A second fishery harvested any fish that were surplus to escapement needs.

Under this management scenario, stocks and catches still declined but not as severely as in Option 1 (Figure 33). This was reflected by catches which were about 30% higher than in Option 1.

Option 3: Option 3 represented the most conservative approach. Chum were not harvested unless escapements were secured. As a result, only one fishery was staged to harvest surplus fish.

Even with this conservative approach to management, Area 26 chum stocks gradually declined and there were no harvestable surpluses available (Figure 34).

Option 4: In this scenario, Kyoquot and Checleset stock complexes were managed separately. Only Kyoquot stocks were subjected to commercial fishing and only surpluses to escapement needs were harvested. Checleset stocks were managed to an aggregate escapement target of 20,000 spawners, while Kyoquot stocks were managed to a target of 100,000 spawners.

With this approach, Checleset chum declined to an escapement level of about 8000 spawners over 15 years. However, during the first 8 years of the simulation target escapement was exceeded four times (Figure 35). As in Option 3, the abundance of Kyoquot chum declined. No harvestable surpluses of Kyoquot chum were

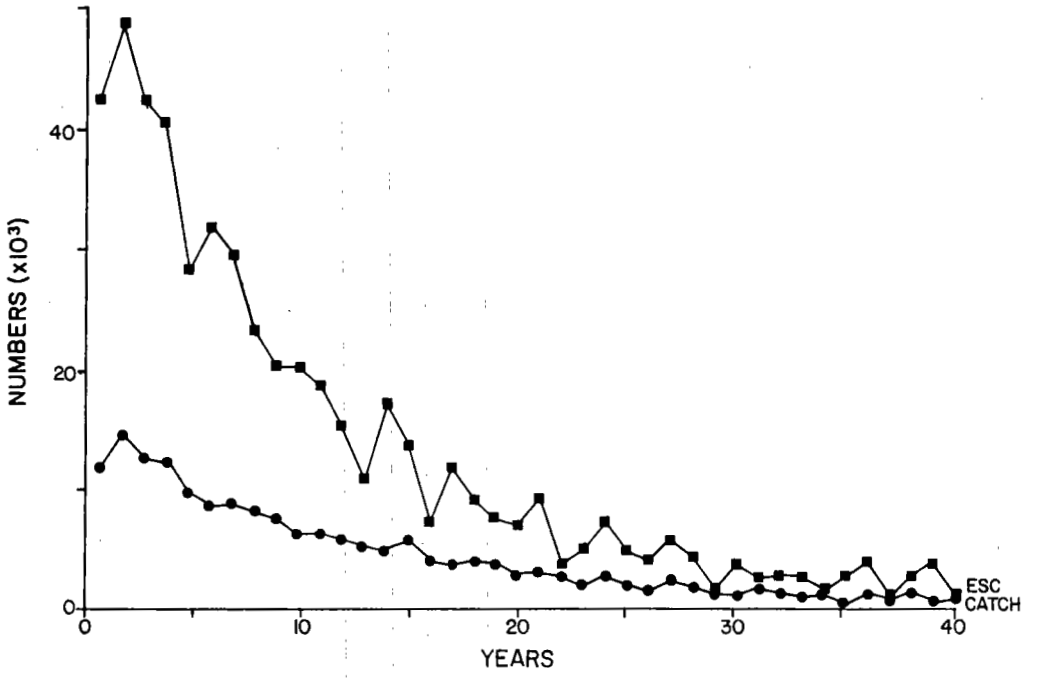

Figure 32. Projected catches and escapements of Area 26 chum under Option 1 (test fishery up to 50% harvest).

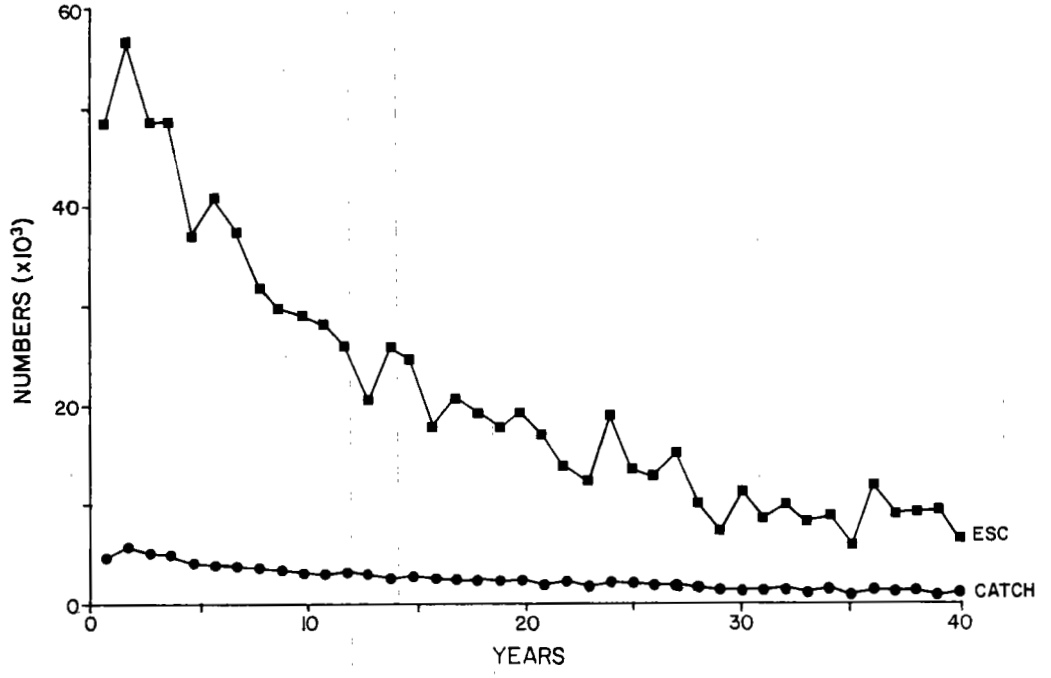

Figure 33. Projected catches and escapements of Area 26 chum under Option 2 (test fishery up to 20% harvest).

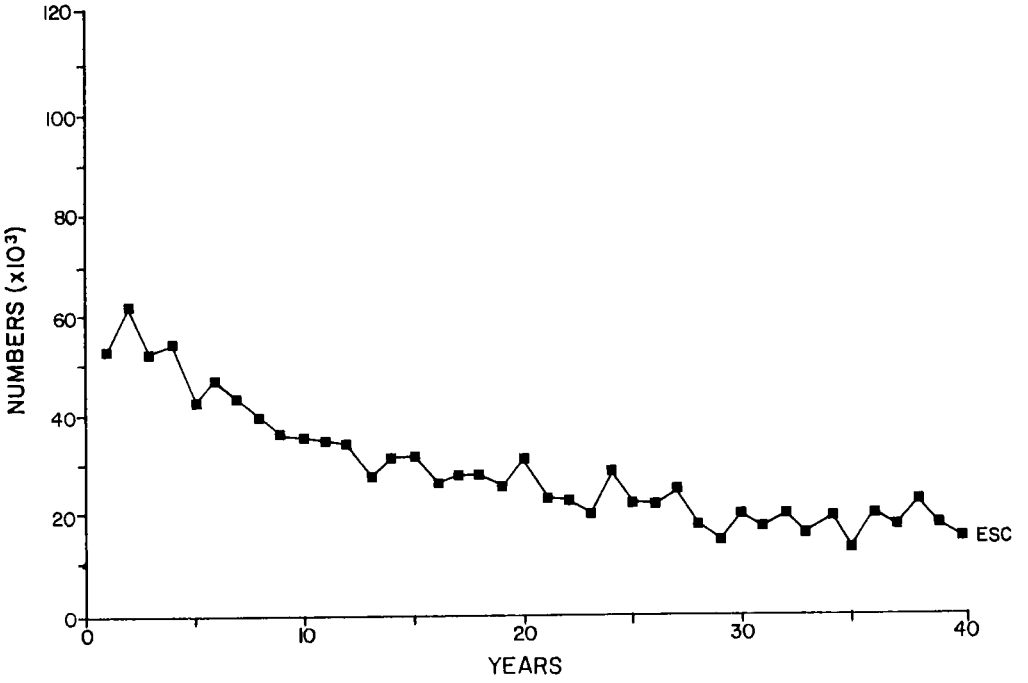

Figure 34. Projected escapements of Area 26 chum under Option 3 (surplus harvest only).

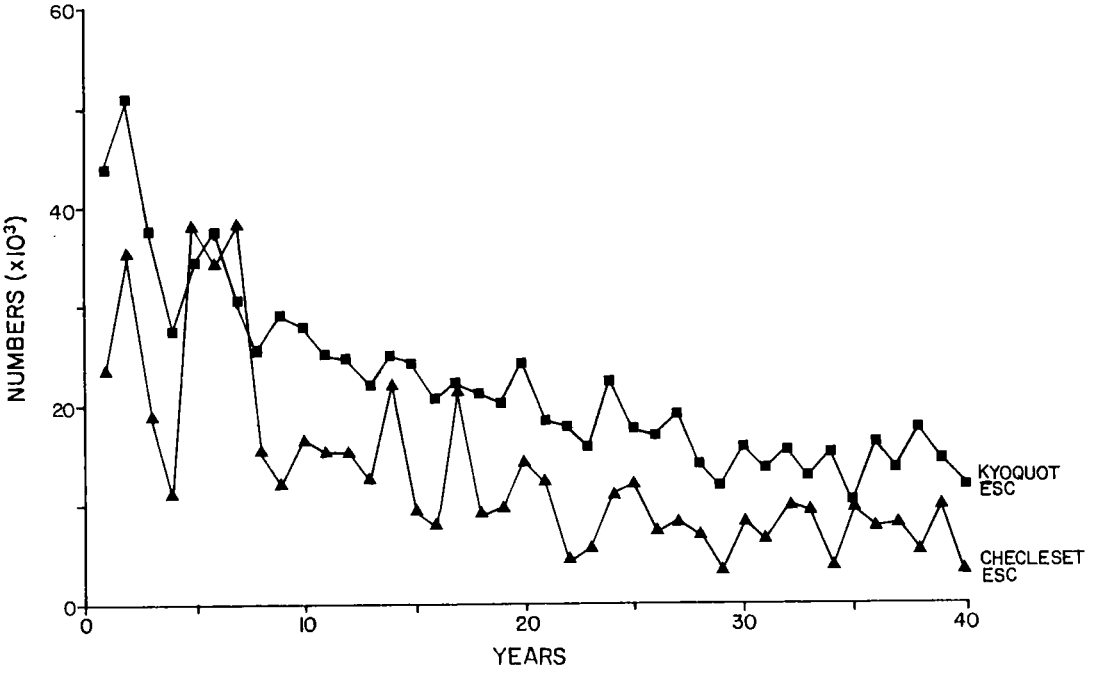

Figure 35. Projected escapements of Area 26 chum under Option 4 (two-stock management, surplus harvests only).

available, and the small number of surplus fish from the Checleset stock were not harvested.

6.9.2 Summary and Conclusions

Results of the modelling indicated that based on the average rate of return, rebuilding of Area 26 chum stocks would not occur. Even the most conservative management strategy of harvesting only surplus fish failed to promote rebuilding of these stocks. Natural variability among chum stocks may be sufficiently high that the target escapement cannot be met consistently each year, regardless of which management strategy is employed. However, it is apparent that there is a need for better information on Area 26 stocks to determine their actual status. It is also important that a conservative approach to chum management be continued so that overharvesting does not occur in years of low returns. This will require regular implementation of an in-season test fishery to assess stock abundance.

7. STATISTICAL AREA 27

Statistical Area 27 (Quatsino) is located on the northwest coast of Vancouver Island between Cape Scott and Cape Cook (Brooks Peninsula). Most development activity has occurred around Quatsino Sound, and the complex of inlets in Queen Charlotte Sound including Holberg, Neroutsos and Rupert (Figure 36 and Table 15). The terrain in Area 27 is rugged, and there is very high precipitation, particularly during late November and early December. Flash floods and low summer flows are common to streams in the area.

7.1 Stock Description

Streams in Area 27 support all five species of Pacific salmon. Sockeye and pink stocks are passively managed, while coho and chinook stocks are actively managed on a coastwide basis as part of the Canada/U.S. Salmon Treaty. Chum are actively managed on a local scale.

7.1.1 Sockeye

Sockeye are found in the Mahatta and Marble River systems within Area 27. Escapements to the area have been generally less than 3000 sockeye since 1965. However, the Marble River was recorded as having 2000 spawners in 1981.[32] Historically, Marble River sockeye accounted for 65% of the total escapement to Area 27. Target escapements for Area 27 sockeye were set at 20,000 in 1986; however, estimated escapement was only 360 spawners.[12,32]. Information on the migration timing of these sockeye stocks is currently limited.

7.1.2 Chum

Chum are the predominant salmon species in Area 27, and the target escapement for the area is 100,000 spawners. Sixty-one streams are known to support chum populations, and there are no individual systems that account for the majority of production. The target escapement has not yet been achieved, and the total stock has only reached 100,000 fish on three occasions since 1951. Chum escapements have ranged from 11,100 in 1962 to 94,300 in 1951.

Important chum-producing streams in Area 27 are Cayeghle Creek and Jim's Creek. Historically, these systems supported 27% of the total escapement to the

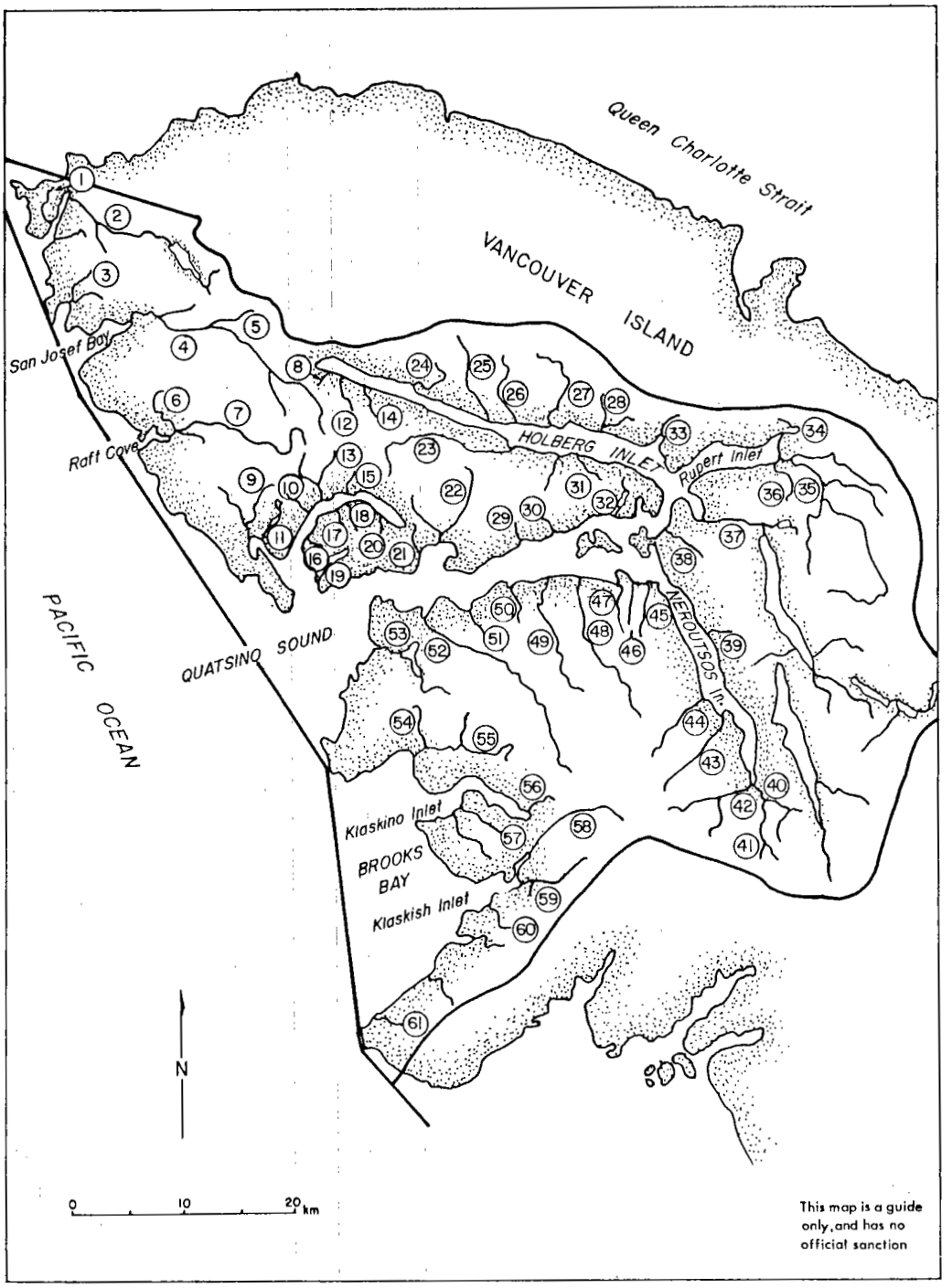

Figure 36. Statistical Area 27, showing location of salmon-producing streams (for key to streams see Table 15).

Table 15. Key to salmon-producing streams in Statistical Area 27 (from Figure 36).

20.	Ahwhichaolto Creek (Upper)	54.	Keith River
18.	Ahwhichaolto Creek (Lower)	49.	Kewquodie (Johnson) River
17.	Bear Creek	58.	Klaskish River
29.	Bish Creek	15.	Klayina (Tenaad) Creek
55.	Buck Creek	48.	Klootchlimmis (Ingersol) River
60.	Canoe Creek	22.	Koprino River
61.	Cape Cook Creek	38.	Kwakwesta (Sawmill) Creek
1.	Cape Scott Creek	9.	Kwatleo (Browning) Creek
40.	Cayeghle Creek	11.	Leeson Lake Creek
43.	Cayuse Creek	31.	Lewis Creek
50.	Cleagh River	7.	Macjack Creek
24.	Cleesklagh (6 Mile) Creek	52.	Mahatta River
36.	Coetkwass Creek (Rupert River)	37.	Marble River
42.	Colonial (Main) Creek	51.	Monkey Creek
32.	Colony Creek	19.	Montgomery Creek
53.	Culleet Creek	21.	McNiffe (Duck) Creek
13.	Denad (Gaato) Creek	39.	Nequiltpaalis Creek
3.	Dominic Creek	28.	Nuknimish (Apple) Creek
59.	East Creek	12.	Pegattem (2 Mile) Creek
2.	Fisherman River	16.	Quashtin Creek
10.	Galato (Devil Club) Creek	6.	Ronning Creek
14.	Gleerup (3 Mile) Creek	4.	San Josef River
5.	Goodspeed (Spruce) Creek	46.	Skidine Creek
23.	Hathaway (Halfway) Creek	45.	Smith Creek
36.	Hawishakwi Creek	33.	Stephens (Coal Harbour) Creek
56.	Head (Mary) River	44.	Teeta River
25.	Hushamu (Pearson) Creek	41.	Utlah Creek
29.	Ilstad Creek	27.	Wanokana (Crawford) Creek
57.	Jims Creek	34.	Washlawlis (Lagoon) Creek
8.	Johnny Creek	35.	Waukwaas (Waukanas) Creek
47.	Julian Creek	26.	Youghpah (Price's) Creek

area. Other significant chum producers include Colonial, Denad and Klayina creeks and Klaskish and Koprino rivers. In recent years, chum escapements to Johnny and Pegattem creeks have also been high.

There is limited information regarding the run timing of Area 27 chum stocks through the fishing area. However, it is known that chum generally arrive in the spawning streams in late September or early October. Spawning generally peaks in late October and is complete by mid-November. The escapement count for 1986 was 59,940 chum salmon for all of Area 27.[12]

7.1.3 Chinook

Recent escapement records indicate that there are 3 streams in Area 27 that support spawning significant populations of chinook. These are the Marble and Klaskish rivers and East Creek. Marble River chinook generally account for over 50% of the total escapement to the area. DFO records indicate that Area 27 streams supported major populations of chinook from the late 1940s through the early 1960s. However, during the 1960s and early 1970s average escapements declined to 200-600 spawners. More recently, chinook stocks have been rebuilding and the Marble River currently supports an annual escapement that ranges from 750 to 5000 chinook. The migration timing of Area 27 chinook through the fishing areas is not well documented. An escapement of 1500 chinook was estimated for 1986.

7.1.4 Coho

Over 40 streams in Area 27 support or have supported coho in the past. The largest producer is the Marble River, which had an average escapement of approximately 4700 coho between 1974 and 1983. Estimated escapements have ranged from a low of 110 to a high of 20,000 since the 1950s and the 1986 estimate was 15,000.[12]. The target escapement for Quatsino Sound was recently set at 50,000 spawners.[32]

The reliability of coho escapement data is a problem in the management of all areas along the B.C. coast. The difficulties in obtaining reliable coho escapement data are discussed in section 2.1.4.

7.1.5 Pink

Pink salmon have been recorded in 12 streams within Area 27, but about 75% of the total escapement is to Waukwaas Creek. Waukwaas pink salmon are predominantly an even-year stock. From 1972 to 1982, escapements averaged 23,200 spawners and ranged from 1500 to 65,000. In 1965, an escapement of 3500 odd-year pinks to Waukwaas Creek was recorded. Since 1979, odd-year escapements have ranged between 25 and 200 spawners. Escapement in 1986 was 36,315 pink salmon. Target escapements for even- and odd-year pinks in Area 27 were set at 50,000 and 2000 fish, respectively.[32]

7.1.6 Steelhead

The Marble and Mahatta rivers are the major steelhead producers in Area 27. Declines in the size of some summer runs of steelhead have been observed. Information regarding the run timing of steelhead through the fishing areas is presently unavailable.

7.2 Managed Fisheries

7.2.1 Chum

During the period 1951-1960, commercial catches of Area 27 chum averaged about 4400 (range 2000 - 176,000). However, since 1960, the fishery has been located more seaward, near the surfline. Harvests have declined and catches were thought to be composed mainly of passing chum stocks.[11] Fisheries were generally held from June through September, and Central Coast sockeye (Rivers and Smith inlets), Fraser River sockeye and various other mixed chum and pink stocks were intercepted. There have been no fishery openings for chum within Area 27 since 1981.

Apart from chinook, which are managed on a coastwide basis, the only actively-managed stock in Area 27 is the complex of Quatsino chum populations. In recent years, the management approach has been to avoid the harvest of passing chum stocks as much as possible; consequently, fisheries have been opened infrequently. However, commercial harvest of local chum may be continued if these stocks rebuild. It is uncertain whether there is any potential for rebuilding chum stocks to the point where harvestable surpluses are available. The total run size of Area 27 chum has seldom exceeded 100,000 in the past. Any harvesting of chum that would

be permitted in the area would likely be a mixed-stock fishery, because there is no single system that accounts for the majority of chum production. Further, to ensure best possible quality it would be necessary to hold fisheries away from terminal locations; consequently, stocks could not be fished discretely.

Gillnet test fisheries for Area 27 chum were held each fall between 1977 and 1980 but no significant relationship between catch and total stock size was found. However, test fisheries may provide more useful results in the future if recommended changes to the fisheries are implemented, most notably a reduction in the duration of each set.[11]

7.3 Current Enhancement Activities

Although there are no major enhancement facilities currently in operation in Area 27, several public involvement projects are under way. Most of the effort is directed towards production of chum, although chinook, coho and pink stocks are also being enhanced. In 1986, the enhancement strategy for Area 27 was changed so that greater emphasis will be placed on chinook and coho production in the future. Target systems for chinook are the Marble and Klaskish rivers and East Creek.[33] A summary of enhancement projects in Area 27 is provided in Table 16.

7.4 Habitat Status

Area 27 is mountainous, and flow regimes of the river systems are variable due to steep slopes and very high rainfall. About 50% of the watersheds in the area have been logged to some degree, and the overall impact on salmon habitat is considered moderate.[4] In addition, local impacts associated with the operations of a copper mine at Rupert Inlet and a pulp and paper mill at Port Alice have also occurred. At Port Alice, the major environmental concern is the demand for fresh water, which results in significant fluctuations in the level of Alice Lake and the Marble River.[5] There is also concern regarding low levels of dissolved oxygen in Rupert Inlet during summer.

A summary of the salmon-producing streams in Area 27 is presented in Table 17.

Table 16. Production capacity of current enhancement facilities in Statistical Area 27 (based on SEP biostandards).[17,33]

Facility/Project	Target System	Egg Target	Expected Adult Returns
Stephens Creek (CEDP)			
Chum	Stephens Cr.	1,000,000	7,500
	Waukwaas Cr.	500,000	3,750
	Coetkwaas Cr.	50,000	3,750
Coho	Stephens Cr.	120,000	1,440
	Waukwaas R.	150,000	1,800
	Coetkwaas Cr.	15,000	180
	Wauskana Cr.	50,000	600
	Washlawlis Cr.	75,000	900
	Hathaway Cr.	25,000	300
Quatsino School and Community			
Chum	Local Creeks	30,000	367
Mahatta Fisheries Society			
Chum	Monkey Cr.	50,000	612
Coho	Monkey Cr.	10,000	162
	Mahatta R.	100,000	1,620
Botel Family			
Coho	Hecate Cove	10,000	162
Western Forest Products			
Chum	Goodspeed R.	150,000	1,800
Chinook	Marble R.	500,000	5,400
Coho	Marble R.	250,000	4,050
	Goodspeed R.	150,000	2,430
Western Forest Products and Port Alice Fish and Wildlife Association			
Coho	Pt. Alice area	50,000	810

Table 17. Numbers of significant salmon streams by species in Statistical Area 27.[31]

Species	Total Streams	Significant Streams	Percent MRE
Sockeye	4	2	90
Coho	48	14	85
Pink	19	10	97
Chum	61	22	80
Chinook	8	3	99

[a] Total Streams - number of streams that support or have supported the noted salmon species in the past.

[b] Significant Streams - most important in terms of salmon production.

[c] Percent MRE - percentage contribution of the significant streams to the maximum recorded escapement.

7.5 Management Conflicts

7.5.1 Management Uncertainties

The major uncertainty regarding management of Area 27 chum stocks is the variability in return rates and age composition of these stocks. This is compounded by the fact that the accuracy of escapement estimates in past years is very uncertain and historic catch information for Area 27 stocks is limited (due to the lack of directed fisheries on Quatsino stocks and stock separation information from mixed-stock harvests). Consequently, forecasting returns and managing fisheries is extremely difficult. To reduce uncertainty regarding the actual run size, stock abundance is assessed in-season. However, a significant relationship between test fishery catches and total stock abundance has not yet been established.

Another factor that affects the management of Area 27 chum stocks is uncertainty regarding escapement targets. Although targets have been set for stocks or stock aggregates, the validity of these targets is not known because reliable escapement data and information regarding rates of return over a wide range of escapement levels are lacking. Most of the data on return rates were collected in years when there were low to moderate escapements to the area.

7.5.2 Mixed-Stock Harvest

Historically, the Quatsino Sound fishery was a mixed-stock fishery that harvested various local and passing stocks. During recent years, the management approach has been to avoid the interception of passing stocks and consequently the opening of fisheries has been infrequent. Area 27 chum stocks are currently managed to an aggregate escapement target of 100,000 spawners, and no single system contributes a large proportion to the total run. As a result, any fishery in Area 27 would be located in an area where Quatsino Sound stocks are mixed to ensure that a sufficient number of chum were available for harvest. A mixed-stock fishery on local populations would, therefore, be unavoidable. However, this would only cause mixed-stock problems if there were significant differences in productivity among the stocks. Some interceptions of coho and steelhead would also likely occur in this fishery.

7.6 Rebuilding Potential

7.6.1 Chum

There appears to be some potential for rebuilding Quatsino chum stocks if factors that are currently limiting chum production could be identified. The average escapement is presently at about 40,000 spawners and the target is 100,000 spawners. The current approach of managing Area 27 chum stocks to target escapement may allow rebuilding of these stocks. However, the total stock has exceeded 100,000 chum on only three occasions since 1951 and has not shown significant rebuilding despite a major reduction in harvest effort since 1960. The reasons for this lack of rebuilding are unclear but may be the result of several different factors such as outside interception of stocks, suppression of the population below a critical threshold level and reduced freshwater survival due to habitat degradation. Reduced marine survival due to long-term oceanographic effects (temperature, currents, etc.) could possibly limit the rebuilding potential of these stocks. However, other west coast chum populations have not shown this repression. There are concerns regarding population levels in Neuroutsos Inlet[34], and it is possible that changes in the local marine environment could be affecting the survival of chum in this particular area.

7.6.2 Pink

Based on historic escapement data, there appears to be some potential for rebuilding Area 27 pink stocks. At present, these stocks are not actively managed. However, they would not support a major harvest even if rebuilding of populations occurred. Furthermore, the timing of the local pink run coincides with the sockeye fishery in Johnstone Strait, which may prevent attraction of a large fleet.

7.7 Management Options for Rebuilding

7.7.1 Management Uncertainties

A better understanding of the factors that have limited production of Area 27 chum in the past is necessary for rebuilding of these stocks. Tagging of stocks would help determine whether Quatsino chum are taken in other fisheries outside Area 27, while downstream trapping of juveniles would provide some indication of

their freshwater survival. Enhancement of local stocks would boost smolt output and, thereby, promote rebuilding if the population has been reduced to the point where natural rebuilding cannot occur. However, in response to a growing sport demand and the lack of production by chum stocks, despite enhancement and an absence of net fisheries, there has recently been a shift in the emphasis of enhancement activities in Area 27 away from chum to coho and chinook production.

In the longer term, improved stock data are necessary to determine the appropriate escapement target more accurately and reduce uncertainty in the forecasting of returns. If rebuilding of chum stocks occurs and fisheries targeting on Area 27 chum are staged, a test fishing program would be necessary to determine actual in-season abundance so that the risk of overharvesting these populations is minimized.

7.7.2 Mixed-Stock Harvest

Unless Area 27 chum are being intercepted outside of the Quatsino Sound area, mixed-stock harvest is not currently a management concern. If outside interceptions are occurring, a tagging program for local chum would be an appropriate management tool to determine where the interceptions are taking place.

Potential mixed-stock problems would be limited to resident stocks provided that future net fisheries in Area 27 are kept within Quatsino Sound and adjacent inlets. Accurate information regarding productivity, run timing and approach routes to natal streams of these stocks would be required to resolve potential mixed-stock harvest problems within Area 27.

7.8 Potential Enhancement Activities

7.8.1 Marble River Facility (Project No. 27-3A)

This proposed project would expand the existing chinook facility to facilitate the incubation of an additional 250,000 coho eggs and 100,000 steelhead eggs, which is expected to bring total production to 7500 chinook, 9400 coho and 1000 steelhead adults.

7.8.2 Side Channel Rehabilitation

Rehabilitation of side channel habitats to help stabilize chum production for specific stocks may have application to some West Coast Vancouver Island systems. The technique involves habitat manipulations to formerly active flood channels separated from the mainstem of the river.[20] Channels are excavated to ensure a steady supply of groundwater and are landscaped to provide suitable spawning substrate and water depths for spawning chum. Mainstem currents do not normally pass through these side channel habitats and the problem of scouring is therefore minimized. Development of side channel spawning areas can help stabilize chum production by reducing the impacts of flood events and thereby increasing freshwater survival in some years.[21] To date, experimental side channels in the lower mainland of British Columbia have shown egg to fry survival rates approximately twice those of comparable natural spawning areas.[20] Implementation of this form of enhancement would necessarily be dependent on site location and conditions as well as cost effectiveness.

7.9 Results of Simulation Modelling

A computer simulation model was used to investigate various fisheries management options for Area 27 chum. Results of the modelling are intended to indicate only the range of possible outcomes associated with the various management options and some of the merits and shortcomings involved with implementation of these strategies.

7.9.1 Chum

A conservative approach to managing Area 27 chum stocks was modelled to investigate the potential rates of rebuilding. The rate of return was an average based on 10 years of data. The average return rate was 1.81 recruits per spawner with a variance of 2.43. Quality of the catch was assumed to be semi-bright in all cases.

All of the Area 27 chum stocks were managed as one large aggregate. The simulation involved one fishery that harvested chum that were surplus to escapement needs.

Results of the modelling indicated that Area 27 chum stocks rebuilt slowly (Figure 37). Over the 40-year simulation period, the population stabilized at about 82,000 spawners and no harvestable surpluses were available.

7.9.2 Summary and Conclusions

A conservative approach to the management of Area 27 chum is necessary if these stocks are to rebuild to the target escapement. If the population is currently suppressed as a result of poor freshwater survival, an increase in productivity may allow the population to naturally rebuild to the target level. This may be accomplished by further enhancing local stocks for a minimum of one or two cycles. If stock rebuilding to target levels is achieved, potential economic benefits could be significant. However, alternate management approaches such as a shift in the emphasis of enhancement activities should be carefully considered. The evaluation of various management alternatives depends on the availability of better information on local chum stocks.

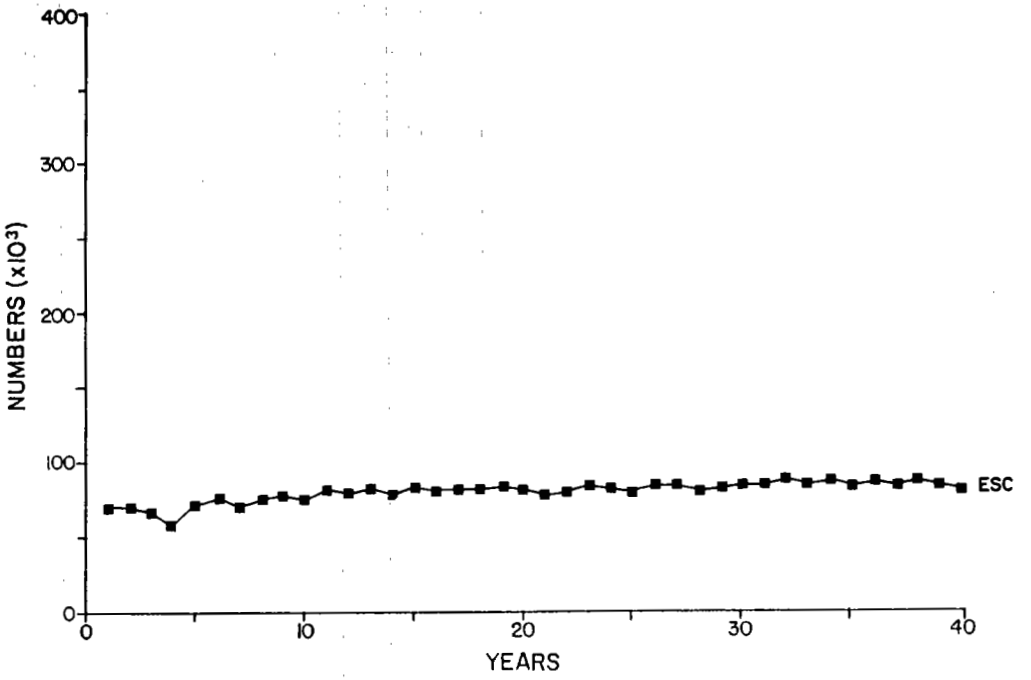

Figure 37. Projected escapements of Area 27 chum under Option 1 (aggregate stock management with surplus harvests only).

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9. GLOSSARY

Actively-Managed Stocks – salmon stocks that receive priority with regard to management decisions governing the fisheries; that is, they will cause a fishery to be altered if conservation measures are required. Actively-managed stocks are usually abundant, economically valuable stocks.

Backplanting – returning artificially-propagated fry/smolt to site of origin (see "satelliting").

Bar fishery – a fishery from a sand bar in a river.

Beach tie-off – securing the end of a seine net by tying the end to a tree or rock on a beach while the net is fed out from the seine boat.

Boat-day – one boat involved in fishing for one day or portion thereof.

Box boundaries – boundaries of an area in an inlet or strait between which fishing is not permitted, to protect pre-spawning adult fish. See also "Stream Boundaries".

Bunt mesh – the bottom strip of mesh in a seine net. Regulations govern the size of the bunt mesh so that (in theory) small fish can escape as the seine is pursed.

Buy-back program – a publicly-funded purchase of existing fishing licences and associated boats for the purpose of retiring the fishing capacity of the vessel from the fleet.

By-catch – catch of non-target species.

Carcass weir – device, usually a fence, across a stream or channel where drifting or spent fish accumulate and can be enumerated and removed.

Cassette incubator – container consisting of numerous compartments, each large enough for one or a few salmonid eggs, enclosed with a porous cover to permit water flow. Used for incubating eggs in a river or lake environment.

Catch ceiling – a regulatory constraint on the maximum number of fish which can be caught by a particular fishery.

Catch per drift – catch during one drift of a gillnet.

Catchability coefficient (q) – the fraction of a fish stock caught by a defined unit of fishing effort.

CEDP – Community Economic Development Project.

Clean-up fisheries – usually terminal, single-stock fishery intended to take fish surplus to escapement requirements at the end of the run.

Closures – termination of a fishery in a specified area during a specified time.

Counting weir – device, usually a fence, used to temporarily stop migrating adult salmonids to permit enumeration.

Cycle – refers to life cycle of salmon from egg to spawning adult.

Cyclic dominance – the tendency for each sockeye spawning area to produce larger numbers of fish in some years and not in others. The dominant cycle years are repeated every four years in the Fraser River. Others have 5 year cycles.

Dead pitching – pitching salmon carcasses on to stream banks to count them and/or recover tags.

Directed fishery – commercial fishery directed at a specific stock by time or space.

Discount rate or **social discount rate** – a factor that is used like an interest rate to reduce values occurring in the future to their equivalent value in the present. Discount rates are used in the calculation of net present values (NPV).

Diversion rate – the proportion of returning salmon (generally referring to sockeye salmon) that returns, for example, to the Fraser via Johnstone Strait.

Donor stocks - particular population of salmonids from which eggs and/or milt are taken for the purpose of enhancing the same population or for transplanting to other streams.

Drifted gill net - a gill net fished without anchor or attachment to shorelines.

Effort response - a change in the number of active fishermen (effort) in response to a change in catch success.

Emergence - stage in salmonid's life when incubation is complete and young fish emerge from the gravel and begin to swim actively in search of food.

Enhancement - techniques used to increase the production of salmonid stocks through intervention by man. May pertain to fish culture techniques, stream improvements, etc.

Enumeration fence - see "counting weir".

Environmental loss - loss of potential escapement causing failure to meet target escapement, because of environmental variability affecting survival rates (ocean processes, flooding, freezing, etc.).

Enzootic - of a disease, peculiar to or constantly present in a locality.

Epizootic - of a disease, temporarily prevalent.

Escapement - number of fish which survive all fisheries and are estimated to be on the spawning grounds.

Exploitation rate - the probability that a fish will die from fishing during a specified period. Also, the proportion of a group of fish (usually total stock) that are removed by fishing during a period.

Exploratory opening - see Test Dip Fishery.

EXPO '86 - transportation and communications exposition held in Vancouver in 1986. It attracted large numbers of tourists to British Columbia.

Fishery - a fish harvesting activity that is defined by some combination of gear, area, time and/or target species.

Fixed catch approach - management strategy used in a mixed-stock fishery where the catch is held to an absolute number (catch ceiling). The underlying assumption is that stock abundance is increasing or stable, otherwise the ceiling has to be adjusted. (The latter strategy then resembles the fixed harvest rate approach.)

Fixed harvest rate approach - management strategy used in mixed-stock fishery. It is assumed that harvest rate can be fixed at a constant level (proportion of the available stocks) by constraining time spent fishing or the amount of fishing gear used in a given area for a given time.

Flow storage works - dam or works to store water during high-flow periods for release during low-flow periods.

Forgone catch - fish in excess of those expected to return to spawn in a given stock, and therefore not caught, resulting in escapement higher than target.

Fry - a stage in the life of a fish from the time it starts actively swimming and feeding to age 14 days.

Gurdie - a winch that is used to raise and lower trollers' lines.

Hails on the grounds - counts made by Fishery Officers on patrol vessels or charter patrolmen hailing commercial fishermen while on fishing grounds.

Hanging lakes - lakes formed by glacial scour, frequently above valley bottom or fjord.

Harvest rate - the harvest proportion of a particular group of fish in a specified area over a specified time (also defined by species, sex, cohort, harvesting fishery, etc.).

Incidental catch - catch of fish other than the target species.

Incubator – a unit constructed to hold fertilized eggs until hatching or emergence.

Index stock – salmon stock deemed to be representative of adjacent salmon stocks. High quality data are usually gathered for this stock.

Indicator stock – see "index stock".

Inside/Outside – refers to inside (e.g., Johnstone Strait) and outside (West Coast and Juan de Fuca Strait) of Vancouver Island.

Interception fishery – a fishery which captures (intercepts) fish from a number of stocks (i.e., is not stock-specific). This term is often used to refer to international interceptions, but in this report it is often defined synonymously with mixed-stock fishery. Although mixed-stock problems may result from interception fisheries the two are not really synonymous. The intentive understanding of interception fishery is that it differs from terminal fisheries in that stocks are intercepted before reaching their natal streams. It could be possible to have an interception fishery on a single stock.

IPSFC – International Pacific Salmon Fisheries Commission.

Key stock – a large or otherwise important salmon stock for which better quality data are available or will be obtained in the future, equivalent to an indicator or index stock.

Key stream – a stream in which one or more key (index) salmon stocks spawn.

Known-stock fishery – commercial fishery targeted on a specific stock of salmon.

Mainstem – principal course of river.

Management to escapement – management of fisheries in a manner that ensures (within technical limits) that the target escapement reaches the spawning area.

Management uncertainty loss – loss of potential escapement to a fishery causing failure to meet target escapement, because of inaccurate estimation of run size or escapement.

Mean return rate - a measure of average spawning yield, (yield may be in juvenile/adult spawners, juvenile/adult catch, etc.). See also productivity.

Migrant releases - release from hatchery of salmonids that are smolted and will migrate downstream.

Mixed-harvest loss-failure - loss of potential escapement to incidental harvest in mixed-stock fishery. This can only be considered a loss if it results in less than target escapement.

Net present value (NPV) - abbreviation for "present value of net economic benefits". Future streams of project benefits and costs are estimated and the difference is the future stream of net economic benefits. This stream is translated into a present value by discounting future values by the social discount rate. The resulting figure is called the "net present value". In the Salmon Stock Management Plan the future stream of benefits and costs are calculated over a period of 40 years. The only costs considered are those for harvesting and processing (management, capital and operating costs are not included).

Objective - a statement of intent about resource use that is specified with respect to species, area, fishery, or resource uses.

Odd/Even - refers to discrete pink runs which occur in either odd or even years.

Open sets - refers to seine sets where a skiff or running line is used to bring the end of the net back to the boat rather than tying off at the shore.

Opening - date and time set by DFO for the commencement of a specific fishery.

Optimum escapement - an estimate of the numbers of spawners that will meet (but not exceed) the capacity of the river system.

Outplanting - see "transplanting".

Passively-managed stocks - salmon stocks not directly managed but affected incidentally as the result of active management of other stocks. The fishery will not be altered to protect these stocks, by definition.

Pathogenesis - the origin and development of a disease.

Pieces - individual fish (in a commercial catch).

Pink corridor - this is a boundary regulation in Johnstone Strait to conserve Johnstone Strait and Strait of Georgia pink stocks while fishing for Fraser River sockeye. A ribbon boundary closes the shore on the mainland side of the strait in a half mile wide strip from tidewater. The ribbon strip switches to the Vancouver Island side of the Strait at Chatham Point, and continues to end of fishing area. This regulation is usually in place during the first three weeks in August.

PIP - Public Involvement Project.

Policy - a statement of intent about resource use that has a national or regional scale.

Pre-migrant - young salmon prior to migration downstream to marine environment.

Presmolt - usually pertains to salmonid species that rear for extended periods of time (one year or more) in fresh water; the stage during which the fish is a yearling but has not yet smolted.

Production - the number of fish produced, often used in a stock-specific sense or for a particular enhancement project.

Production release - release of salmonids, usually high numbers, from an enhancement facility, that have been raised using standard fish culture techniques (as opposed to experimental releases).

Productivity - the rate of production, usually in terms of returning adults per spawner (stock specific).

Qualla - refers to external chum colour (and therefore quality). Falls between brights (high quality) and darks (low quality). Also known as semi-brights.

Raceway - rectangular fish-rearing containers with high exchange rates of water and vertical walls.

Rack fisheries - commercial fishery targeted on excess hatchery stock. This may occur at the hatchery, and does not necessarily require boats.

Ribbon boundary - a specified boundary parallel to a shore of an inlet or pass which is closed to fishing to protect a portion of the migrating salmon.

Satelliting - an enhancement strategy whereby eggs and milt from a particular salmonid stock are incubated and reared in a central facility or different stream, then returned to donor stream.

Scale pattern analysis - analysis of the patterns on scales of fish to distinguish between stocks and to identify age composition.

Sea pen - net enclosures suspended in sheltered saltwater bays containing salmon for rearing purposes.

Semi-bright - see "qualla".

SEP biostandard - criteria used to estimate production of salmonid reproduction in the wild or in various types of enhancement facilities. Includes estimates of fecundity and survival during each life stage for each species.

Shaker abundance - numbers of undersized salmon available for capture by sport and commercial fishermen.

Shaker catch - numbers of undersized salmon caught and released by sport and commercial fishermen.

Shaker mortality - shakers which do not survive the catch and release process.

Silver bright - type of mature salmon (chum) which has a silvery appearance, and is classified as top quality in the fishing industry.

Smolts - a juvenile salmon that has undergone or is undergoing physiological and behavioural changes in preparation for migration from fresh to salt water.

Spawning channel - an artificial channel constructed for returning adults to spawn in, with ideal gravel and flow conditions.

Squishers – undersized fish caught by commercial seine fishermen which are gilled in the net, and then crushed as the net is wound onto the drum.

Stock – fish of a single species that spawn in a particular geographical area at the same time.

Strategy – a collection of management actions for meeting an objective.

Straying – returning adults which stray from normal migration route and spawn in an area different from the one in which they originated.

Stream boundaries – boundaries of an area around the mouth of a river within which fishing is not permitted, to protect pre-spawning adult fish. See also Box Boundaries.

Subdominant year – the second highest production year of a stock (see "cyclic dominance").

Subyearling – stage in salmonid's life during the first year of rearing prior to the end of the calendar year (see "yearling").

Surplus to escapement – the number of returning salmon beyond estimated optimum or target escapement. These fish are available for harvest and therefore constitute the allowable catch.

Systemic – of the bodily system as a whole.

Target – refers to the level of escapement at which management plans are aimed. It is the best estimate of "optimum" currently available.

Terminal fisheries – fishery conducted near the head of inlets or mouths of rivers where discrete stocks can be fished.

Test dip fishery – one-day opening of commercial fishery to assess stock strength.

Test harvest loss – loss of potential escapement causing failure to meet target escapement, because of test fishery operation conducted to estimate run size.

Total stock – catch plus escapement.

Transplanting – releasing hatchery-raised juveniles in a stream other than the one in which the parent stock originated.

Upwelling gravel box – box filled with gravel for incubating salmonid eggs with water flowing through from bottom to top.

Voluntary emergence – pertains to incubation of fish eggs in an artificial container where fry swim out of incubation media of their own volition. In non-voluntary systems, fry are manually transferred from incubating container.

Window – a period of time during which an activity occurs.

Yearling – a stage in a salmonid's life reached when a new calendar year begins during juvenile rearing period (a subyearling becomes a yearling on January 1st).

APPENDIX I

PRESENT STOCK STATUS FOR STATISTICAL AREAS 21-27, WEST COAST VANCOUVER ISLAND

AREA 22 STOCK STATUS

Stock(s)	Ave. Escapements 1950-59	1960-69	Ave. 1970-79	Ave. 1980-85	Target Escapement	Age Composition	Rate of Return ($x \pm s^2$)
Chum							
Nitinat River	36,300	41,100	68,400	83,500	125,000	0.34 Age 3 0.62 Age 4 0.04 Age 5	4.26 ± 29.27
Sockeye							
Hobiton Creek	6,200	6,300	4,600	17,200	20,000		
Chinook							
Nitinat River	1,600	2,200	1,400	3,800			
Coho							
Cheewhat Creek Doobah Creek Caycose River Nitinat River Hobiton Creek	3,400	3,000	1,800	200			
Pinks							
No pink stocks produced in Area 22.							
Steelhead							

AREA 23 STOCK STATUS

Stock(s)	Ave. Escapements 1950-59	1960-69	Ave. 1970-79	Ave. 1980-85	Target Escapement	Age Composition	Rate of Return ($x \pm S^2$)
Chum							
Nahmint Sarita Toquart Rivers Effingham River Henderson River Salmon Creek	158,200	98,800	137,000	83,400	150,000	0.31 Age 3 0.65 Age 4 0.04 Age 5	1.09 ± 0.18
Sockeye							
Somass River Great Central Lake Sproat Lake	43,300	57,400	168,600	342,000	350,000		
Henderson Lake	15,600	32,300	11,100	39,000	50,000		
Chinook							
	13,600	12,000	12,900	21,112	85,000		
Coho							
	61,500	56,000	72,600	11,100			
Pink							
	Escapement estimates unavailable for some years.						
Steelhead							

AREA 24 STOCK STATUS

Stock(s)	Ave. Escapements 1950-59	1960-69	Ave. 1970-79	Ave. 1980-85	Target Escapement	Age Composition	Rate of Return ($x \pm s^2$)
Chum							
Atleo Megin Moyeha Rivers Tranquil Bawden Bay Creek	69,800	39,500	59,000	72,600	100,000	0.33 Age 3 0.64 Age 4 0.03 Age 5	1.79 ± 0.55
Sockeye							
Kennedy Lake Clayoquot Arm Clayoquot River Kennedy River Kennedy Lake	48,000	22,000	27,000	28,000	120,000		
Chinook							
Kennedy River	5,200	1,774	499	<200			
Coho							
Kennedy River Tranquil Creek Moyeha River Megin River Lost Shoe Creek Kootowis Creek Hootla Kootla Creek Cypre River Clayoquot River Atleo River	18,000	13,800	8,500	2,900			
Pinks (e)							
Bedwell River	550	4,766	10,226	1980) 3,604			
Moyeha River				82) 0			
Sydney River				84) 0			
Steelhead							

AREA 25 STOCK STATUS

Stock(s)	Ave. Escapements 1950-59	1960-69	Ave. 1970-79	Ave. 1980-85	Target Escapement	Age Composition	Rate of Return ($x \pm S^2$)
Chum							
Conuma Inner Basin Tahsis Zeballos Rivers Burman River Canton Creek Chum Creek Deserted Creek Leiner River Park River Sucwoa River Tlupana River Tsowwin River	76,000	114,400	94,300	138,000	150,000	0.38 Age 3 0.58 Age 4 0.04 Age 5	2.67 ± 6.92
Chinook							
Burman River Conuma River Deserted River Gold River	5,900	8,500	4,000	2,500	5-6,000		
Coho							
Burman River Conuma River Gold River Leiner River Tahsis River Tlupana River	15,600	17,500	11,000	4,300			
Pinks							
Burman River Leiner River Zeballos River	8,800	107,300	81,500	16,800			

AREA 25 STOCK STATUS

Stock(s)	Ave. Escapements 1950-59	1960-69	Ave. 1970-79	Ave. 1980-85	Target Escapement	Age Composition	Rate of Return ($x \pm S^2$)
Steelhead							
Gold River							
Heber River							
Sockeye							
Oktwanch River	2,300	4,700	7,200	9,300			
Mochalat River							

AREA 26 STOCK STATUS

Stock(s)	Ave. Escapements 1950-59	1960-69	Ave. 1970-79	Ave. 1980-85	Target Escapement	Age Composition	Rate of Return ($x \pm s^2$)
Chum							
Chamiso Creek Clanninick Creek Kauwinch River Malksope River Tahsish River	71,900	39,000	59,900	84,600	120,000	0.40 Age 3 0.58 Age 4 0.02 Age 5	3.38 ± 25.40
Sockeye							
Jansen Lake Creek	2,900	4,400	1,500	2,300			
Chinook							
Kaouk River Power River Tahsish River	6,100	3,200	1,600	1,600			
Coho							
Artlish River Battle River Clanninick River Kaouk River Kauwinch River Malksope River Narrowgut Creek Nasparti River Ououkinsh River Power River Tahsish River	16,600	4,300	4,800	1,700			

AREA 26 STOCK STATUS

Stock(s)	Ave. Escapements 1950-59	1960-69	Ave. 1970-79	Ave. 1980-85	Target Escapement	Age Composition	Rate of Return ($x \pm s^2$)
Pink (e)							
Tatcho Creek Kaouk River Battle River Artlish River	14,400	35,900	62,800	5,000			
Steelhead							

AREA 27 STOCK STATUS

Stock(s)	Ave. Escapements 1950-59	1960-69	Ave. 1970-79	Ave. 1980-85	Target Escapement	Age Composition	Rate of Return ($x \pm s^2$)
Chum							
Cayeghle Creek Colonial Creek Denad Creek Jim's Creek Johnny Creek Klaskish River Klayina Creek Koprino River Pegatten Creek	49,700	21,100	36,600	45,400	100,000	0.37 Age 3 0.60 Age 4 0.03 Age 5	1.81 ± 2.43
Chinook							
Marble River Klaskish River East Creek	3,300	700	800	2,900			
Coho							
Marble River + 40 other systems	35,500	18,000	21,000	6,100	50,000		
Pink (e)							
Waukwaas + 12 other systems	81,000	41,400	23,200	24,900	50,000 (even)		
Steelhead							
Marble River Mahatta River							

AREA 27 STOCK STATUS

Stock(s)	Ave. Escapements 1950-59	1960-69	Ave. 1970-79	Ave. 1980-85	Target Escapement	Age Composition	Rate of Return ($x \pm S^2$)
Sockeye							
Mahatta River Marble River	6,300	1,600	700	600	20,000		

APPENDIX II

HABITAT STATUS FOR STATISTICAL AREAS 22-27, WEST COAST VANCOUVER ISLAND

INTRODUCTION

The habitat information tables were prepared by Howard Paish and Associates under contract to the Department of Fisheries and Oceans. Each table summarizes habitat status for one species in one Sub-area (e.g., Rivers Inlet Sockeye, Gardner Canal Pink, Cumshewa Chum). These sub-area summaries form the basis for the Habitat Overview in the Salmon Stock Management Plan.

The purpose of the Habitat Overview is to link stock and escapement information to information on habitat status and development. Each table has five sections:

1. Stock Group
2. Stock Data
3. Management Style
4. Habitat Notes
5. Summary

The Stock Group section identifies the stock or group of stocks by species and management unit covered in the table. The Stock Data section summarizes current, target, and maximum recorded escapements in an attempt to link stock status, (current escapement) to habitat status and potential (target and maximum recorded escapements). The Management Style Section indicates whether the stock is actively or passively managed.

The Habitat Notes describe the historic and current status of habitat and the future outlook. This information facilitates interpretation of the Stock Data linking actual and potential stock production to habitat status. The production potential of the natural habitat, and of only improved habitat are also indicated.

The Summary section contains subjective gradings of habitat in terms of ability to achieve current targets, current status and future outlook, and the production potential from natural and improved habitat.

HABITAT INFORMATION TABLE

STOCK GROUP Nitinat Sockeye Area 22

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	9.5*	25	16.8

MANAGEMENT STYLE

Active X

Passive ___

Unknown ___

No. of Streams 2

No. of Significant Streams 1

HABITAT NOTES: Dominated by enhanced Hobiton Lake stock.

Historic Status	Logged.
Current Status	Lake fertilization began in 1977. Lake fertilization.
Future Outlook	
Natural Habitat Production Potential	
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
High	High	High		

CONCLUSION

* Pre-enhancement

HABITAT INFORMATION TABLE

STOCK GROUP Nitinat Chum Area 22

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	237	125	89.0

MANAGEMENT STYLE

Active X(?)

Passive ___

Unknown X

No. of Streams 5

No. of Significant Streams 2

HABITAT NOTES: Completely dominated by Nitinat chum.

Historic Status	Natural flow instability and obstructions. Logged since 1940's, with moderate impacts. Siltation and debris. Gravel recruitment seems satisfactory.
Current Status	Hatchery at Nitinat River. First returns in 1984. Logging has probably peaked and is continuing. Logged areas regenerating.
Future Outlook	Continued logging. Forest regeneration.
Natural Habitat Production Potential	Probably returning to historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
High	Medium-High	High		

CONCLUSION

Habitat loss is probably not the major cause of stock declines, but would have contributed.

HABITAT INFORMATION TABLE

STOCK GROUP Nitinat Coho Area 22

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	10.9	-	0.2

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 5

No. of Significant Streams 5

HABITAT NOTES: Dominated by Nitinat River.

Historic Status	Natural flow instability and obstructions. Logging with moderate impacts from 1940's on. Siltation and debris. Gravel recruitment seems satisfactory.
Current Status	Logging probably peaked and is continuing. Logged areas regenerating.
Future Outlook	Continued logging. Forest regeneration.
Natural Habitat Production Potential	Probably returning to historic levels.
Improved Production Potential	Small stream improvement.

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium-High	High	Medium-High	

CONCLUSION

Habitat loss is probably not the major cause of stock declines, but would have contributed.

HABITAT INFORMATION TABLE

STOCK GROUP Nitinat Chinook Area 22

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	3.5	-	4.0

MANAGEMENT STYLE: Active ___ Passive X Unknown ___

No. of Streams 1

No. of Significant Streams 1

HABITAT NOTES: Nitinat River.

Historic Status	Natural flow instability and obstructions. Logged since 1940's, with moderate impact. Siltation and debris. Gravel recruitment seems satisfactory.
Current Status	Logging probably peaked, and is continuing. Logged areas regenerating.
Future Outlook	Continued logging. Forest regeneration.
Natural Habitat Production Potential	Probably returning to historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium-High	High	High	

CONCLUSION

Habitat loss is probably not the major cause of stock declines, but would have contributed.

HABITAT INFORMATION TABLE

STOCK GROUP Barkley Sound Sockeye Area 23

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement	MANAGEMENT STYLE
Thousands		400	381	

Active X
Passive ___
Unknown ___

No. of Streams 2

No. of Significant Streams 2

HABITAT NOTES: Completely dominated by lake fertilization on Somass and Henderson systems.

Historic Status	Natural flow instability. Extensive logging since 1920's, with moderate to high impacts. Low to moderate industrial and settlement impacts on Alberni Canal (Somass System). Some water use concerns.
Current Status	Extensive artificial facilities on Somass system. Logging and development have probably peaked. Continued logging.
Future Outlook	Continued logging and development activity on Somass system.
Natural Habitat Production Potential	
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
High	High	High		

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Barkley Sound Chum Area 23

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	326	150	77

MANAGEMENT STYLE

Active ___
Passive ___
Unknown X

No. of Streams 42

No. of Significant Streams 3

HABITAT NOTES:

Historic Status	Natural flow instability. Extensive logging since 1920's, with moderate to high impacts on about 80% of the streams. Industrial and settlement impact on Alberni Canal (Somass System), low to moderate. Some water use concerns. Extensive artificial facilities on Somass system.
Current Status	Extensive artificial facilities on Somass system. Logging and development have probably peaked. Continued logging.
Future Outlook	Continued logging and development activity on Somass system.
Natural Habitat Production Potential	
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
High	Medium-High	High		

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Barkley Sound Pink Area 23

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement	MANAGEMENT STYLE
Thousands	7.4		.0028	

Active ___
Passive X
Unknown ___

No. of Streams 8
No. of Significant Streams 3

HABITAT NOTES: Minor stock.

Historic Status	Natural flow instability. Extensive logging since 1920's, with moderate to high impacts. Low to moderate industrial and settlement impacts on Alberni Canal (Somass System). Some water use concerns. Extensive artificial facilities on Somass system.
Current Status	Extensive artificial facilities on Somass system. Logging and development have probably peaked. Continued logging.
Future Outlook	Continued logging and development activity on Somass system.
Natural Habitat Production Potential	
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
		Medium		

CONCLUSION

Habitat probably not the reason for depressed stock.

HABITAT INFORMATION TABLE

STOCK GROUP Barkley Sound Chinook Area 23

STOCK DATA	Maximum Recorded Escapement	Target/* Optimum Escapement	Current Average Escapement
Thousands	24	85	76 (1985)

MANAGEMENT STYLE

Active ___
Passive X
Unknown ___

No. of Streams 16
No. of Significant Streams 4

HABITAT NOTES: Major production facility at Robertson Creek.

Historic Status	Natural flow instability. Extensive logging since 1920's, with moderate to high impacts on about 80% of the streams. Low to moderate industrial and settlement impacts on Alberni Canal (Somass System). Some water use concerns. Major sport fishery on Somass system.
Current Status	Robertson Creek Hatchery in operation. Logging and development have probably peaked. Continued logging.
Future Outlook	Continued logging and development activity on Somass system.
Natural Habitat Production Potential	
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium-High	High	Low-Medium	High

CONCLUSION

Habitat deterioration has probably had a severe effect on some systems, e.g. Sarita River.

* Target and average escapement values represent wild and hatchery aggregates.

HABITAT INFORMATION TABLE

STOCK GROUP Barkley Sound Coho Area 23

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	199	-	45 (1985)

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 37

No. of Significant Streams 9

HABITAT NOTES: Historically dominated by Somass System.

Historic Status	Natural flow instability. Extensive logging since 1920's, with moderate to high impacts on about 80% of the streams. Low to moderate industrial and settlement impacts on Alberni Canal (Somass System). Some water use concerns.
Current Status	Logging and development have probably peaked. Continued logging.
Future Outlook	Continued logging and development activity on Somass system.
Natural Habitat Production Potential	
Improved Production Potential	Small stream restoration and improvement.

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential

CONCLUSION

Habitat deterioration has probably had a major impact on coho production.

HABITAT INFORMATION TABLE

STOCK GROUP Clayoquot Sockeye Area 24

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	106	120	36

MANAGEMENT STYLE

Active X

Passive ___

Unknown ___

No. of Streams 8

No. of Significant Streams 6

HABITAT NOTES:

Historic Status	Some natural flow instability. Logging on about 60% of watersheds since 1950's, with overall moderate impacts, but high on some: siltation, debris, scouring and gravel removal. Some streams now have park status.
Current Status	Stable with continued logging. Logged watersheds regenerating but residual impacts from earlier logging. Lake fertilization (Kennedy Lake).
Future Outlook	Continued logging with better habitat control.
Natural Habitat Production Potential	Affected by logging, but probably returning to near historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
Medium-High	Medium-High	High-Medium		High

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Clayoquot Chum Area 24

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	240	100	76

MANAGEMENT STYLE

Active ___

Passive ___

Unknown X

No. of Streams 24

No. of Significant Streams 9

HABITAT NOTES:

Historic Status	Some natural flow instability. Logging on about 60% of watersheds since 1950's, with overall moderate impacts, but some high: siltation, debris, scouring and gravel removal. Some streams now have park status.
Current Status	Stable, with continued logging. Logged watersheds regenerating but residual impacts from earlier logging.
Future Outlook	Continued logging with better habitat control.
Natural Habitat Production Potential	Affected by logging, but probably returning to near historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium	High	High-Medium	

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Clayoquot Pink Area 24

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	24		3.6*

MANAGEMENT STYLE

Active ___
Passive X
Unknown ___

No. of Streams 9
No. of Significant Streams 4

HABITAT NOTES: Minor stock.

Historic Status	Some natural flow instability. Logging on about 60% of watersheds since 1950's, with overall moderate impacts, but high on some: siltation, debris, scouring and gravel removal. Some streams now have park status.
Current Status	Stable, with continued logging. Logged watersheds regenerating but residual impacts from earlier logging.
Future Outlook	Continued logging with better habitat control.
Natural Habitat Production Potential	Affected by logging, but probably returning to near historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium-High			

CONCLUSION

* 1980 only.

HABITAT INFORMATION TABLE

STOCK GROUP Clayoquot Coho Area 24

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	36		2.4

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 26

No. of Significant Streams 11

HABITAT NOTES:

Historic Status	Some natural flow instability. Logging on about 60% of watersheds since 1950's, with overall moderate impacts, but high on some: siltation, debris, scouring and gravel removal. Some streams now have park status.
Current Status	Stable, with continued logging. Logged watersheds regenerating but residual impacts from earlier logging.
Future Outlook	Continued logging with better habitat control.
Natural Habitat Production Potential	Affected by logging, but probably returning to near historic levels.
Improved Production Potential	Potential for small stream improvement.

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Low-Medium	Medium-High	Medium-High	High

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Clayoquot Chinook Area 24

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	10.4		.29

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 10

No. of Significant Streams 6

HABITAT NOTES:

Historic Status	Some natural flow instability. Logging on about 60% of watersheds since 1950's, with overall moderate impacts, but high on some: siltation, debris, scouring and gravel removal. Some streams now have park status.
Current Status	Stable, with continued logging. Logged watersheds regenerating but residual impacts from earlier logging.
Future Outlook	Continued logging with better habitat control.
Natural Habitat Production Potential	Affected by logging, but probably returning to near historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium	High	High-Medium	

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Nootka/Esparanza Sockeye Area 25

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	20.5		7

MANAGEMENT STYLE

Active ___

Passive ___

Unknown ___

No. of Streams 10

No. of Significant Streams 5

HABITAT NOTES:

Historic Status	Natural flow instability compounded by logging on about 55% of drainages since the 1950's. Moderate impacts, some locally severe, including siltation, scouring, debris and gravel removal. Pulpmill on tidewater at Tahsis.
Current Status	Logging continuing.
Future Outlook	Logging continuing with better habitat controls. Forest land recovery.
Natural Habitat Production Potential	Below historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium	Medium-High	Medium-High	

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Nootka/Esparanza Pink Area 25

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	299		<0.2 (1985)

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 33

No. of Significant Streams 18

HABITAT NOTES:

Historic Status	Natural flow instability compounded by logging since the 1950's, on about 55% of the drainages. Moderate impacts, some locally severe, including siltation, scouring, debris and gravel removal. Pulpmill on tidewater at Tahsis.
Current Status	Logging continuing.
Future Outlook	Logging continuing with better habitat controls. Forest land recovery.
Natural Habitat Production Potential	Below historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium	Medium-High	Medium-High	

CONCLUSION

Probably affected by scouring and gravel removal, but it is unlikely that habitat change would account for total decline.

HABITAT INFORMATION TABLE

STOCK GROUP Nootka/Esparanza Chum Area 25

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	399	150	142

MANAGEMENT STYLE

Active X(?)

Passive ___

Unknown ___

No. of Streams 40

No. of Significant Streams 26

HABITAT NOTES:

Historic Status	Natural flow instability compounded by logging on about 55% of drainages, since the 1950's. Moderate impacts, some locally severe, including siltation, scouring, debris and gravel removal. Pulpmill on tidewater at Tahsis.
Current Status	Logging continuing.
Future Outlook	Logging continuing with better habitat controls. Forest land recovery.
Natural Habitat Production Potential	Below historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
High	Medium-High	High		

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Nootka/Esparanza Chinook Area 25

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	28	6	2.8

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 29

No. of Significant Streams 11

HABITAT NOTES:

Historic Status	Natural flow instability, compounded by logging since the 1950's on about 55% of the drainages. Moderate impacts, some locally severe, including siltation, scouring, debris and gravel removal. Pulpmill on tidewater at Tahsis.
Current Status	Logging continuing.
Future Outlook	Logging continuing with better habitat controls. Forest land recovery.
Natural Habitat Production Potential	Below historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
High	Medium	High		

CONCLUSION

Logging has probably had an impact on chinook production.

HABITAT INFORMATION TABLE

STOCK GROUP Nootka/Esparanza Coho Area 25

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	60		5.8

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 31

No. of Significant Streams 17

HABITAT NOTES:

Historic Status	Natural flow instability compounded by logging since the 1950's, on about 55% of the drainages. Moderate impacts, some locally severe, including siltation, scouring, debris and gravel removal. Pulpmill on tidewater at Tahsis.
Current Status	Logging continuing.
Future Outlook	Logging continuing with better habitat controls. Forest land recovery.
Natural Habitat Production Potential	Below historic levels.
Improved Production Potential	Small stream restoration.

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium	Medium-High	Medium-High	Medium-High

CONCLUSION

Coho have probably suffered most through habitat change.

HABITAT INFORMATION TABLE

STOCK GROUP Kyuquot Sockeye Area 26

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	7.3		3.0

MANAGEMENT STYLE

Active ___
Passive ___
Unknown X

No. of Streams 4
No. of Significant Streams 2

HABITAT NOTES: Minor stock.

Historic Status	Natural flow instability. Extensive logging since late 1950's. Moderate to high impacts, including siltation, debris, gravel removal and diversions.
Current Status	Logging may have peaked, but is continuing.
Future Outlook	Forest land recovery. Gravel recruitment uncertain.
Natural Habitat Production Potential	Below historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Low-Medium	Medium	Medium	

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Kyuquot Pink (even year) Area 26

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	225		5

MANAGEMENT STYLE

Active ___

Passive ___

Unknown X

No. of Streams 19

No. of Significant Streams 9

HABITAT NOTES:

Historic Status	Natural flow instability. Extensive logging since late 1950's. Moderate to high impacts, including siltation, debris, gravel removal and diversions.
Current Status	Logging may have peaked, but is continuing.
Future Outlook	Forest land recovery. Gravel recruitment uncertain.
Natural Habitat Production Potential	Below historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Low-Medium	Medium	Low-Medium	

CONCLUSION

Assume that gravel loss has contributed significantly to stock declines.

HABITAT INFORMATION TABLE

STOCK GROUP Kyuquot Chum Area 26

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	213	120	76.5

MANAGEMENT STYLE

Active X

Passive ___

Unknown ___

No. of Streams 23

No. of Significant Streams 12

HABITAT NOTES:

Historic Status	Natural flow instability. Extensive logging since late 1950's. Moderate to high impacts, including siltation, debris, gravel removal and diversions.
Current Status	Logging may have peaked, but is continuing.
Future Outlook	Forest land recovery. Gravel recruitment uncertain.
Natural Habitat Production Potential	Below historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
High	Medium	Medium-High		

CONCLUSION

Seems less affected than other species.

HABITAT INFORMATION TABLE

STOCK GROUP Kyuquot Chinook Area 26

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	18.6		1.4

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 18

No. of Significant Streams 5

HABITAT NOTES:

Historic Status	Natural flow instability. Extensive logging since late 1950's. Moderate to high impacts, including siltation, debris, gravel removal and diversions.
Current Status	Logging may have peaked, but is continuing.
Future Outlook	Forest land recovery. Gravel recruitment uncertain.
Natural Habitat Production Potential	Below historic levels.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Low-Medium	Medium	Medium	

CONCLUSION

Assume that logging has made a major contribution to this stock decline, but not likely to be the sole reason.

HABITAT INFORMATION TABLE

STOCK GROUP Kyuquot Coho Area 26

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	42		1.3

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 23

No. of Significant Streams 12

HABITAT NOTES:

Historic Status	Natural flow instability. Extensive logging since late 1950's. Moderate to high impacts, including siltation, debris, gravel removal and diversions.
Current Status	Logging may have peaked, but is continuing.
Future Outlook	Forest land recovery. Gravel recruitment uncertain.
Natural Habitat Production Potential	Below historic levels.
Improved Production Potential	Potential for small stream improvement.

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Low	Medium	Medium	Medium

CONCLUSION

Habitat loss has almost certainly contributed significantly to this decline. Dates for MRE's would bear this out.

HABITAT INFORMATION TABLE

STOCK GROUP Quatsino Sockeye Area 27

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	12.2	20	1.2

MANAGEMENT STYLE

Active ___

Passive ___

Unknown X

No. of Streams 4

No. of Significant Streams 2

HABITAT NOTES: Minor stock. Mahatta and Marble Rivers.

Historic Status	Natural instability. Extensive logging from 1960's on, with moderate impacts.
Current Status	Logging has probably peaked.
Future Outlook	Continued lower level of logging.
Natural Habitat Production Potential	Return to near historic level.
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium	Medium-High	Medium-High	

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Quatsino Pink (even) Area 27

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	190	even 50 odd 2	(even) 24.86

MANAGEMENT STYLE

Active ___
Passive ___
Unknown X

No. of Streams 19

No. of Significant Streams 10

HABITAT NOTES:

Historic Status	Natural flow instability. Logging from early 1960's on an estimated 50% of streams. Moderate impacts, but high on some streams - siltation, gravel removal, scouring, diversions and debris. Pulp mill at Port Alice. Local impacts.
Current Status	Mine at Rupert Inlet. Local impacts. Continued logging.
Future Outlook	Continued logging. Forest land regeneration. Gravel recruitment uncertain.
Natural Habitat Production Potential	
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium	Medium	Medium	

CONCLUSION

Gravel loss has probably contributed to stock declines.

HABITAT INFORMATION TABLE

STOCK GROUP Quatsino Chum Area 27

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	173	100	42.9

MANAGEMENT STYLE

Active ___
Passive ___
Unknown X

No. of Streams 61
No. of Significant Streams 22

HABITAT NOTES:

Historic Status	Natural flow instability. Logging from early 1960's on an estimated 50% of streams. Moderate impacts, but high on some streams - siltation, gravel removal, scouring, diversions and debris. Pulp mill at Port Alice. Local impacts.
Current Status	Mine at Rupert Inlet. Local impacts. Continued logging.
Future Outlook	Continued logging. Forest land regeneration. Gravel recruitment uncertain.
Natural Habitat Production Potential	
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium	Medium-High	Medium-High	

CONCLUSION

HABITAT INFORMATION TABLE

STOCK GROUP Quatsino Chinook Area 27

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	10.6		3.1

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 8

No. of Significant Streams 5

HABITAT NOTES:

Historic Status	Natural flow instability. Logging from early 1960's on an estimated 50% of streams. Moderate impacts, but high on some streams - siltation, gravel removal, scouring, diversions and debris. Pulp mill at Port Alice. Local impacts.
Current Status	Incubation and transplant on Marble system. Mine at Rupert Inlet. Local impacts. Continued logging.
Future Outlook	Continued logging. Forest land regeneration. Gravel recruitment uncertain.
Natural Habitat Production Potential	
Improved Production Potential	

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium	Medium	Medium	

CONCLUSION

Habitat loss has probably contributed to chinook decline.

HABITAT INFORMATION TABLE

STOCK GROUP Quatsino Coho Area 27

STOCK DATA	Maximum Recorded Escapement	Target/ Optimum Escapement	Current Average Escapement
Thousands	127	50	7.34

MANAGEMENT STYLE

Active ___

Passive X

Unknown ___

No. of Streams 48

No. of Significant Streams 14

HABITAT NOTES:

Historic Status	Natural flow instability. Logging from early 1960's on an estimated 50% of streams. Moderate impacts, but high on some streams - siltation, gravel removal, scouring, diversions and debris. Pulp mill at Port Alice. Local impacts.
Current Status	Mine at Rupert Inlet. Local impacts. Continued logging.
Future Outlook	Continued logging. Forest land regeneration. Gravel recruitment uncertain.
Natural Habitat Production Potential	
Improved Production Potential	Probably potential for small stream improvement.

SUMMARY

Current Target Achievability	Current Status	Future Outlook	Natural Production Potential	Improved Production Potential
	Medium	Medium	Medium	

CONCLUSION

Habitat loss has probably contributed to stock declines.

APPENDIX III

DISTRIBUTION OF IMPORTANT SALMONID DISEASE AGENTS AND PARASITES IN STATISTICAL AREAS 21-27, WEST COAST VANCOUVER ISLAND

DISTRIBUTION OF IMPORTANT SALMONID DISEASE AGENTS AND PARASITES IN WEST COAST VANCOUVER ISLAND STATISTICAL AREAS 22-27.[1]

An introduction to the analysis of the distribution of salmonid disease agents and parasites in British Columbia is provided in Volume A. The introduction includes a discussion of data sources and notes on all of the important salmonid disease agents and parasites included in the analysis.

Fish health surveys on the West Coast of Vancouver Island (Statistical Areas 22 to 27) have been limited primarily to the Nitinat River system in Area 22, the Somass River system in Area 23 (includes Sproat and Great Central Lakes) and the Kennedy Lake system. Sampling has also occurred at the Tlupana Hatchery (Conuma River) and several other sites in Area 25 (Canton Creek, Gold River and Sucwoa River) and at the Marble River in Area 27 (Table III-1 and Figure III-1).

In the Nitinat River System, the furunculosis bacterium was found in Nitinat Lake chum during 1982 and in some hatchery chinook. (Ceratomyxa shasta was also found in Nitinat Lake chum that same year. The agent for bacterial kidney disease (BKD) was diagnosed in Hobiton River coho in 1984. Henneguya cysts were found in Nitinat River chum and chinook salmon in 1979 and 1980, respectively, and in Hobiton Lake sockeye in 1980.

In the Somass River system, the Robertson Creek hatchery has had a number of disease agents and parasites. The furunculosis bacterium has been found in sockeye, chinooks, coho, rainbow trout and steelhead. Agents were found for proliferative kidney disease (PKD) in coho and steelhead and BKD in chinook and coho. Sockeye and chinook were found with the infectious hematopoietic necrosis (IHN) virus and the enteric redmouth disease bacterium was found in steelhead and chinooks. Henneguya cysts have been found in coho.

The furunculosis bacterium was also found in chinook taken from Sproat Lake and Sproat River as well as in rainbow from the the Stamp River. Henneguya cysts were found in Somass River and Great Central Lake sockeye and in coho taken at the Sproat Lake fishway.

Elsewhere in Statistical Area 23, Henneguya cysts were found in Henderson Lake sockeye and the BKD bacterium was found in Nahmint River chinook. No disease agents or parasites have been found at the Thorton Creek hatchery near Ucluelet. A number of fish farms in Area 23 have had agents for furunculosis and BKD in chinook and chum.

Table III-1. Distribution of salmonid disease agents and parasites on West Coast Vancouver Island.[2,3]

Location			Findings* by Species**							
Area	Sample Site	Total No. Examined	No Disease	F	PKD	BKD	IHN	C.S.	ERM	HEN	Other Disease
22	Hobiton Lake	54								SK	
22	Hobiton R. & L.	55	SK								SK
22	Hobiton R. & L.	1				CO					
22	Nitinat Hatchery	152		CN							CN
22	Nitinat Hatchery	135									
22	Nitinat Hatchery	1									CO
22	Nitinat L.	20	CN								
22	Nitinat L.	61		CM				CM			CM
22	Nitinat River	90								CN	
22	Nitinat River	55								CM	
23	Alberni Inlet	1								CN	
23	Alberni Inshore Water										CN
23	Fish Farms (5)	19 cases	CN	CN		CN					CN
23	Fish Farms (5)	33 cases	CO	CO		CO					CO
23	Gr. Central L. (fishway)	156								CO	
23	Gr. Central L. (fishway)	2,622								SK	
23	Great Central Lake	1	RT								
23	Great Central Lake	38	CO								
23	Great Central Lake	16	CT								CT
23	Great Central Lake	120					SK				SK
23	Great Central Lake	17	DV								
23	Henderson Lake	1,564								SK	
23	Nahmint River	1				CN					
23	Port Alberni Area	1									DV
23	Port Alberni Area	28	RT								RT
23	Port Alberni Area	1									CT
23	Robertson Ck. & Hatchery	13 cases	RT	RT							RT
23	Robertson Ck. & Hatchery	7 cases	SK	SK			SK				SK

*Disease/Agents and Parasites:

F - Furunculosis
PKD - Proliferative kidney disease
BKD - Bacterial kidney disease
IHN - Infectious hematopoietic necrosis
CS - Ceratomyxa shasta
HEN - Henneguya salminicola
ERM - Enteric redmouth disease

**Salmonid Species:

CN - Chinook
CM - Chum
CO - Coho
SK - Sockeye
PK - Pink
ST - Steelhead Trout
RT - Rainbow Trout

continued . . .

Table III-1. concluded.

Location			Findings* by Species**								
Area	Sample Site	Total No. Examined	No Disease	F	PKD	BKD	IHN	C.S.	ERM	HEN	Other Disease
23	Robertson Ck. & Hatchery	84 cases	CO	CO	CO	CO				CO	CO
23	Robertson Ck. & Hatchery	56 cases	ST	ST	ST				ST		ST
23	Robertson Ck. & Hatchery	58 cases	CN	CN		CN	CN		CN		CN
23	Robertson Creek										SK
23	Robertson Creek Hatchery	100	(No HEN in CN)								
23	Somass R.	1									SK
23	Sproat Lake (at fishway)	2,714	(No HEN in SK)								
23	Sproat Lake (at fishway)	102	CO							CO	
23	Sproat Lake and River						SK				SK
23	Sproat Lake and River			CN			CN				
23	Stamp River			RT							
23	Thornton Creek Hatchery	7 cases	CM								
23	Thornton Creek Hatchery	8 cases	CO								CO
23	Thornton Creek Hatchery	2 cases	CN								CN
23	Tofino										CO
24	Kennedy Lake (Clayoquot)									SK	
24	Kennedy Lake (Main)									SK	
24	Kennedy Lake (south end)						SK				
25	Canton Creek	27									CO
25	Conuma Foreshore	11									CN
25	Conuma R., Tlupana Hatch.	257	CM								CM
25	Conuma R., Tlupana Hatch.	1								SK	
25	Conuma R., Tlupana Hatch.	39	CN								CN
25	Conuma R., Tlupana Hatch.	36	(No HEN in CO)								
25	Conuma R., Tlupana Hatch.	120									
25	Conuma R., Tlupana Hatch.	77	(No HEN in CM)								
25	Conuma R., Tlupana Hatch.	43	CO								
25	Gold R.										RT
25	Sucwoa River	24	CO								
25	Tahsis General Area	5	CT								
25	Tahsis General Area	1									
25	Tahsis General Area	30	CO								
25	Tahsis General Area	15	CM								
27	Marble R.				CO						
27	Marble R.			CN							
27	Off Cape Scott	1									
27	Spring Island Area	1									

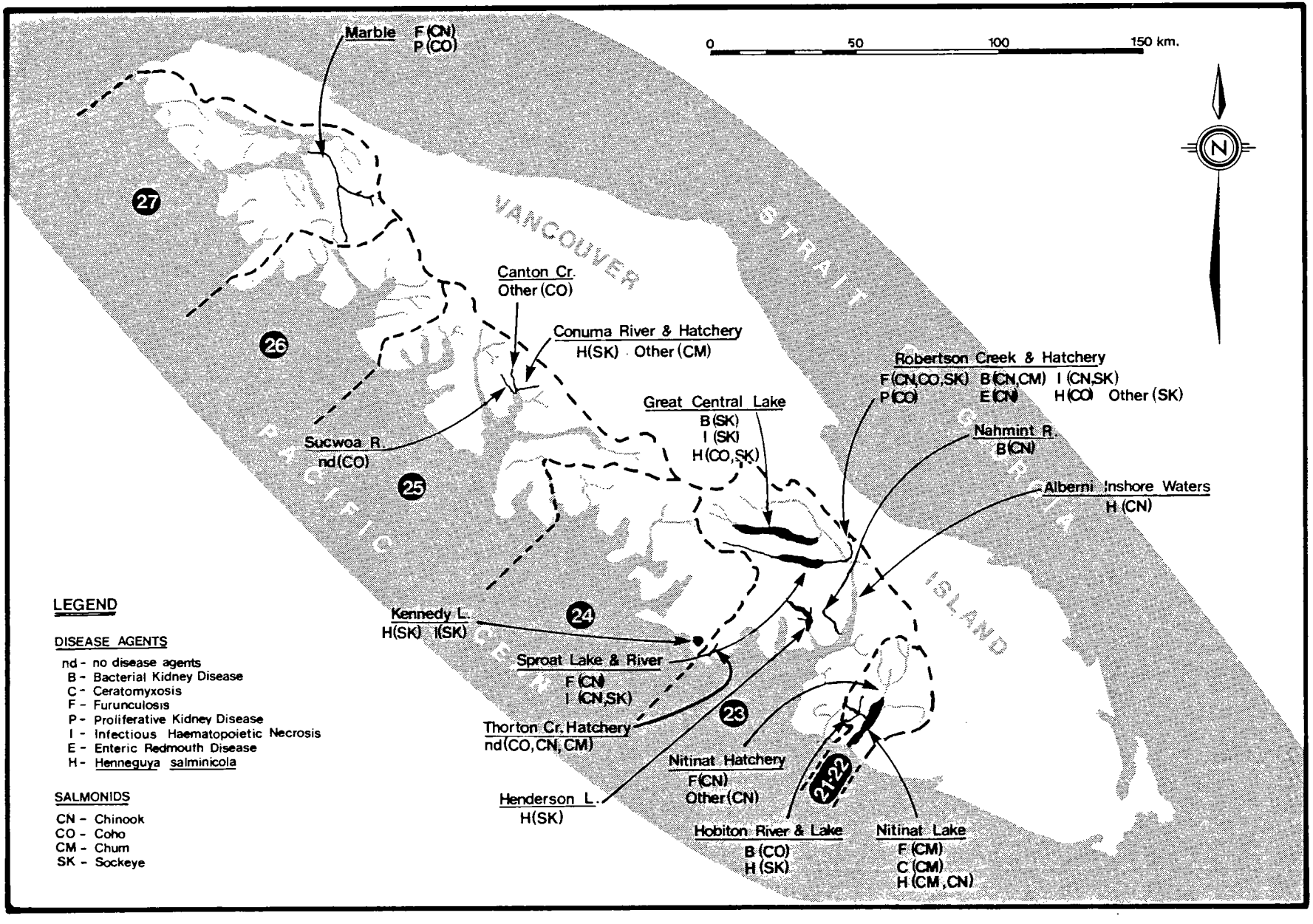

Figure III-1. Distribution of salmonid disease agents and parasites on West Coast Vancouver Island.

Kennedy Lake is the only system in Area 24 which has been sampled for salmonid disease agents or parasites. Henneguya cysts were found in sockeye samples in 1979 and 1980.

At the head of Tlupana Inlet in Nootka Sound, the Conuma River hatchery has had Henneguya cysts in sockeye. No Henneguya cysts were found in samples of 36 coho and 77 chum in 1981, and no disease agents or parasites were found in chinook at the Conuma hatchery or in coho from the nearby Sucwoa River and Canton Creek.

In the Marble River system (Area 27), agents were found for furunculosis in chinook and proliferative kidney disease in coho. No fish health surveys have been undertaken in Area 26.

REFERENCES

1. McDougal, R.D. and Associates. 1986. Distribution of important salmonid disease agents and parasites in the Queen Charlotte Islands. Prep. under contract for DFO in consultation with Fish Health and Diagnostics Section, Pacific Biol. Sta., Nanaimo, B.C.

2. DFO. 1985. Fish health data base. Updated September 1985. Can. Dep. Fisheries and Oceans, Vancouver, B.C.

3. Boyce, N.P., Z. Kabata and L. Margolis. 1985. Investigations of the distribution, detection, and biology of Henneguya salmonicola (Protozoa, Myxozoa), a parasite of the flesh of Pacific salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1405: 55 p.