FRASER RIVER PINK

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Prepared by

FRASER RIVER ACTION PLAN,

Fishery Management Group

Pêches et Océans Fisheries and Oceans Canada

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1. The Fraser River supports the largest pink salmon population in the northeast Pacific basin south of Alaska. Between 1981 and 1991, the total return of Fraser River pink salmon on the odd-year cycle has averaged around 17 million fish. Escapements since 1959 have ranged from approximately 1 to 13 million spawners.

2. The Hell's Gate landslide in 1913 blocked virtually all upriver migration of pink salmon and nearly decimated the upper Fraser River pink stocks. At certain flow conditions, the Fraser River canyon continues to impede the migrating stocks and this hinders stock rebuilding efforts.

3. Pink salmon juveniles emerge in the early spring and migrate immediately to the Fraser River estuary. The sub-adults rear for approximately one year in the ocean, migrating as far as the Gulf of Alaska. The 2-year old adults return via the Johnstone Strait or the Juan de Fuca Strait to spawn in the Fraser River .

4. The Fraser River pink salmon spawn in odd years, hence most of the total species production occurs on the odd year cycle. The even year abundance is insignificant and there are no directed fisheries on pinks in even years.

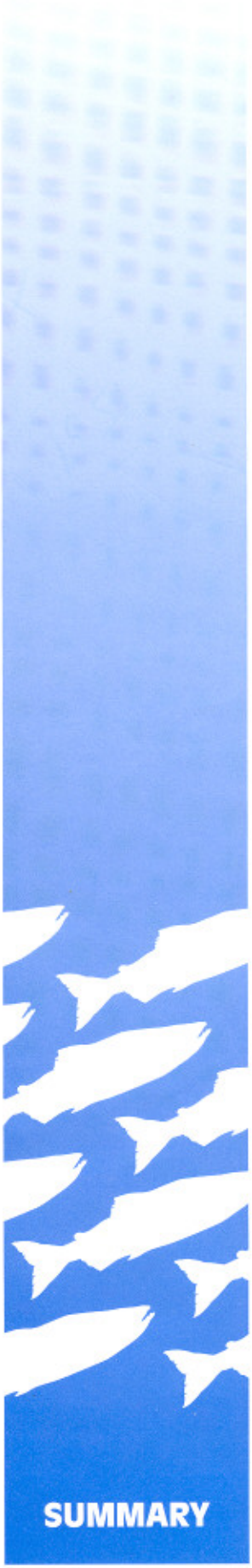
5. The Fraser River pink stocks are broadly categorized into early and late runs. The early run group comprises about 85% of the total return and includes mainly stocks from the lower Fraser River mainstem, the Thompson River and the Seton Creek areas. The late run stocks generally utilize the Fraser River tributaries below Hope, B.C., with the Harrison and Chilliwack rivers supporting the largest stocks in this group.

6. Fraser River pink stocks are harvested in the Canadian and U.S. commercial fisheries. Since 1985, the joint Canada-U.S. Fraser River Panel of the Pacific Salmon Commission has directed the fishery management strategies within the Panel waters for international conservation and equitable harvest sharing of the Fraser River pink stocks. The fishing plans are governed by escapement goals and allocation issues. The total escapement goal for the Fraser River pink salmon, as established by the Department of Fisheries and Oceans, has been set at 6 million spawners. Harvest management strategies are geared to achieve this goal by reducing exploitation rates.

7. During 1981 to 1993, the Fraser River pink salmon have contributed on the odd year cycle, an average of about 7 million and 2.5 million fish, respectively, to the total Canadian and U.S. fisheries. Presently, a major portion of the Canadian commercial catch is taken in the Johnstone Strait - Sabine Channel area. Significant catches are also taken in the North Coast, West Coast Vancouver Island, Juan de Fuca Strait, and Fraser River - Strait of Georgia fisheries. Catches of Fraser River pinks have been relatively minor in each of the Native and sport fisheries, generally below 100,000 fish on the odd year cycle.

8. Pink salmon enhancement in the Fraser River watershed is currently limited to four spawning channels (Upper and Lower Seton Creek, Weaver Creek and Jones Creek), as well as some hatchery production. Information from the Seton Creek spawning channels indicates a potential for rebuilding Fraser River pink stocks using the spawning channel enhancement technology.

9. The abundance of Fraser River pink salmon has increased in recent cycles. However, the maximum production capacity of the Fraser River system is presently unknown. Estimates of the Fraser River capacity to produce pink salmon have been based on stock-recruit and spawning capacity analysis. The stock-recruit analysis predicts an optimum escapement estimate of 7.6 million fish which translates to a maximum sustained catch of 9 million pieces and a total return of about 16.6 million adults. This analysis suggests that the optimum exploitation rate would be about 54%. A preliminary estimate of the spawning capacity, developed in 1959 by the International Pacific Salmon Fisheries Commission for the entire Fraser River watershed, ranged from a low of 3.1 million to a high of 7.5 million spawners. The wide range is due to the uncertainty in the estimates of available spawning area for the mainstem Fraser River stock group.



SUMMARY

1.0 OVERVIEW

The Fraser River supports the largest pink salmon run in British Columbia (Fig. 1), with an average of 17 million fish reported for the 1981-1991 odd year cycle (Fig. 2). Although information on the size of historical runs is limited, Fishery Officer reports indicate that in the early 1900s, millions of pink salmon had spawned in Seton Creek and the Thompson and Nicola rivers above Hell's Gate (Fig. 1). The size of total pink salmon runs prior to 1913 has been estimated at 28 million pinks (Fishery Officer reports). The Hell's Gate rockslide of 1913 drastically reduced the Fraser pink run by completely blocking access to upstream spawning areas. With the installation of the Hell's Gate fishway in 1946 to reopen the upstream fishing areas, construction of spawning channels at Seton Creek, and a reduction in exploitation rates, pink escapements to the Fraser system have increased substantially, with nearly 13 million reported in 1991 (Fig. 2).

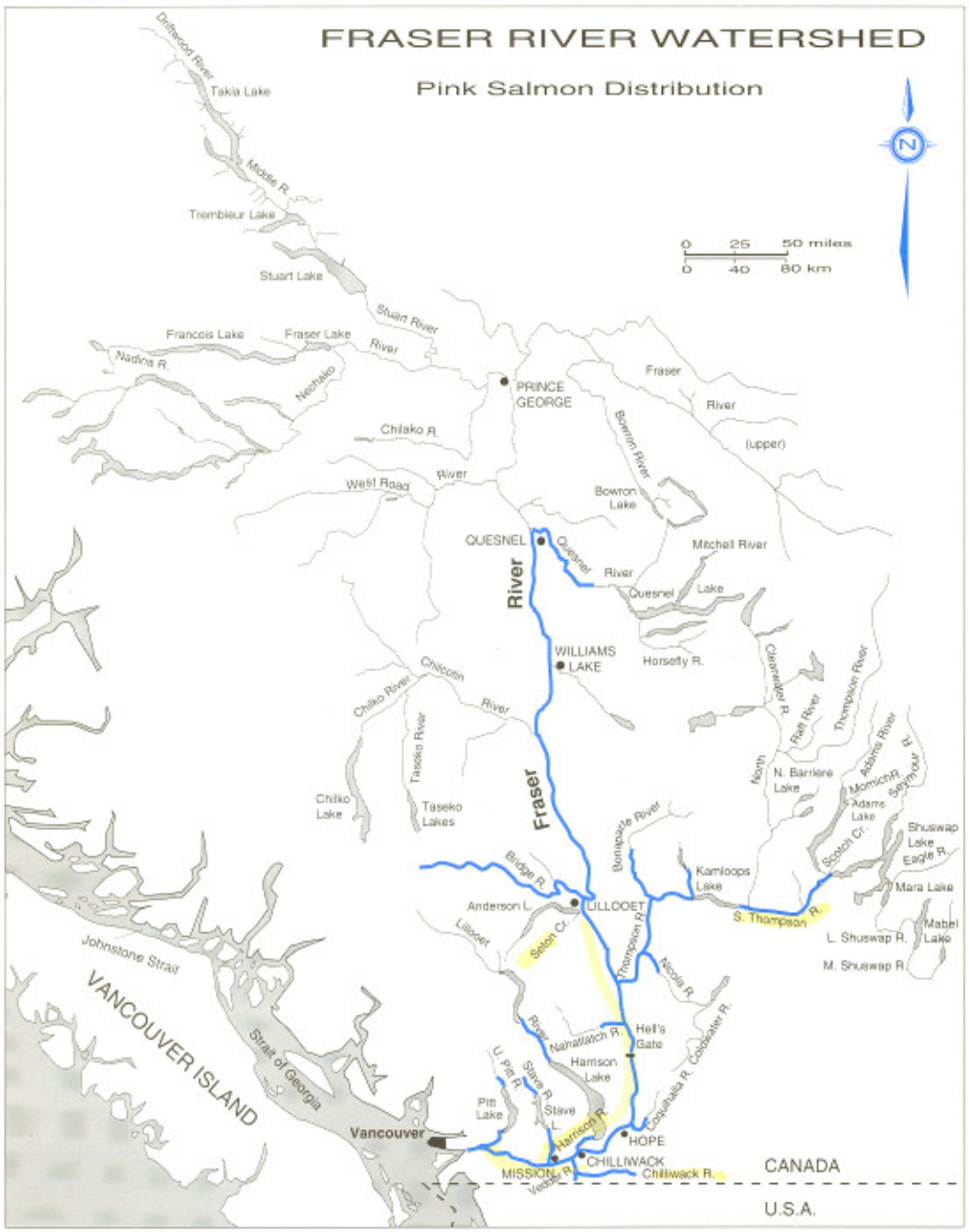


Fig. 1. Pink salmon spawning areas in the Fraser River watershed.

2.0 LIFE HISTORY

Fraser River pink salmon juveniles emerge in early spring and migrate immediately to the Fraser estuary, with peak downstream migration at Mission, B.C. observed during the last week of April. Upon reaching the estuary in May, the juveniles immediately enter salt water, then disperse to the southern areas of the Strait of Georgia (the Gulf and San Juan islands), and to some extent to the northern portions of the Strait of Georgia (Anon. 1962, Healey 1978). Pink juveniles rear in the Strait of Georgia until mid-summer, then migrate to the outer waters from July through September. Their migration range extends into the Gulf of Alaska where the fish mature. The sub-adult Fraser River pink salmon rear for approximately one year in the ocean before returning to spawn at age 2. Pink salmon returns in a given year originate from a single brood year. This is unlike other salmon species which return from various spawning (brood) years (generally ages 3 - 5). It is important to note, therefore, that a failure in the pink salmon escapement in one year cannot be compensated by other brood year returns.

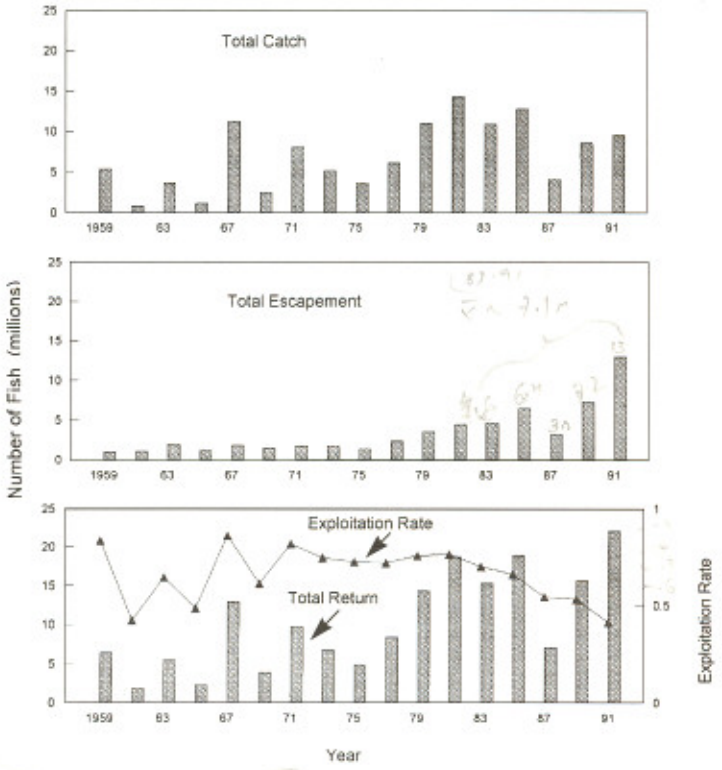


Fig. 2. Total Fraser River pink salmon catch, escapement, total return and exploitation rate (solid line) 1951-1991.

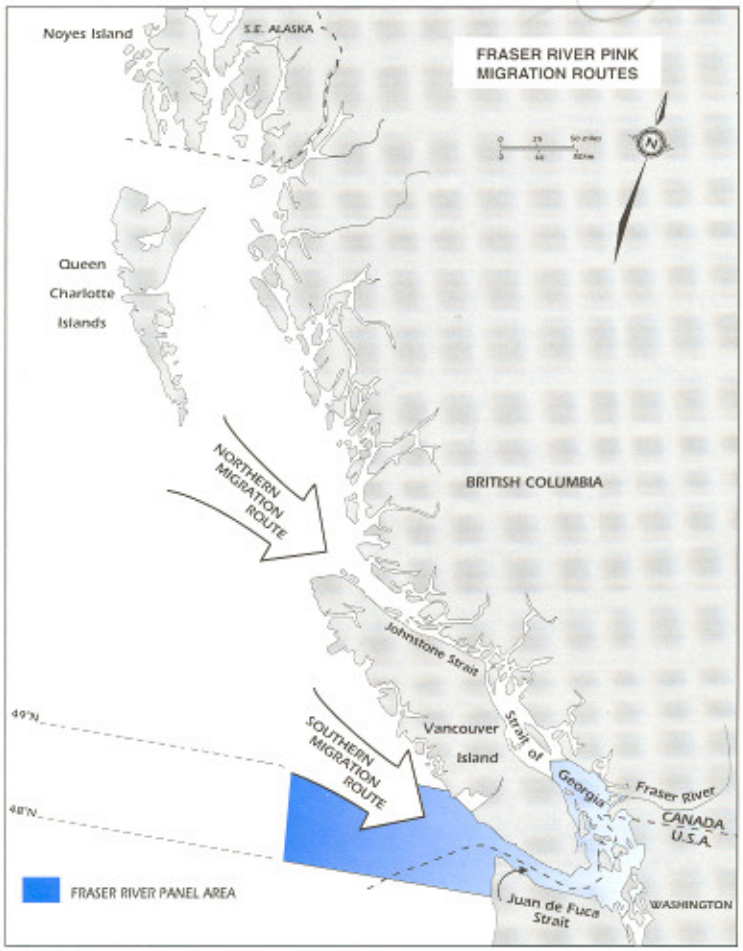


Fig. 3. Migration routes utilized by Fraser pink salmon - northern route (via Johnstone Strait) and southern route (via Juan de Fuca Strait).

LIFE HISTORY

The returning adults enter the Strait of Georgia via Johnstone or Juan de Fuca straits (Fig 3). Both the northern and southern approach routes are used but the diversion rate varies slightly on each return cycle. In most years after the mid-1970s, the return migration through Johnstone Strait has averaged about 32% but has reached occasionally up to 60%. The return timing into the Strait of Georgia is usually during August and late September, with peak abundance in the fishing areas from late August to mid-September. The Fraser River pink stocks are vulnerable to the southern B.C. and U.S. fisheries for a considerable length of time since the estimated travel time to the Fraser River estuary from Juan de Fuca Strait or upper Johstone Strait is approximately 7 and 15 days, respectively. The majority of Fraser River pink salmon return to their natal streams during September and October, with peak spawning occurring in October. Like other southern Strait of Georgia pink stocks, most of the Fraser River pink stocks spawn on the odd year cycle.

3.0 STOCK DESCRIPTION

Fraser River pink stocks are broadly categorized into early and late runs. In recent years (1981 - 1991) there were approximately 100 streams with observed pink salmon escapements in the Fraser watershed. This is an increase over the previous years (1969 - 1979) when approximately 50 streams were reported with pink salmon escapements. Tagging studies indicate that the migration timing of the early and late groups to the lower Fraser River is separated by only about 7-10 days, and that their average spawning timing differs by only about one week. The earlier run is the larger, comprising about 85% of the total return. This stock group includes mainly pink stocks from the lower Fraser mainstem, several Fraser Canyon tributaries, the Thompson River and Seton Creek (Fig. 1). The late run group generally includes stocks utilizing the lower Fraser River tributaries below Hope, B.C., with the Harrison and Chilliwack rivers supporting the largest pink stocks in the late run group. In addition to the above stocks, several minor stocks are scattered in the upper Fraser River watershed, as far north as the Quesnel River. The major stocks are described below.

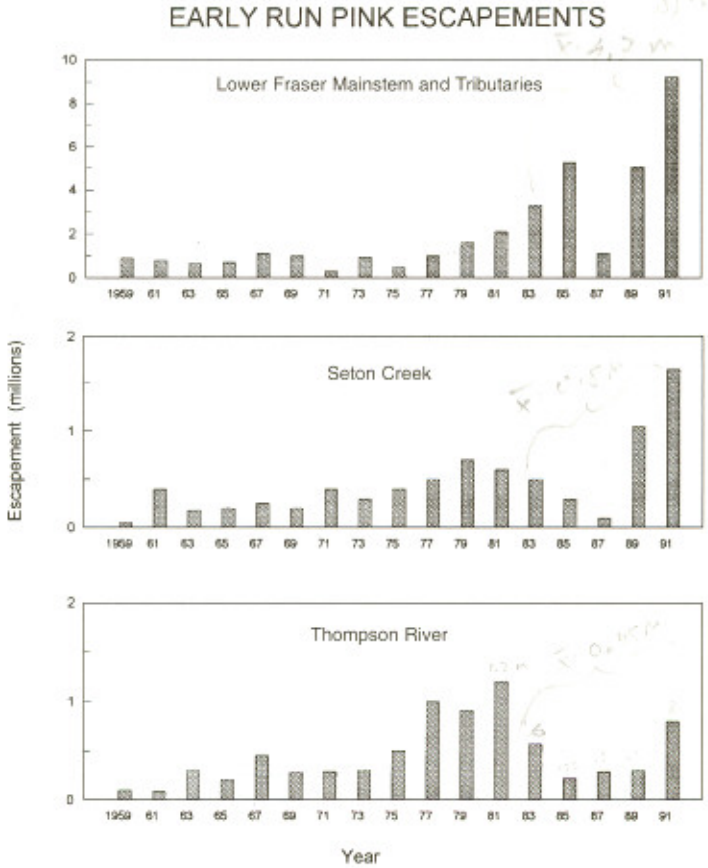


Fig. 4. Escapement estimates for the Fraser River early run pink stocks: lower Fraser mainstem and tributaries, Seton Creek, and Thompson River, 1959 - 1991.

3.1 EARLY FRASER RIVER PINK STOCK ASSEMBLAGE

Lower Fraser River Mainstem and Tributaries - Early

The lower Fraser mainstem and tributary stocks (Coquihalla, Chehalis, Nahatlatch, Jones Creek and miscellaneous

tributaries) comprise the largest pink salmon group in the Fraser River watershed. Estimated escapements of the Fraser River mainstem stocks have increased greatly in recent years (Fig. 4), with an average of 4.7 million spawners reported for the 1983-1991 period (7 million if the low 1987 return is disregarded), and a peak of 9.3 million in 1991. The average peak spawning timing for this stock group is October 8-16.

Seton Creek Stock Group - Early

The Seton Creek group includes stocks from the Seton, Gates and Portage creeks, as well as the Bridge River. Escapement estimates for this stock group have averaged around 0.8 million pink salmon for the 1983-1991 cycle years, with a peak of over 1.5 million reported in 1991 (Fig. 4). The low return in 1987 was likely due to the harsh winter conditions encountered during brood incubation. This stock group may have the potential to rebuild rapidly as indicated by the significant increases in the 1989 and 1991 escapements. The average peak spawning period for this stock group is October 7-18.

Thompson River Stock Group - Early

The Thompson River stock group is composed of several small stocks that spawn largely in the South Thompson River and its tributaries (Fig. 1). The escapement of this stock group has increased steadily to a maximum of 1.2 million in 1981, then declined sharply to below 0.4 million in the later 1980s, rebounding significantly in 1991 (Fig. 4). The peak spawning timing for this stock group is around October 10-18.

3.2 LATE FRASER RIVER PINK STOCK ASSEMBLAGE

The late run Fraser River pink stocks consist mainly of the Harrison River population. Other smaller late run stocks include: Weaver Creek, Chilliwack-Vedder River, Sweltzer Creek and Stave River (Fig. 1). The late run stocks have a mean peak spawning timing around October 10-29, or about a week later than the early runs.

Harrison River Stock Group - Late

The Harrison River stock group is currently the third largest Fraser River pink population, after the Fraser mainstem and the Seton Creek groups (Figs. 4 and 5). Escapement estimates for the Harrison stock group have averaged around 0.2 million spawners from 1959 to 1983, but have increased significantly since then, peaking at about 1.2 million in 1987 (Fig. 5). These stocks may be responding to the reduction in the

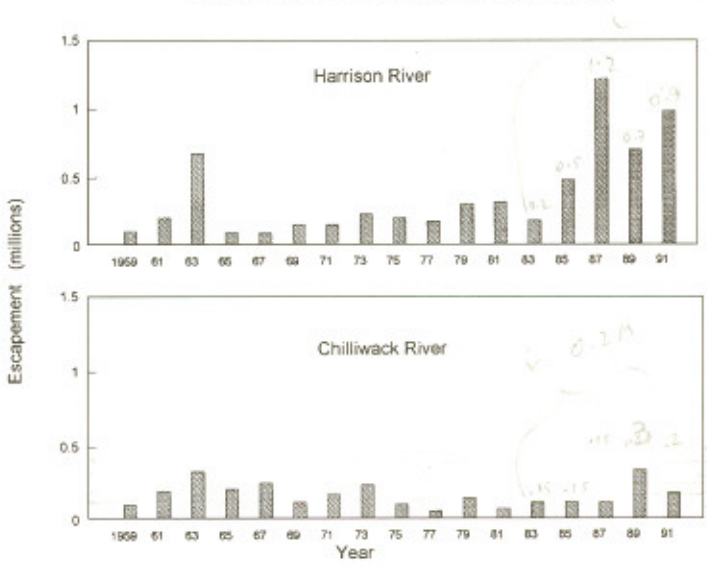


Fig. 5. Escapement estimates for the Fraser River late run pink stocks: Harrison River and Chilliwack River, 1959-1991.

STOCK DESCRIPTION

exploitation rate (see below), and show a significant potential for rebuilding. The peak spawning timing for this stock group is from October 16 to 20.

Chilliwack River Stock Group - Late

The Chilliwack River stock group has a somewhat different escapement pattern compared to the other Fraser River pink stocks (Fig. 5). Until the mid-1970s, mean escapements were relatively high at around 0.2 million, but declined to half that level in later years. The escapement peaked in 1989 at over 0.3 million spawners, but the incubation survival for this brood was reduced probably due to severe flooding in November of that year. The rebuilding of the Chilliwack River stock group may be strongly affected by the severe winter flooding conditions in this watershed, which result in major losses during incubation.

4.0 HARVEST MANAGEMENT

During the early development of salmon fisheries in British Columbia, pink salmon were of little interest because sockeye salmon were abundant and more desirable (Anon. 1962). The pink salmon fishery developed rapidly, however, especially in northern Puget Sound where catches included stocks destined to the Fraser River system, and other B.C. and Puget Sound streams. At present, the Fraser River pink salmon constitute an important fishery resource and are targeted by several commercial net and troll fisheries in both B.C. and the U.S..

4.1 CURRENT MANAGEMENT STRATEGY

Prior to 1985, the International Pacific Salmon Fisheries Commission (IPSFC) was responsible for managing the Fraser River pink salmon within the "Convention Area" (Fig. 6). The catch taken within that area was shared equally between Canada and the United States. The Pacific Salmon Treaty, signed in 1985, increased Canada's management authority and responsibilities for the Fraser River pink stocks, and established a Canada/U.S. catch-sharing arrangement. This agreement includes Fraser River pink salmon caught in all

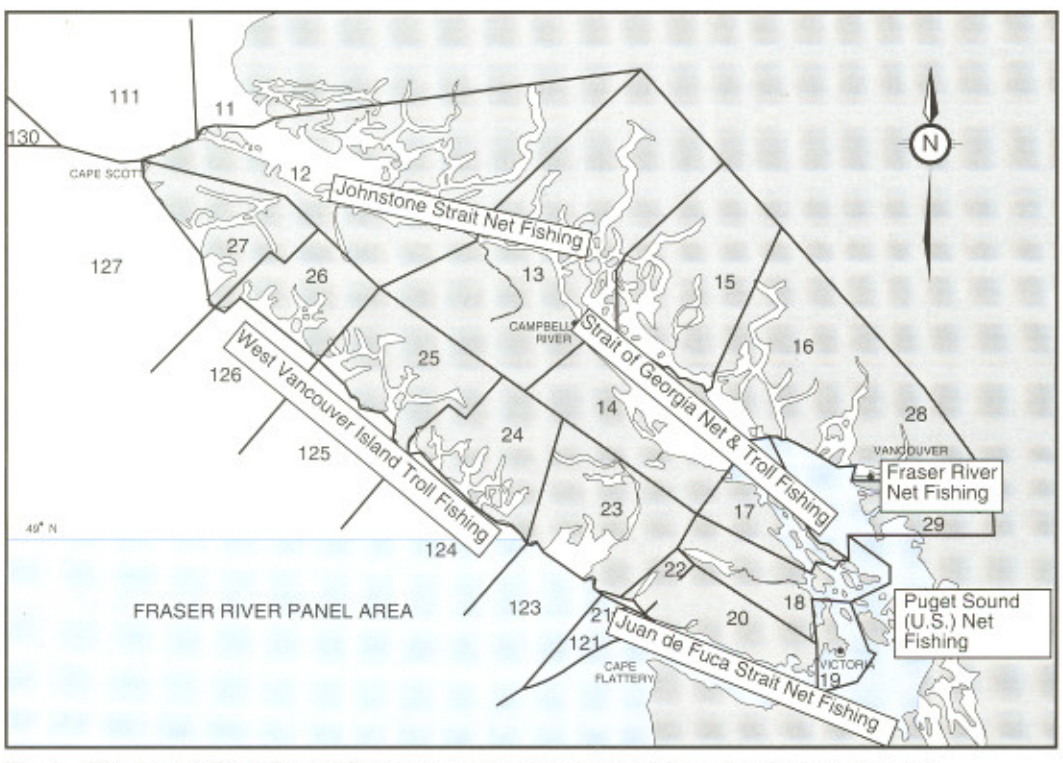


Fig. 6. The Fraser River Panel (Convention) area in relation to fishery managment areas.

fisheries, both inside and outside the original Convention Area. The Fraser River Panel, under the guidance of the Pacific Salmon Commission (PSC), develops initial fishing plans and conducts in-season management of the Fraser River pink salmon to meet the following key objectives: 1) spawning escapement goals, 2) allocations between Canada and the United States, and 3) domestic allocations for each country. Since the Fraser River Panel manages the fisheries targeting on both pink and sockeye salmon returning to the Fraser River, fishery management strategies for these two species are similar (see Sockeye Report, DFO 1995) for more details.

In general, the timing and duration of the South Coast fisheries are determined by the abundance of salmon stocks within the fishing areas, and the size and mobility of the fishing fleet. Management of these fisheries is based initially on pre-season forecasts of stock abundance. Forecasts for adult pink salmon runs are based on juvenile abundance and survival rates estimated from salinity and juvenile to adult survival data. The forecasting of diversion rate, (i.e., the use of northern route (Johnson Strait) versus southern route (Strait of Juan de Fuca)) is also important in fisheries management. For example, the proportion of Fraser River pink salmon using the northern route during 1975-1983 ranged from 25% to 66%. The pre-season forecasts are later refined by in-season estimates derived from test fishery, harvest and escapement data, as well as stock composition analysis which involves both the Fraser and non-Fraser stocks.

Fraser pink salmon are managed as a single stock because different runs co-migrate through the fishing areas and cannot be distinguished individually. Consequently, the management of this population is based on in-season estimates of the total run size. However, depending on the pre-season forecasts and assumptions about timing, different exploitation rates may be applied to the early and late run stock groups to meet specific escapement targets. Based on the in-season estimates, the PSC may adjust the estimated stock size and escapement goals, and amend the catch ceilings for pink salmon in the different fisheries.

An unavoidable by-catch of other stocks and species occurs during the Fraser River pink salmon fishery because of overlapping migration timing among different stocks. The annual harvest management strategies developed for pink salmon take into account the escapement goals and allocation issues set for these other stocks and species, such as the late Fraser sockeye. In addition, the harvest on the late-run pink and sockeye salmon is coordinated with consideration given to the conservation needs of coho salmon. Currently, the management of the Fraser River pink salmon is focused primarily on the commercial fisheries which harvest the vast majority of this population. To date, management actions for the sport fishery and the Native net fishery on the Fraser River pink salmon have been minimal since these catches have been relatively low.

The overall exploitation rate on the Fraser River pink salmon has averaged approximately 70% during 1959 to 1981 (Fig. 2). Since that time, the Department of Fisheries and Oceans (DFO) has pursued a strategy of exploitation rate reduction in order to rebuild the Fraser River pink stocks by increasing the spawning escapement. The total escapement goal for Fraser River pink stocks is based on a 70% harvest rate objective to test varying levels of escapement. Several additional return cycles are required in order to determine the escapement levels that will lead to increased total returns of the Fraser River pink stocks.

4.2 ALLOCATION

International Allocation

Until the 1950s, the U.S. fisheries caught more Fraser River pink salmon than the Canadian fisheries. The initiation of new fishing areas (seaward to the U.S. area) and the

establishment of the Pink Salmon Protocol in 1957 resulted in approximately equal Canada-U.S. pink salmon shares. Subsequently, with the signing of the Pacific Salmon Treaty in 1985, a fixed portion of the total allowable catch (TAC) of Fraser River stocks was allocated to the United States, with Canada taking the majority of the catch. Within a given year, the United States could harvest up to a pre-determined percentage of the TAC (e.g. 25.7% of the TAC for pink salmon in 1991). The U.S. catch for the 1989-1992 period was limited to a maximum of 7,200,000 pink salmon plus adjustments for catch shortfalls of 113,000 pinks that occurred during the four-year management period ending in 1988.

Domestic Allocation

The Canadian pink salmon allocation is for all "southerly migrating pink salmon stocks". These include Fraser River, southern British Columbia and Washington State stocks. For the 1991-1994 season, the Canadian domestic allocation for pinks proceeded under the guidelines established by the Minister of Fisheries and Oceans. Since pink salmon allocations are set in percentages, the actual numbers of fish allocated to the different fisheries, such as troll, may be adjusted several times during the season as run size estimates are updated. In 1991, the Canadian domestic allocation for these stocks was as follows: purse seines - 58%, outside troll - 29%, gillnets - 9%, and inside troll - 4%.

4.3 STOCK MONITORING

Stock monitoring of the Fraser River pink salmon is an essential component in managing the pink salmon fisheries. The monitoring program is conducted in the Fraser River Panel Area (Fig. 6) by the PSC, and in other B.C. areas jointly by DFO and PSC. This program is generally similar to that described for the Fraser River sockeye (DFO 1995), and includes assessment of the run size, timing and migration pathways; racial stock identification; and escapement enumeration. Estimation of the in-season run strength is based on all catches (commercial, test fishery, Native, U.S. and recreational).

Genetic Stock Identification

During the odd years when pink salmon return to the Fraser River, genetic stock identification (GSI) is used to identify catches of Fraser River pink salmon harvested in mixed-stock fisheries from northern British Columbia to Washington. The results of GSI analysis of commercial catch samples provide catch estimates and information on timing and relative abundance of the Fraser River pink salmon; these data are then used for analysis of run size and migration patterns.

The GSI technique requires knowledge of the genetic differences among stocks that potentially contribute to the fisheries of interest. Protein analysis using electrical current (electrophoresis), is conducted on tissue samples from pink salmon collected on the spawning grounds to establish a "baseline" of genetic standards. To estimate the most likely composition of stocks in the mixed catches, the genetic composition of tissue samples taken from pink salmon caught in mixed-stock fisheries is then compared to the baseline standards using "maximum likelihood" computer models.

The GSI analysis of commercial and test fishing catches are generally conducted from July through September. The PSC staff may sample commercial pink salmon landings at Bellingham, Blaine, Vancouver, Steveston, Ucluelet, Tofino, Winter Harbour and Prince Rupert. Commercial pink salmon landings from Johnstone Strait fisheries may be sampled by DFO personnel in Port Hardy and Alert Bay. Washington State commercial troll samples are obtained by Washington Department of Fisheries personnel. For example in 1991,

14,700 pink samples in 104 collections were analyzed for Fraser River stock contributions. Stock composition estimates for both Fraser and non-Fraser stocks are multiplied by the catch in each fishery to generate summaries of catch by stock, by area and gear type.

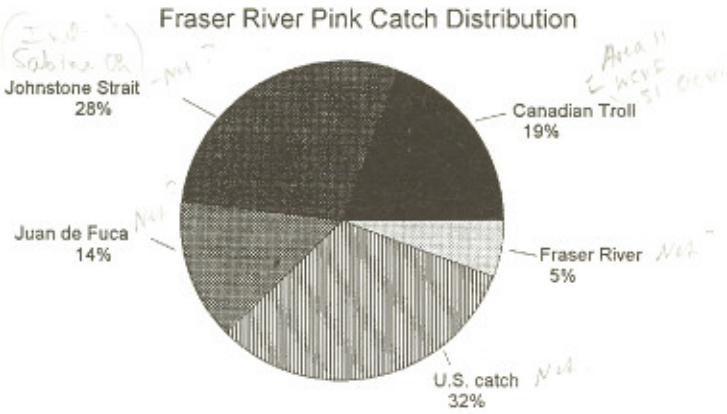


Fig. 7. Percent catch distribution of Fraser River pink salmon by fishery, 1973 - 1991.

The results of in-season GSI analysis are incorporated into assessments of the return strength of Fraser River pink salmon. The results of these analysis assist the Fraser River Panel in making adjustments to the fishing plans for the purpose of achieving international and domestic catch allocations and the gross escapement goal.

4.4 PINK SALMON FISHERY MANAGEMENT AND CATCHES

Fraser River pink salmon migrate along the northern and southern routes, and are generally susceptible to similar fisheries as the Fraser River sockeye (e.g. Area 11 net and troll, the WCVI troll, Johnstone Strait net and troll, Strait of Georgia troll, Sabine net, Fraser River net, Canadian Juan de Fuca net and U.S. net fisheries, Fig. 6). Once in the river, pink salmon are also subjected to a series of Native food fisheries along the mainstem Fraser and in some tributaries. However, the catch

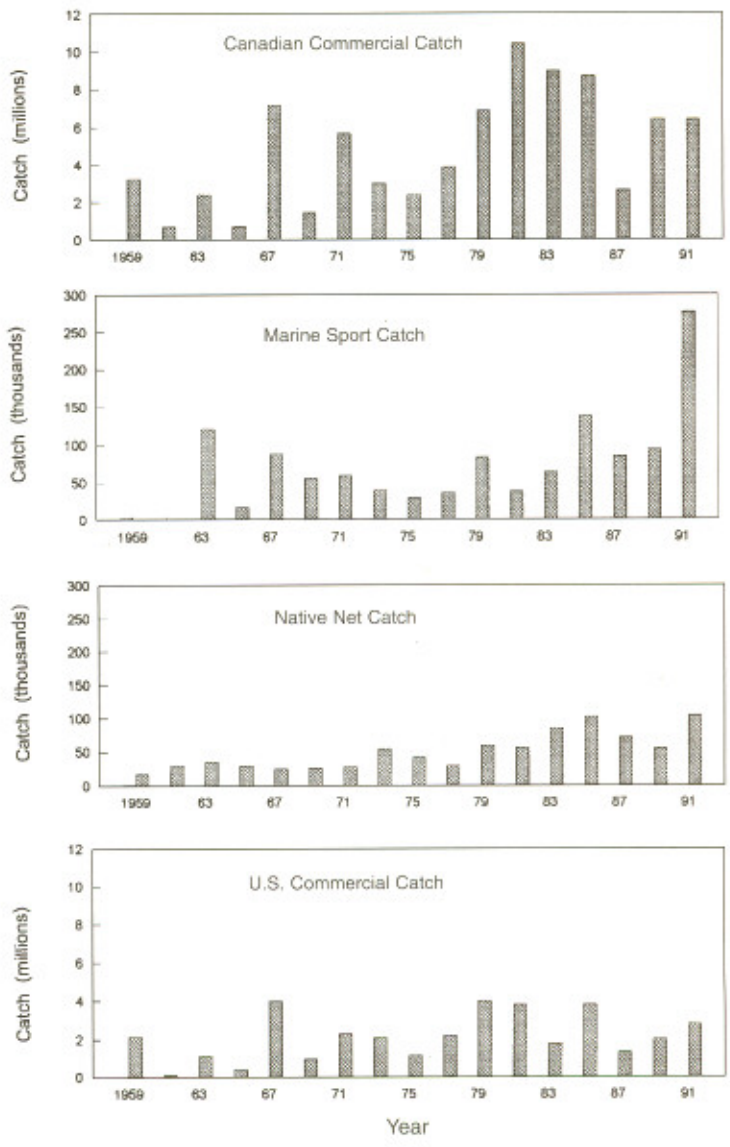


Fig. 8. Fraser River pink salmon catches by user group and country, 1959 - 1991.

HARVEST MANAGEMENT

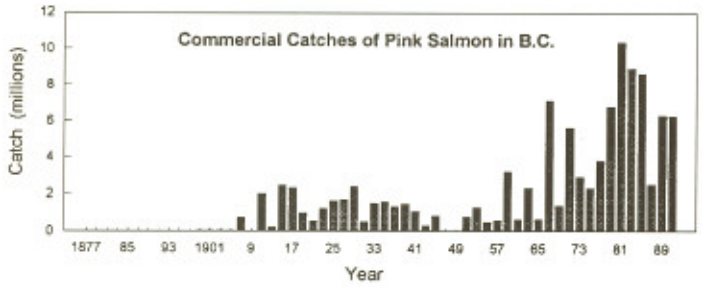


Fig. 9 . Historical commercial catches (odd years) of Fraser River pink salmon in British Columbia, 1877-1991 .

distribution of the Fraser River pink salmon, (Fig. 7), differs from the catch of Fraser sockeye. A greater proportion of pinks than sockeye is caught by fisheries outside the Fraser River area. Also, troll allocation of pinks is greater than that of sockeye, while the gillnet share is smaller. Native food fish catch is much lower than of sockeye, and sport catch is also relatively low.

Figure 8 shows the annual catches of Fraser River pink salmon in each of the Canadian commercial, U.S. commercial, marine sport and Native fisheries, on the odd year cycle during 1959 to 1991. In recent years (1981-1991), the total Canadian commercial catch has averaged 6.8 million and the U.S. commercial catch 2.5 million pinks. Figure 9 shows the historical catch trends for pink salmon since 1877 for the total Canadian commercial fisheries. Catches were of little importance until 1909 when the Fraser River terminal fishery became a significant and dominant harvester of the Fraser River pinks. Subsequently, major pink catches were also taken in other areas (see below). During each of 1981, 1983 and 1985, the

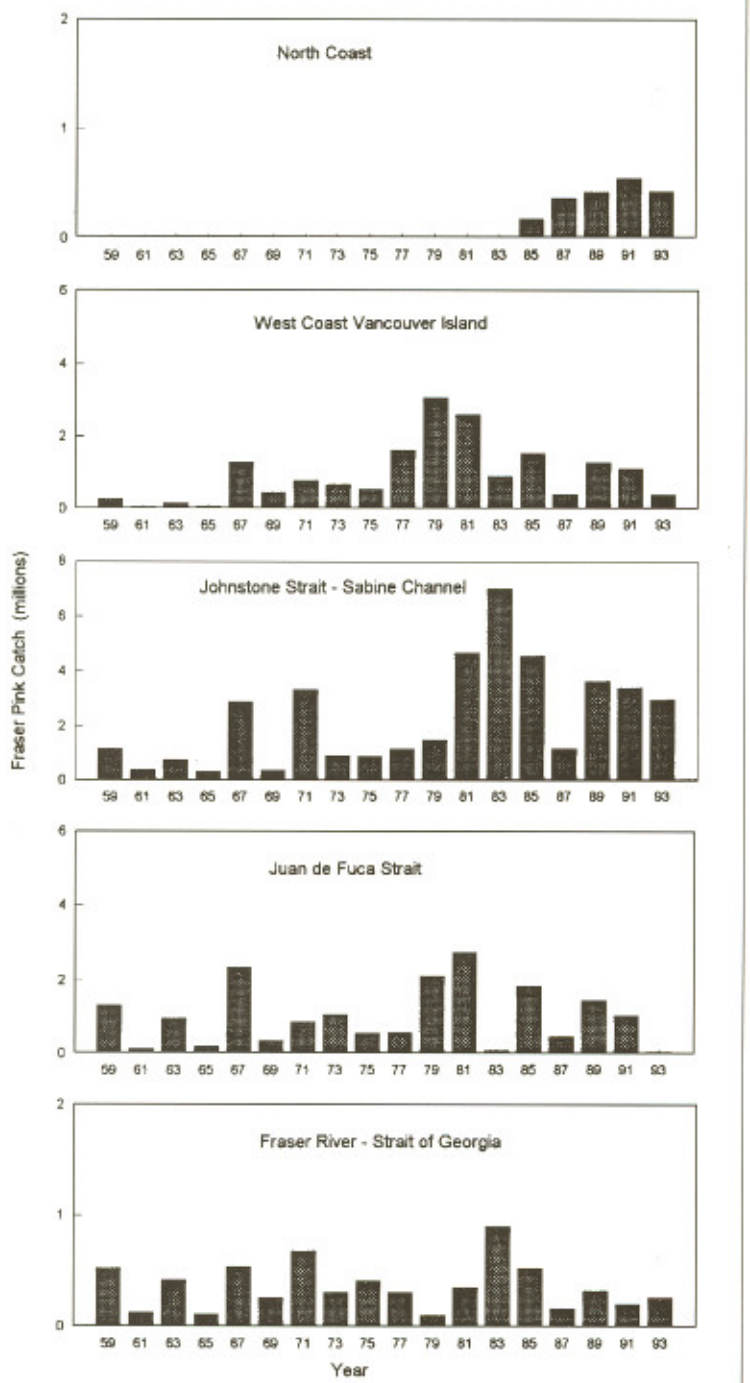


Fig. 10. Fraser River pink salmon catches (odd years) by major Canadian fisheries, 1959 - 1993.

HARVEST MANAGEMENT

total Canadian commercial catch of Fraser River pinks has exceeded 8 million fish (Fig. 9). As stated earlier, the Canadian commercial fisheries targeting on the Fraser River pink salmon generally follow the same management strategies and fishing patterns as the commercial fisheries targeting on the Fraser sockeye (see Sockeye Report, DFO 1995). Pink salmon catches in the major fisheries are described below.

North Coast Fishery

Catches of Fraser River pink salmon in the North Coast fishery (Statistical Areas 1-10) have become significant only since the mid-1980s, with approximately 0.2-0.5 million fish taken on the odd year cycle (Fig. 10) .

WCVI Troll Fishery

The West Coast of Vancouver Island (WCVI) troll fishery shows highly variable catches of Fraser River pinks, and can be a significant harvester of this population with 1.5 - 3 million fish taken on the odd year cycle during 1977-1981 (Fig. 10). Catches peak in late August or early September, and are taken mostly during a 2-3 week period.

Johnstone Strait - Sabine Channel Fisheries

The Johnstone Strait - Sabine Channel fisheries (Statistical Areas 11-16) currently take the majority of the Canadian commercial catch of Fraser River pink salmon. The highest catches in this region were reported for the 1981-1993 period when 3 to 7 million fish were taken on the odd year cycle (except in 1987, Fig. 10). The majority of the catch in this area is taken by net gear, although troll catches are also significant.

Juan de Fuca Strait Fishery

The Juan de Fuca Strait fishery shows wide fluctuations in the annual catches of Fraser pinks, from less than 0.1 million to 2.7 million fish in 1981 (Fig. 10).

Fraser River - Strait of Georgia Fisheries

Catches of Fraser pink salmon in the Fraser River - Strait of Georgia fisheries are generally minor and have been less than 0.5 million fish on the odd year cycle (Fig. 10). Most of this catch is taken in Area 29 troll fishery, with minor net catches taken in the Strait of Georgia and in the vicinity of the Fraser River mouth. Note that gillnet fisheries on Fraser pink salmon are not conducted in the in-river portion of Area 29 due to by-catch concerns.

Marine Sport Fishery

A limited sport fishery on the Fraser River pink salmon is conducted in B.C. waters (Strait of Georgia, as well as in the Juan de Fuca and Haro Strait regions - Statistical Areas 19 and 20), with about 20% of the total sport catch taken in the U.S. waters in recent years. The Canadian sport fishery on salmon is regulated by daily and annual bag limits, size limit restrictions, and by variable time and area closures. From 1963 to 1983, the combined Canadian and U.S. sport catch of pink salmon has averaged around 50,000 fish annually, but peaked at approximately 275,000 in 1991 (Fig. 8). In the future, a greater sport fishing effort and larger sport catches of pink salmon may be expected due to the declining returns of and conservation concerns for the chinook and coho salmon; the latter two species were historically the preferred species in the Strait of Georgia sport fishery.

Native Food Fishery

Pink salmon are the least desirable species in the Fraser River Native food fishery, and many incidentally caught pinks may be discarded. Traditionally, pink salmon were of minor importance to the Native fishery because the flesh quality was unsuitable for long-term preservation. Pink salmon catches in the Native fishery are relatively small, averaging approximately 72,000 fish for the 1981-1991 period (Fig. 8). The majority of the catch is taken in the lower reaches of the Fraser River below Boston Bar.

Recent changes in the fishing policy allowing for the sale of Native catch under the Aboriginal Fisheries Strategy initiatives, have led to negotiations for a larger allocation of the Fraser River pink salmon.

U.S. Fishery

The three U.S. commercial fisheries targeting on the passing Fraser River pink (and sockeye) stocks are the U.S. side of Juan de Fuca Strait, Salmon Banks and Point Roberts (Fig. 6). These fisheries are described in the Sockeye Report (DFO 1995). For the 1981-1991 period, the mean commercial U.S. catch of Fraser River pinks on the odd year cycle was approximately 2.5 million, with a maximum of 4 million reported in some years (Fig. 8). For the 1989-91 period, the cumulative U.S. catches of Fraser River pink salmon totalled 5,097,000 fish.

Incidental Catches of Other Stocks and Species

Most of the incidental catches taken in fisheries targeting on the Fraser River pink salmon occur in the Johnstone Strait and Juan de Fuca Strait interception fisheries, and in the Fraser River terminal mixed-stock fishery. These fisheries intercept other south coast pink and sockeye stocks; summer chum, chinook, coho and steelhead stocks; as well as passing U.S. stocks. There is minor interception of fall chum stocks during the later pink (and sockeye) fisheries. In particular, the pink fishery in Johnstone Strait may harvest considerable numbers of chum salmon, and the pink fishery in Juan de Fuca Strait has the potential to harvest considerable numbers of coho, especially in late September. Sockeye allocations are adjusted to account for the incidental sockeye catches in fisheries directed at pink salmon stocks.

5.0 ENHANCEMENT

Pink salmon enhancement in the Fraser River watershed is currently limited to four spawning channels (Upper and Lower Seton Creek, Weaver Creek, and Jones Creek), as well as some hatchery production. Total annual production of enhanced Fraser River pink salmon for the 1983-1989 period averaged approximately 763,000 returns (Fig.11), or nearly 5% of the overall return.

The Jones Creek spawning channel, situated in the lower Fraser Valley near Hope B.C., commenced operation in 1954 (Fraser and Fedorenko 1983) with the aim of mitigating the effects of a hydroelectric storage dam on the upper Jones Creek watershed. This channel can accommodate approximately 2,000 pink spawners and at full capacity should produce annually an estimated 35,000 pink adults which are part of the early run component. The Upper and Lower Seton Creek spawning channels are adjacent to Seton Creek near Lillooet, B.C., (Fig.1). These channels were built to compensate for the loss of more than 25,000 m2 of spawning grounds due to the construction of a hydroelectric dam in the late 1950s (Cooper 1977). The two channels commenced operation in the 1960s, and have the capacity

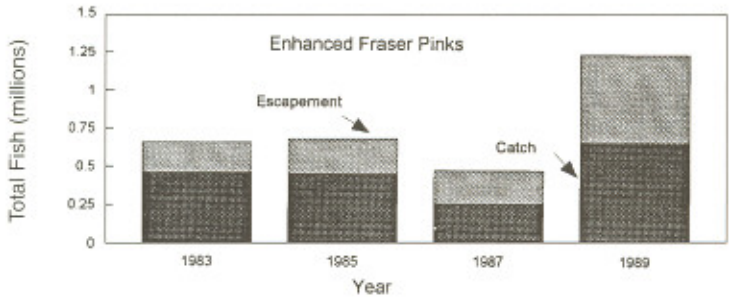


Fig. 11. Catch and escapement of enhanced Fraser River pink stocks, 1983-1989.

to accommodate about 6,000 and 21,000 spawners, respectively. This translates to a total production capacity for the combined Seton Creek channels of approximately 900,000 adults. The Weaver Creek channel, constructed primarily for sockeye production, has a reserved spawning capacity for pink salmon of up to 5,000 spawners. The results from the Seton Creek spawning channels indicate that there is a potential to rebuild Fraser River pink stocks using the spawning channel enhancement technology.

In addition to the spawning channels, minor production to restore pink salmon stocks has been attempted at several facilities: Alouette River Correctional Facility, Kanaka Creek, Centre Creek, Chilliwack River, and at Kawkawa Creek; the latter facility has a groundwater fed spawning channel. The development of enhancement technology for pink salmon in a "conventional" hatchery is in its infancy, and current hatchery production is insignificant compared to the total returns. However, the potential release of marked hatchery-produced pink juveniles would provide valuable information on harvest rates and catch distribution for the enhanced pink stocks. Such information should lead to the development of better harvest management strategies for the protection and rebuilding of pink salmon stocks.

6.0 CURRENT PRODUCTION TARGETS

The production capacity of the Fraser River pink salmon is presently underutilized, as suggested by the variable total returns in recent years (Fig. 2). This section summarizes the information related to estimating the Fraser River capacity to produce pink salmon. Reliable escapement and catch data are available only since 1959 (17 cycles). As a result, estimates of production capacity would be influenced by the extreme variations in stock size during this short period. In addition, historical catch data for the Fraser River pink salmon do not reflect the historical abundance since these stocks were underutilized prior to the decimation of the upper stocks in the 1913 Hell's Gate landslide. Consequently, two other approaches were used to determine the stock rebuilding potential:

1. Determining the relationship between the size of spawning populations and the resulting total returns (stock-recruit analysis), and
2. Estimating the quantity and quality of available spawning gravel.

6.1 STOCK-RECRUIT ANALYSIS

Reasonably accurate estimates of the Fraser River pink salmon escapements have been available since 1957 and for catches since 1959. Analysis of these data was conducted on all stocks combined since the catch could not be separated into discrete stock components. The stock-recruit analysis predicted an optimum escapement estimate of 7.6 million fish which would provide a maximum sustained catch of 9 million pieces and a total return of about 16.6 million adults, for an optimum exploitation rate of about 54%. These estimates are biased by the 1985 brood year data where a large spawning escapement yielded a low total

return in 1987 (Fig. 2) probably due to low water conditions and abnormally low winter incubation temperatures. A more reliable estimate of the rebuilding potential may be derived by continuing to increase the escapement levels for several more cycles.

6.2 POTENTIAL SPAWNING CAPACITY ANALYSIS

A preliminary estimate of the spawning capacity for the entire Fraser River watershed was developed in 1959 by the IPSFC. This estimate was based on the available spawning area (suitable gravel and flow conditions) and on assumptions regarding the area required by each spawning pair to maximize incubation survival (Saxvik MS 1959). The spawning capacity estimates ranged from a low of 3.1 million to a high of 7.5 million pink spawners. This wide range was due to the uncertainty in the estimates of available spawning area for the mainstem Fraser River stock group. The actual capacity of the spawning area may be assessed only by increasing the escapements to levels that result in decreasing returns due to overspawning.

Since 1959, escapements of Fraser River pink salmon have ranged from approximately 1 million to 13 million spawners (Fig. 2). Escapements for the 1981-1991 cycles have averaged 7.2 million and have resulted in total annual returns of nearly 17 million adults (Fig. 2). Additional information on total returns and egg-to-fry survivals over a wide range of spawning population sizes is required to confirm the spawning capacity estimates. Additional habitat information (e.g. on spawning area, gravel quality and effects of river conditions during incubation) is required to develop an optimum escapement estimate for each stock group.

6.3 PRODUCTION POTENTIAL CONSIDERATIONS

Prior to 1913, the upper Fraser River pink stocks were considered to be the largest pink stock group in the Fraser River (Ricker 1989). Several factors may be limiting the future production from the upper Fraser River pink stocks. Migration difficulties through the Fraser River canyon were the original cause for their decline. Despite the construction of the Hell's Gate fish ladder and in-river work to reduce the flow velocity, low water levels continue to obstruct pink salmon migration. At low flows, the Fraser River is forced through a very narrow channel; this creates high flow velocities impassable to pink salmon. In addition, fish size tends to be smaller in years of high returns (PSC 1988). The smaller adults have an even greater difficulty in traversing the canyon area; they may also have less energy remaining for reproduction which may lead to lower productivity (Ricker 1989).

The fluctuations in the pink salmon escapement levels observed since 1983 have been caused presumably by low flows in the Fraser River canyon during the upriver migration and/or adverse environmental conditions during spawning and incubation. Additional information is required to clarify the relationship between migration distance, fish size and productivity in order to determine the potential "optimum" spawning goals for the upper Fraser River pink stocks. If the productivity of the upper Fraser River pink stocks is indeed reduced, then the exploitation rate on these stocks must be lower than that for the lower Fraser River pink stocks. However, it would be difficult to apply differential exploitation rates to the two stock groups because their migration timing overlaps in the commercial fisheries. Such rebuilding of the upper Fraser River stocks via a lower exploitation rate would result in lost opportunities to maximize harvest of the stronger lower Fraser River stocks. Alternate harvest strategies may have to be developed, such as more terminal in-river fisheries and, if possible, targeting on discrete stocks in the marine fisheries.

The above analysis is somewhat uncertain at the present time. Certainly, careful monitoring of the total returns from increased escapements is essential to derive more

accurate rebuilding goals for Fraser River pink salmon. The brief two-year life cycle of pink salmon, relative to other salmon species, may allow for rapid rebuilding of the Fraser River pink stocks. However, a rapid increase in abundance may necessitate an increased harvest rate to reap the benefits of rebuilding. If the surplus pink salmon cannot be fished discretely, then other species that may require rebuilding and have a longer life cycle (e.g. some of the late sockeye and upper Fraser River coho stocks) may be impacted negatively. In addition, the evaluation of benefits from increased pink salmon production should consider the fact that the size of individual pink salmon declines as the size of the return increases.

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8.0 REFERENCES

Anon. 1962. Pink salmon of the Fraser River region. In: Internat. North Pacific Fish Comm. Bull. No. 9: p. 53-62.

Cooper, A.C. 1977. Evaluation of the production of sockeye and pink salmon at spawning and incubation channels in the Fraser River system. Internat. Pacific Salmon Fish. Comm. Progr. Rep. No. 36: 80 p.

Department of Fisheries and Oceans. 1995. Fraser River Sockeye, Internal Report, Vancouver, B.C.: 55p.

Fraser, F.J. and A.Y. Fedorenko. 1983. Jones Creek pink salmon spawning channel: a biological assessment 1954 to 1982. Can. Tech. Rep. Fish. Aquat. Sci. 1188: 89 p.

Healey, M.C. 1978. The distribution, abundance and feeding habits of juvenile Pacific salmon in Georgia Strait, British Columbia. Fish. & Marr. Serv. Tech. Rpt. 788: 89 p.

Pacific Salmon Commission. 1988. Report of the Fraser River Panel to the Pacific Salmon Commission on the 1987 Fraser River Sockeye and Pink Salmon Fishing Season: 48 p.

Ricker, W.E. 1989. History and present state of the odd-year pink salmon runs of the Fraser River region. Can. Tech. Rep. Fish. Aquat. Sci. 1702: 37 p.

Saxvik, P. MS 1959. Determination of optimum escapements by means of surveys of spawning grounds. Unpubl. notes used for presentation at meeting of IPSFC. July 6 and 7, 1959.