History and Status of Pacific Salmon in British Columbia

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Henderson, M.A., and C.C. Graham. History and current status of Pacific salmon in British Columbia. N. Pac. Anadr. Fish Comm. Bull. No. 1: 13-22

Pacific salmon colonized the west coast of Canada following the last ice age (Groot and Margolis 1991) and are now found throughout British Columbia. British Columbia salmon have been harvested by members of the aboriginal community for several thousand years (Kew and Griggs 1991). More recently however, particularly over the last 125 years, salmon have also become the focus of intense commercial and recreational fisheries (Shephard et al. 1985). This paper reviews the history and status of the five major species of Pacific salmon in this century, and provides a brief summary of the major factors currently thought to affect the status of each stock.

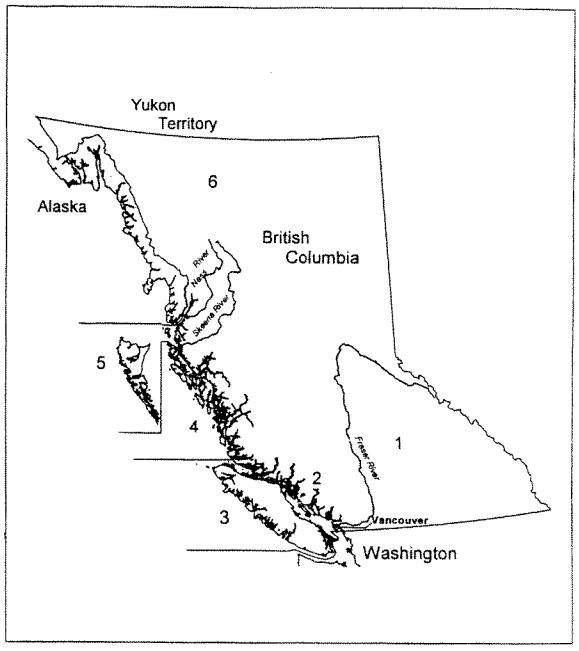
INTRODUCTION

The purpose of this paper is to provide a summary of the history and current status of salmon in British Columbia. More specifically, we provide a description of the general distribution of sockeye *(Oncorhynchus nerka),* pink (O. *gorbuscha),* chum (O. *keta),* coho (O. *kisutch),* and chinook salmon (O. *tshawytscha)* in British Columbia, describe historical trends in catch and spawning escapement, and summarize the current status of each species. We also identify those factors that have contributed the most to the current status of the species, and provide an overview of the contribution of the Pacific salmon catch in British Columbia to total Pacific Rim production.

Distribution Of Pacific Salmon Production Systems In British Columbia

Populations of all five species of Pacific salmon considered in this paper can be found throughout the Province of British Columbia, which is 623,000 square kilometers in size and has 2,700 km of coastline. There are approximately 10,000 unique salmon spawning locations in the Province. Although found throughout British Columbia, the relative magnitude of production of each species varies by location along the coast. Generally, the coast of British Columbia can be separated into six production zones; northern British Columbia, north coast, central coast, west coast of Vancouver Island, south coast and the Fraser River (Fig. 1).

Fig. 1. Major Pacific salmon production zones in British Columbia (1-Fraser River; 2-South Coast; 3-west coast of Vancouver Island; 4-central coast; 5-north coast; 6-northern British Columbia and the Yukon Territory).



The total annual return of salmon to the coast of British Columbia is dominated by production originating from the Fraser River and the Skeena River, the two largest river systems on the coast of British Columbia. The Fraser River alone accounts, on average, for over 50% of all British Columbia salmon production and has been described as the

largest single salmon production system in the world (Northcote and Larkin 1989).

Sockeye

Sockeye is the second most abundant species of salmon in British Columbia and is composed of about 900 unique stocks. The distribution of spawning stocks is the consequence of the unique specialization of the species. Sockeye salmon usually spawn in areas associated with lakes, where the juveniles rear before they migrate to sea. Although sockeye production occurs throughout the coast, over 80% of sockeye production comes from two primary systems, the Fraser and Skeena rivers, and four secondary systems, the Nass River on the north coast, Rivers Inlet, and Smith Inlet on the central coast, and Barkley Sound on Vancouver Island. Spawning locations are located throughout the watershed of most large river systems

The Fraser River is the largest sockeye production system in British Columbia and usually accounts for over half the total production of this species. The major sockeye stock complexes in the Fraser River include early and late Stuart, Chilko, Adams, Horsefly, Quesnel, Fraser, Bowron, Harrison, and Weaver. In addition, there at least 80 smaller sockeye production systems ranging in size from several tens of thousands of spawners to a few hundred. Returns of sockeye to several of the major systems on the Fraser are characterized by a distinct four year cycle. In general, there is one year with very high production followed by a year with intermediate production followed in turn by two years of very low production. This cyclic pattern in abundance accounts in a large part for the fluctuations in catch and spawning escapement. In excess of 95% of the sockeye returning to the Fraser River are four years of age. In contrast, other major production systems consist on average of approximately even numbers of four and five year old fish.

The Skeena River system is the second largest sockeye production system in British Columbia. Babine Lake and its tributary streams and lakes are the major production area. The sockeye spawning areas have been supplemented by spawning channels at Fulton River and Pinkut Creek.

Pink

Pink salmon is numerically the most abundant salmon species in British Columbia and consists of about 2200 unique stocks. Pink salmon are distinguished form other Pacific salmon by having a fixed, two-year life span. This has resulted in the development of even and odd year stocks that are reproductively isolated and developed into genetically different lines. In some systems like the Fraser River, only the odd-year line exists in fishable numbers. In other river systems, both even and odd-year lines exist.

Pink salmon production is more dispersed along the coast of British Columbia than is observed in sockeye salmon. Returns to the Fraser and Skeena rivers constitute a significant part of the total annual return but there are other production areas of equal importance. Foremost among these are the central coast and the southwest mainland of British Columbia (excluding the Fraser River) where there are over 600 pink salmon spawning locations. In all areas, pink salmon spawning locations are usually concentrated in the lower portions of watersheds, particularly in the larger river systems.

Chum

Chum salmon have the widest geographic distribution of all Pacific salmon species. They spawn in streams of various sizes. Spawning locations for most chum stocks are in the lower areas of river systems and fry migrate directly to the sea soon after emergence.

There are approximately 1600 chum stocks in British Columbia. These stocks are widely dispersed with major production areas in the Nass River, the central coast, the Fraser River and the east and west coasts of Vancouver Island. A large component of the total chum production, particularly in southern British Columbia, derives from enhanced stocks. Most chum stocks can be identified as either summer or fall runs. The former dominate in northern British Columbia while the latter are more common in southern British Columbia.

Chinook

Chinook salmon originate from approximately 850 stocks in a geographically and physically diverse array of river systems throughout the coast of British Columbia. Unlike pink, chum and coho salmon where production is concentrated in small rivers or the lower portions of larger rivers, chinook spawning stocks can be found from the mouths through to the headwaters of large river systems. Particularly important production areas include the Fraser and Skeena rivers, the east and west coasts of Vancouver Island, and the central coast. The Harrison River chinook stock, located in the lower portion of the Fraser River is the largest single chinook stock in British Columbia and possibly the world.

Coho

Coho salmon are widely dispersed throughout British Columbia and make up about 2600 unique

stocks. In most areas, coho occur in small numbers compared to other species of Pacific salmon. In the larger river systems, including the Fraser, Skeena, Bella-Coola, Nass, and Taku rivers, they migrate some distance inland to spawn in smaller tributaries. Significant production also occurs in individual river systems in the Queen Charlotte Islands, the north and central coast, and both the east and west coasts of Vancouver Island.

HISTORICAL TRENDS IN SALMON PRODUCTION IN BRITISH COLUMBIA

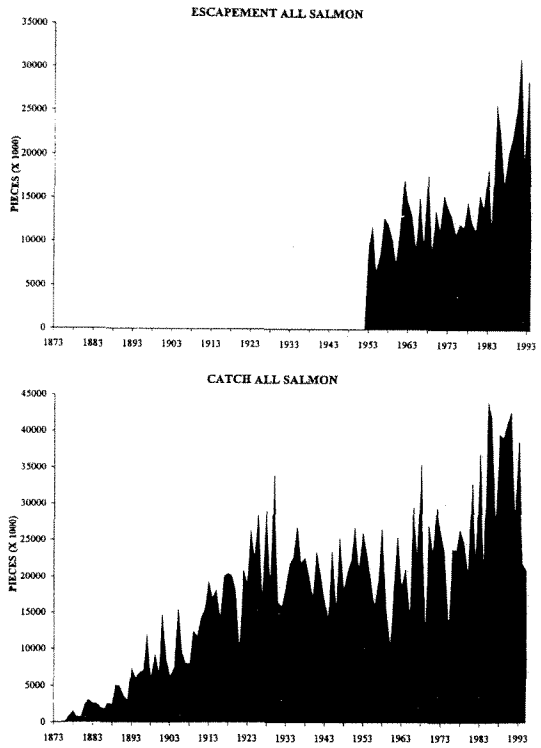
Inferences can be made about historical trends in British Columbia salmon production from catch and spawning escapement data sets. The catch data set provides estimates of the total annual British Columbia salmon catch by species from 1873 to the present. Estimates of catch from 1873 to 1950 are taken from Shepard et al. (1985). More recent catch estimates come from the catch monitoring program of the Canadian Department of Fisheries and Oceans (CDFO). Catch estimates provide an index of salmon abundance (Beamish and Bouillon 1993) from which one can discern periods of major change in fish production.

The spawning escapement data set provides estimates of total annual salmon spawning escapement by species from 1951 to the present and were obtained from the salmon escapement data base of CDFO. There are no reliable estimates of coast-wide spawning escapement or total production (i.e. catch plus escapement) prior to 1951. Catch and spawning escapement data sets, when examined together, provide more complete and detailed information on the status of the species than can be inferred from a catch time series alone.

All Species

The large scale harvest of salmon in British Columbia commenced with the introduction of commercial fish canning operations in the latter part of the 1860s. The all species salmon catch increased discontinuously from that time, peaking in the late 1920s and early 1930s with catches in the range of approximately 25 to 30 million pieces (Fig. 2). Catch subsequently declined to relatively low levels in the 1950s and 1960s. The all species salmon catch has shown a discontinuous increase from the early 1970s through 1995 with the catches in the late 1980s and early 1990s exceeding 40 million fish, greater than the historical high levels observed in the earlier part of the century. The higher levels of catch observed in recent years are the result of increases in spawning escapement and improved marine survival conditions.

Fig. 2. Total annual catch (1873 to 1995) and spawning escapement (1951 to 1994) for all species (sockeye, pink, chum, coho, chinook) of British Columbia salmon.



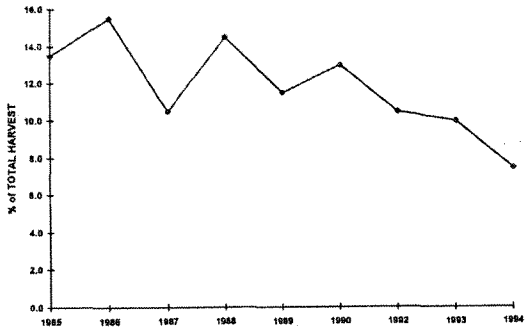
The overall trend in salmon catch throughout the time series is determined primarily by pink and sockeye, the two most abundant salmon species in British Columbia. Despite the increase in recent time, the contribution of British Columbia Pacific salmon production to total Pacific Rim production has declined from approximately 14% in the mid 1980s to 8% in 1994 (Fig. 3). The decline reflects, in part, the rapid increase in wild sockeye and hatchery chum production in Alaska and Japan respectively, and the increasing importance of farmed chinook and coho salmon, particularly in Chile.

The combined spawning escapement of all species of Pacific salmon increased gradually from the early 1950s through the late 1970s. Over the last 1½ decades, escapement levels have increased more rapidly reflecting, in part, an intentional effort to increase the size of many salmon stocks in British Columbia by increasing the number of fish on the spawning grounds. The recent estimates of all species salmon escapement have surpassed 35 million fish.

Sockeye Salmon

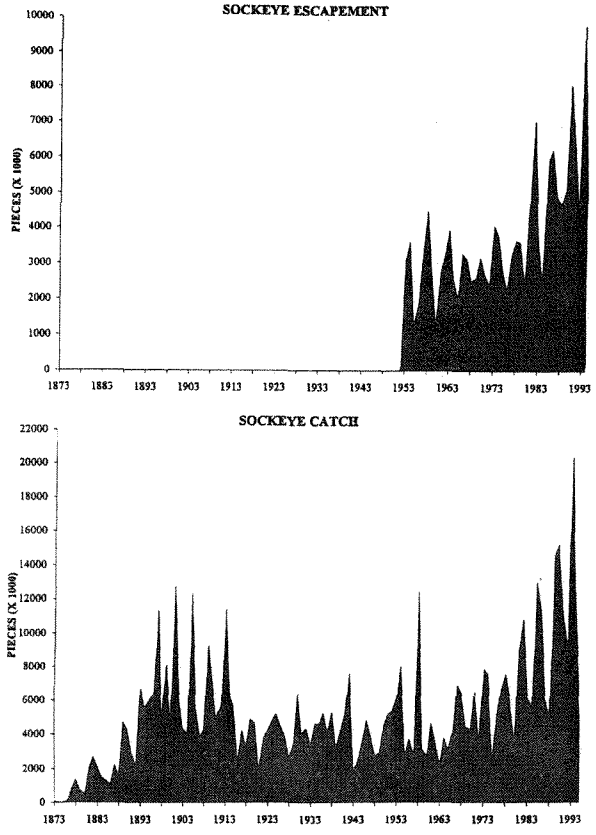
On average, 60% of the total catch originates from the Fraser River. Several of the larger Fraser River sockeye stocks exhibit a distinct four year cycle

Fig. 3. Percent of the total world Pacific salmon production (wild and farmed) contributed by British Columbia from 1985 to 1994.



in abundance; a dominant year with very large returns, followed by a sub-dominant year with approximately half the production observed in the dominant year, followed in turn by two years of low returns. This cyclic pattern in abundance for some of the large Fraser River sockeye stocks accounts, in large part, for the regular fluctuations in catch and spawning escapement (Fig. 4).

Fig. 4. Total annual catch (1873 to 1995) and spawning escapement (1951 to 1994) of British Columbia sockeye salmon.



Sockeye salmon was the initial focus of thecommercial canning industry in British Columbia. Sockeye catches increased rapidly in the late 19th century and the early part of the 20th century. Peak catches during this period were approximately 10 to 12 million fish. There was a precipitous decline in the coast-wide sockeye catch beginning in 1917 to levels of four to five million fish. The reduction in catch was the result of a rock slide in the Hell's Gate area of the lower Fraser River. The slide blocked much of the cross-section of the river and, as a consequence, few sockeye were able to reach their spawning grounds in 1913 and 1914. Passage conditions were dramatically improved following the removal of the obstruction caused by the rock slide and the construction of fishways. However it required several decades to rebuild Fraser River sockeye spawning stocks to their former level.

Catches of British Columbia sockeye salmon remained low through the late 1960s. They began to increase in an exponential fashion beginning in the early 1970s through to the present. Recent catches have been greater than those of the previous peak at the turn of the century with one total annual catch in excess of 20 million fish. The recent increase in the sockeye catch can be attributed to a deliberate attempt to increase the number of fish reaching the spawning grounds, particularly in the Fraser River, in conjunction with the above average marine survival in the 1980s. The increase in sockeye catches was also aided by the development of spawning channels in the Skeena River in the mid 1960s which increased adult returns nearly four-fold (West and Mason 1987).

Coast-wide sockeye spawning escapement has followed a similar trend to that exhibited by catch since 1951 (Fig. 4). Escapements for the period from the mid 1950s through the late 1970s were generally between three and four million fish. More recently however, annual spawning escapement has risen rapidly to levels exceeding 10 million fish.

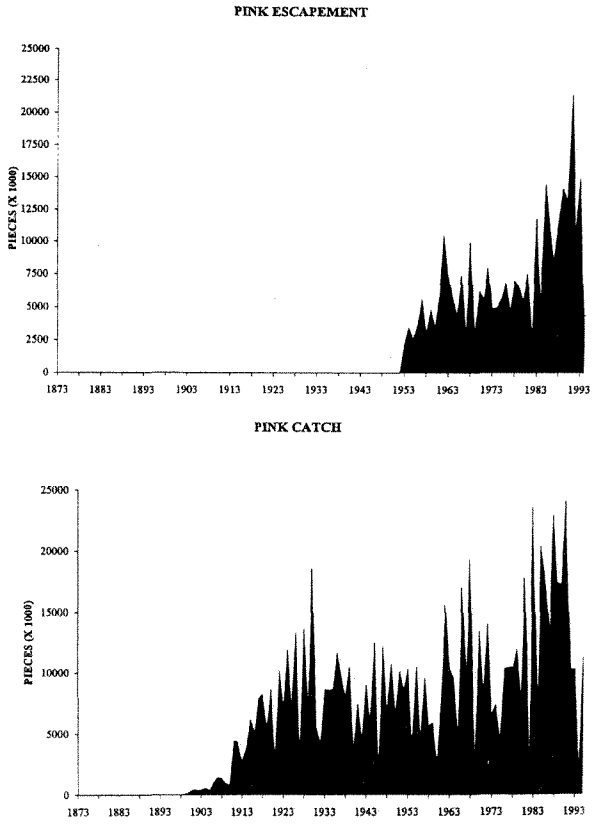
The high levels of sockeye production are the result of efforts to increase spawning escapement to major stocks over the last 30 years combined with a period of high marine survival, particularly in the 1980s. Marine survival appeared to decline in the early 1990s but subsequently increased for the dominate brood years of the 1996 adult returns (1991 and 1992). Alterations to the freshwater habitat of sockeye have been relatively minor and had little effect on sockeye production.

Pink Salmon

Pink is numerically the most abundant salmon species in British Columbia. Large pink salmon fisheries developed two to three decades after the advent of major sockeye fisheries with the first

significant catches occurring in the early part of the 20th century (Fig. 5). The Fraser River is a major contributor to total British Columbia pink salmon production, although to a lesser extent than is the case for sockeye. Fraser River pink production is dominated by a unique "on - off" cycle with large numbers of fish, sometimes in excess of 20 million, returning in odd numbered years and very small numbers, usually a few thousand fish, returning in even numbered years. This feature of the Fraser River pink salmon returns is reflected in the highly discontinuous nature of the total British Columbia catch and spawning escapement time series (Fig. 5).

Fig. 5. Total annual catch (1873 to 1995) and spawning escapement (1951 to 1994) of British Columbia pink salmon.



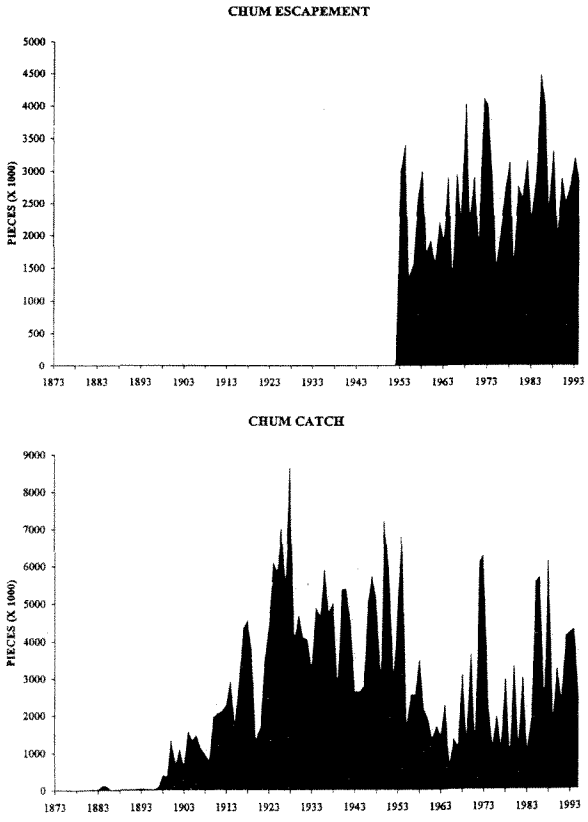
British Columbia pink salmon catch increased rapidly in the early part of the 20th century, reaching a peak of approximately 19 million fish in 1929. The Hell's Gate slide on the Fraser River, referred to above, had less effect on pink returns and catch as much of the pink production from this system originates from the lower river below the location of the slide. British Columbia pink salmon catches declined to lower levels in the 1930s through the 1950s and then subsequently increased through the late 1980s when catches exceeded 20 million fish. The catches of pink salmon have declined in the early 1990s.

Annual pink salmon spawning escapement gradually increased from the early 1950s through the late 1970s and averaged approximately six million fish. Escapements increased rapidly beginning in the early 1980s and peaked in 1991 at over 20 million fish. The relationship between the spawning escapement of pink salmon and subsequent adult returns from the brood year are much more ephemeral than observed in other salmon species. Variations in the rate of marine survival are likely the primary determinate of total pink salmon returns. The significant effect of periodic winter flood conditions in freshwater systems also serves to obscure the relationship between the number of spawners and subsequent returns.

Chum Salmon

Chum salmon is the least abundant of the three salmon species (i.e. sockeye, pink, and chum) of primary interest to the commercial fishing industry in British Columbia. The total catch of chum salmon in British Columbia increased for the early part of the present century through the mid 1920s when the catch peaked in excess of eight million fish (Fig. 6).

Fig. 6. Total annual catch (1873 to 1995)'and spawning escapement (1951 to 1994) of British Columbia chum salmon.



Annual catches then declined discontinuously through the early 1960s to levels generally in the range of one to two million fish. There was no trend in annual catches, although there was significant interannual variation, from the mid 1960s to the mid 1980s. Over the last decade, catches have again increased and have ranged from two to six million fish.

Estimates of total spawning escapement of British Columbia chum salmon have increased slowly and discontinuously since the early 1950s. Typical levels of spawning escapement in recent years are in the range of 2.5 to 3 million fish compared to estimates from the 1950s and 1960 which generally ranged from 1.5 to 2.5 million fish. The decline in chum salmon catches through the 1950s and 1960s was probably the result of excessive harvest and poor marine survival while the more recent improvement can be attributed to the reversal of these two conditions.

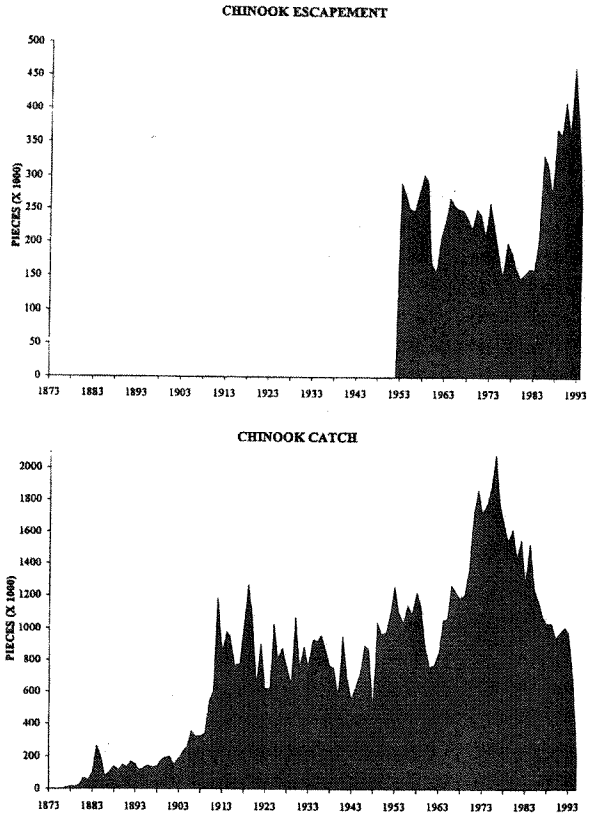
Chinook Salmon

Chinook is the least abundant of the five British Columbia salmon species considered in this paper. During the early part of its exploitation history, chinook salmon was primarily the target of commercial fisheries as was the case for pink, sockeye and chum salmon. However, over the last several decades, an increasingly significant component of the total annual catch has been taken by recreational fishers.

The catch of chinook salmon in British Columbia increased rapidly from the late 19th century through the early part of the 20th century peaking at approximately 1.2 million fish in the early 1920s (Fig. 7). Total annual catches from the mid 1920s to the mid 1960s were relatively stable and generally ranged from 700,000 to 1.3 million. Catches of chinook salmon again increased rapidly from the mid 1960s through the late 1970s and exceeded two million fish in one year. This second period of rapidly increasing chinook catch was primarily the result of an expanding recreational fishery, particularly in southern British Columbia. The annual chinook catch declined discontinuously from the peak catches of the late 1970s to present levels of approximately one million fish.

Estimates of the level of chinook salmon spawning escapement declined from the early 1950s through the mid 1980s, overlapping the period of time when catches were increasing rapidly. The harvest rate exerted on some chinook stocks during this time was too high and lead to a subsequent decline in overall chinook production. Beginning in 1985, a salmon treaty between Canada and the United States

Fig. 7. Total annual catch (1873 to 1995) and spawning escapement (1951 to 1994) of British Columbia chinook salmon.



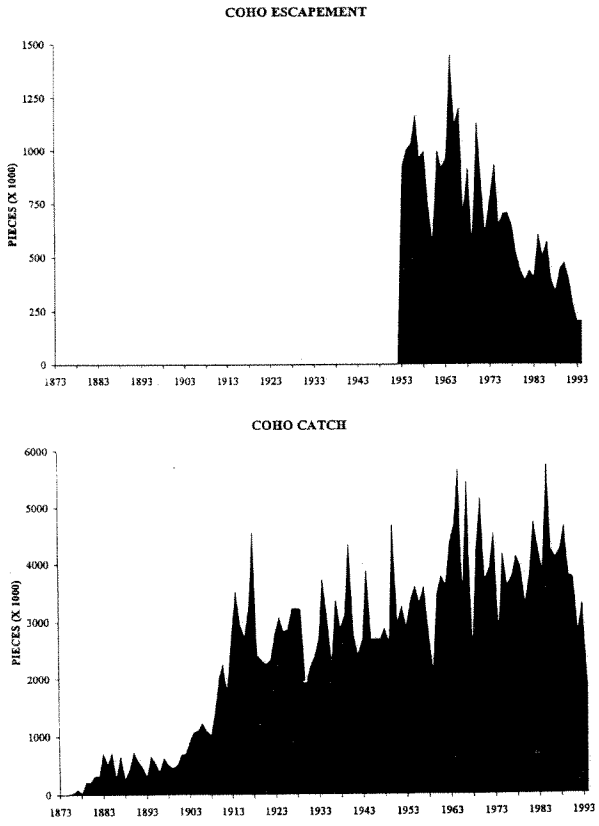
took effect and dealt, in part, with the management and rebuilding of North American chinook stocks. One aspect of the treaty placed reduced limits on the harvest of chinook in different locations along the coast. As a consequence of the treaty, and as a result of management actions in Canada, estimates of annual spawning escapement of chinook salmon have increased from pre-treaty levels of 150,000 to 200,000 to close to 500,000 in recent times. The increase in spawning escapement is resulting in an increase in total chinook abundance in British Columbia.

Coho Salmon

The abundance of coho salmon in British Columbia is much less than observed for pink and sockeye but similar to the abundance of chum. Coho salmon, like chinook, has changed from a species that was primarily harvested by commercial fishers to one where a major component of the total annual harvest is taken by recreational fishers.

Coho catches increased rapidly from the latter part of the 19th century through the early part of the 20th century and peaked at a level in excess of four million fish in 1916 (Fig. 8). There was an abrupt

Fig. 8. Total annual catch (1873 to 1996) and spawning escapement (1951 to 1994) or British Columbia coho salmon.



decline in coho catch over the next few years and then a gradual, discontinuous increase in coho harvest through the mid 1960s when the total catch exceeded five million fish. The annual catch from the mid 1960s through the mid-1980s was relatively stable and generally fluctuated between three and five million fish. Over the last decade however, the total coho salmon catch has declined steadily to levels in some years of less than three million fish.

Estimates of the spawning escapement of coho salmon in British Columbia should be treated as indices of escapement rather than absolute estimates. Coho are the last of the five species of salmon to enter rivers and spawn in British Columbia. Often early winter weather conditions, freshets, and ice formation in rivers precludes obtaining complete estimates of the number of spawners.

Although there were wide fluctuations, estimates of coho spawning escapement were relatively stable between the mid 1950s and the mid 1960s (Fig. 8). However, estimates of spawning escapement declined discontinuously but rapidly from in excess of one million fish in the mid 1960s to 200,000 to 300,000 in recent years. The appearance of a relatively stable catch from the mid 1960s through mid 1980s in the presence of declining spawning escapement indicates that the status of British Columbia coho salmon has been declining in recent time.

Factors leading to the decline in coho abundance over the last thirty years are numerous and complex. Of greatest concern is the alteration of freshwater spawning and rearing habitat. Most coho production in British Columbia originates from small, low gradient river systems. Many of these systems, particularly in southern British Columbia, have been impacted by the process of urbanization and include the effects of channelization, installation of culverts, siltation, and various agricultural and forestry practices that reduce the quality of the freshwater aquatic environment. Further, because coho production originates from a large number of small systems, most fisheries are of a mixed stock nature which tends to over-harvest the less productive stocks. This, combined with the rapid development of the recreational fishery in southern British Columbia in the last thirty years, has resulted in excessive harvest for some stocks. Finally, recent changes in the ocean environment, and particularly in the Strait of Georgia, have resulted in a reduction in marine survival.

CURRENT STATUS OF SALMON SPECIES IN BRITISH COLUMBIA

The above summary of historical trends in salmon catch and escapement provides temporal information on a decadal scale. More current information on species status however is available from assessment work produced over the last five years. Inferences regarding current status are presented first on a coast-wide basis. This is followed by comments on individual stocks or stock groups that exhibit exceptions to the current coast-wide trend. Also identified is the major factor accounting for the current status of a species. All three major factors, marine environment, freshwater environment, and spawning escapement effect total production but in most cases one of these is dominant.

Sockeye Salmon

The current coast-wide status of sockeye salmon is good with catch and spawning escapement stable to increasing and at historical highs (Table 1). The primary causative factor underlying this good sockeye production is a high level of spawning escapement in recent years. Contributing factors include the recent return to favourable marine survival conditions, and maintenance of critical freshwater habitat. Marine survival of sockeye was very high in the 1980s but declined in the early 1990s. Adult sockeye returns were significantly above forecast in 1996 and apparently associated with a return to above average

Table 1. Summary of the current status of salmon species in British Columbia and the major factors effecting current status.

		Major Factors Effecting Current Species Status		
	Status (Trend/Spawning Escapement)	Marine Environment	Freshwater Environment	Spawning Escapement
Sockeye	Stable to Increasing/High			X
Pink	Stable to Increasing/High	X		
Chum	Stable/Medium	X		
Chinook	Increasing/Low-Medium			X
Coho	Decreasing/Medium-Low	X	X	

marine survival. Most of the freshwater habitat concerns for British Columbia sockeye have been mitigated by the remote location of spawning and rearing areas utilized by juvenile sockeye, and the introduction of strict forestry practices designed to protect fish habitat.

Although the coast-wide status of sockeye salmon is good with both catch and spawning escapement at historical highs, there remains some areas of concern. The large, productive stocks in the Fraser and Skeena rivers have responded rapidly to increases in spawning escapement over the last several decades. This is not the situation however for some of the small, less productive stocks. Sockeye stocks from major river systems, such as the Fraser and Skeena, tend to co-migrate through fishing areas in the coastal waters of British Columbia on their return to the spawning grounds as adults. In the past, harvest rates have been set at levels appropriate for the larger, more productive stocks. As a consequence, some of the less productive stocks have been over-harvested and spawning escapement has remained low. We have also observed the continuation of a long-term trend toward less then expected production from three of the secondary sockeye production systems in British Columbia; Rivers Inlet and Smith Inlet on the central coast, and Barkley Sound on the west coast of Vancouver Island. In each case the stocks have not responded to significant increases in spawning escapement and there are no apparent problems associated with freshwater survival conditions or by-catch in fisheries that do not targets these stocks.

Pink Salmon

The current coast-wide status of pink salmon is good (Table 1). Both catch and spawning escapement have been high through most of the 1990s although total production has declined somewhat over the last two years. The cause of the decline is not the result of a reduction in spawning escapement that produced adult returns over the last two years but is probably associated with a decrease in marine survival of juvenile pink salmon. In general, freshwater habitat required by pink salmon is in good condition.

Pink salmon are continuing to recolonize those areas of the Fraser River above Hells Gate where stocks were eliminated or severely reduced in size as a result of the rock slide in 1913 (Ricker 1989). This is, in part, a result of the decline in the number of fisheries that harvest Fraser River pink salmon as a by-catch and an overall reduction in the harvest rate on these stocks groups. Pink salmon originating from the central coast of British Columbia and the west coast of Vancouver Island however continue to produce at less than expected levels. In both cases, a decline in spawning escapement appears to be the primary cause although the reason for the decline is unknown.

Chum Salmon

The total abundance and spawning escapement of British Columbia chum salmon is stable (Table 1) at the present time but less than observed during the earlier part of the century.

Chinook

From a coast-wide perspective, chinook salmon are rebuilding from the very low levels observed in the mid-1980s. Total returns continue to gradually increase and the level of spawning escapement in many stocks is also increasing from low levels, in part as the result of major reductions in catch (Table 1). An increase in spawning escapement is the primary causative factor contributing to the current status of the species.

There remains concern however for several chinook stock complexes, particularly in southern British Columbia. The El Niño events off the west coast of Vancouver Island in 1992 and 1993 resulted in very high mortality on juvenile chinook from approximately 30 stocks that would return as adults in

1995, 1996, and 1997. Although fishing effort on west coast of Vancouver Island stocks has been dramatically reduced in recent years as a result, in some cases almost to zero, spawning escapement remains low and rebuilding these stocks will require several years. The returns for most chinook stocks on the east side of Vancouver Island and the mainland of south western British Columbia are increasing although there are several notable and unexplained exceptions. Foremost among these are the recent low returns to the Campbell River and Harrison River stocks.

Alteration of the freshwater environment is a major concern for chinook production. Chinook generally spend 3 months to a year as juveniles in freshwater and as a result, habitat alteration in urban areas of southern British Columbia can potentially reduce the survival of juvenile chinook. Mitigating against this concern to some extent is the concentration of relatively large chinook stocks in the upper reaches, and less developed areas of some river systems.

Coho Salmon

The abundance of coho salmon in British Columbia continues to decline and the spawning escapement for most stocks is in the medium to low range (Table 1). Of greatest concern are several small coho stocks situated around the Strait of Georgia and the west coast of Vancouver Island in southern British Columbia. These are the stocks that, as described above, are most susceptible to the effects of urbanization.

CURRENT CHALLENGES IN THE ASSESSMENT AND MANAGEMENT OF BRITISH COLUMBIA SALMON

Ensuring the conservation and sustainable use of the Pacific salmon resource of British Columbia requires accurate and timely stock assessment information that incorporates the appropriate elements of uncertainty into the assessments. It also requires that fisheries managers understand the limitations and uncertainty associated with the stock assessment information and, based on that understanding, develop suitably risk averse fishing strategies.

Several changes made to the stock assessment process in recent years have improved the quality of assessment information. These include more accurate estimates of spawning escapement based on the use fences, and hydroacoustic and mark recapture studies, improvements in the quality control procedures for catch estimation, and the development of new stock identification techniques, particularly electrophoretic and DNA based, for apportioning catch to stock. These improvements combined with new analytical techniques allow for a greater degree of certainty in stock assessment information. However our incomplete understanding of the biological processes governing salmon production, particularly as they relate to the ocean environment, combined with the uncertainty in estimates of catch and escapement, imply that fisheries management decisions will always be made in the context of some degree of uncertainty. As a consequence, fishery managers must make explicit decisions about the level of risk they are willing to accept with regard to meeting their objectives (e.g. a spawning escapement target) in the context of developing fishing plans. Those responsible for performing stock assessments must ensure the estimates they generate contain an adequate description of the associated uncertainty.

Future fisheries management strategies must address the complex problem of mixed species and stock fisheries. Fishing regimes must be developed using a more precautionary approach to the pre-season design and in-season implementation so spawning escapement goals or harvest rate guidelines are achieved and not exceeded. Development of new fishery management regimes for salmon will include:

- the use of significant time and area closures to control harvest rates and reduce the potential impact of any single fishery to over-harvest the resource;
- reducing harvest rates in key interception fisheries where greater uncertainty exists regarding the run size and stock composition of the returns; and,
- encouraging development of species selective harvest techniques to reduce the impact of fisheries on non-target species that co-migrate with the target stocks.

Canada has also embarked on a significant program to reduce the harvesting capacity of the commercial fishing fleet in British Columbia in order to improve the management of the fishery and improve the economic returns to individual fishers.

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