NPAFC
Doc. 707
Rev. _____

Distribution and Monitoring of Pink Salmon (*Oncorhynchus gorbuscha*) in British Columbia, Canada – a contribution to the development of a Pink Salmon Watch

by

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submitted to the

North Pacific Anadromous Fish Commission

by

Canada

October, 2003

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Riddell, B.E. and R.J. Beamish. 2003. Distribution and Monitoring of Pink Salmon (*Oncorhynchus gorbuscha*) in British Columbia, Canada. (NPAFC Doc. 707). 33p. Science Branch, Pacific Region, Department of Fisheries and Oceans, Canada.

Distribution and Monitoring of Pink Salmon (*Oncorhynchus gorbuscha*) in British Columbia, Canada – a contribution to the development of a Pink Salmon Watch

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Abstract

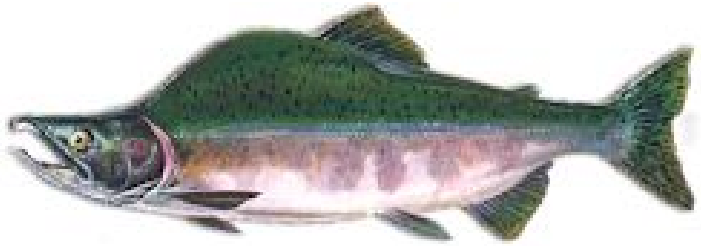
This report provides an inventory of pink salmon in British Columbia (BC), Canada and examines past efforts to monitor the spawning escapement of these salmon. The report is based on recent work conducted for the Pacific Fisheries Resource Conservation Council to provide reference material on the distribution and monitoring of Pacific salmonids in BC and the Yukon Territory. The escapement data has been collected since the early 1950s by the Canadian Department of Fisheries and Oceans, and for pink salmon in the Fraser River by the Pacific Salmon Commission (all data are contained in a Microsoft Access database).

Pink salmon in British Columbia utilize rivers and streams from the Taku River in northern BC south to the Fraser River. Production in the even and odd-year lines of pinks do not necessarily have equal distributions or population sizes. The extreme example is the absence of Fraser River pink salmon in the even years. Similarly, pink salmon along the west coasts of Vancouver Island and the Queen Charlotte Islands have much smaller pink returns in the odd years than in the even years. However, overall, there are hundreds of pink populations that may be included in a subarctic Pacific monitoring program, and there have been extensive efforts to monitor these returns for approximately 50 years. These monitoring efforts do vary by geographic area and time periods, and very few are monitored in a quantitative manner.

This report may be used as a reference for similar reports from other countries but does not presume to recommend a monitoring design. It does discussion sources of variation that should be considered and the need for a common objective as a basis for a monitoring program. Before extensive effort to assess and document this variation is undertaken, there is a need to set objectives and desired levels of precision. Once a comprehensive inventory of pink salmon populations is produced, it is anticipated that the inventory of monitored streams will be up-dated each year. Ultimately, a database will be available to study the impact of climate on one of the key indicator species in the subarctic Pacific.

Introduction

Many scientists recognize that the impact of climate and climate change on the population dynamics of Pacific salmonids could become one of the major problems in fisheries management.



Mature male Pink salmon

One approach to the study of these effects could be to compare physical changes to changes in the dynamics of an indicator species. Pink salmon (*Oncorhynchus gorbuscha*) may be an excellent indicator because they are the most abundant of the Pacific salmon and they are monitored throughout their ranges. In addition, pink salmon have a short life span that consists of only one year class and, basically, a fixed age-at-maturity of two years. The short life span allows changes to be assessed quickly and the impact can easily be assigned to the correct year-class or brood year. Also, the wide spread distribution of pink salmon and their large abundance allows for physical impacts on their dynamics to be compared among a variety of marine and freshwater ecosystems.

Studies of climate impacts on the physical environment benefit from long-term data series such as sea surface temperatures or sea level pressures. Long-term, large scale biological data bases are generally not available and when produced, are not maintained for general use. We propose to develop a biological data base that can be used by anyone interested in assessing the impacts of climate and climate change on fish and fisheries in the subarctic Pacific. This report is a first step in that process and documents the distribution of pink salmon in British Columbia and the Department of Fisheries and Ocean's effort to monitoring the annual returns to these populations.

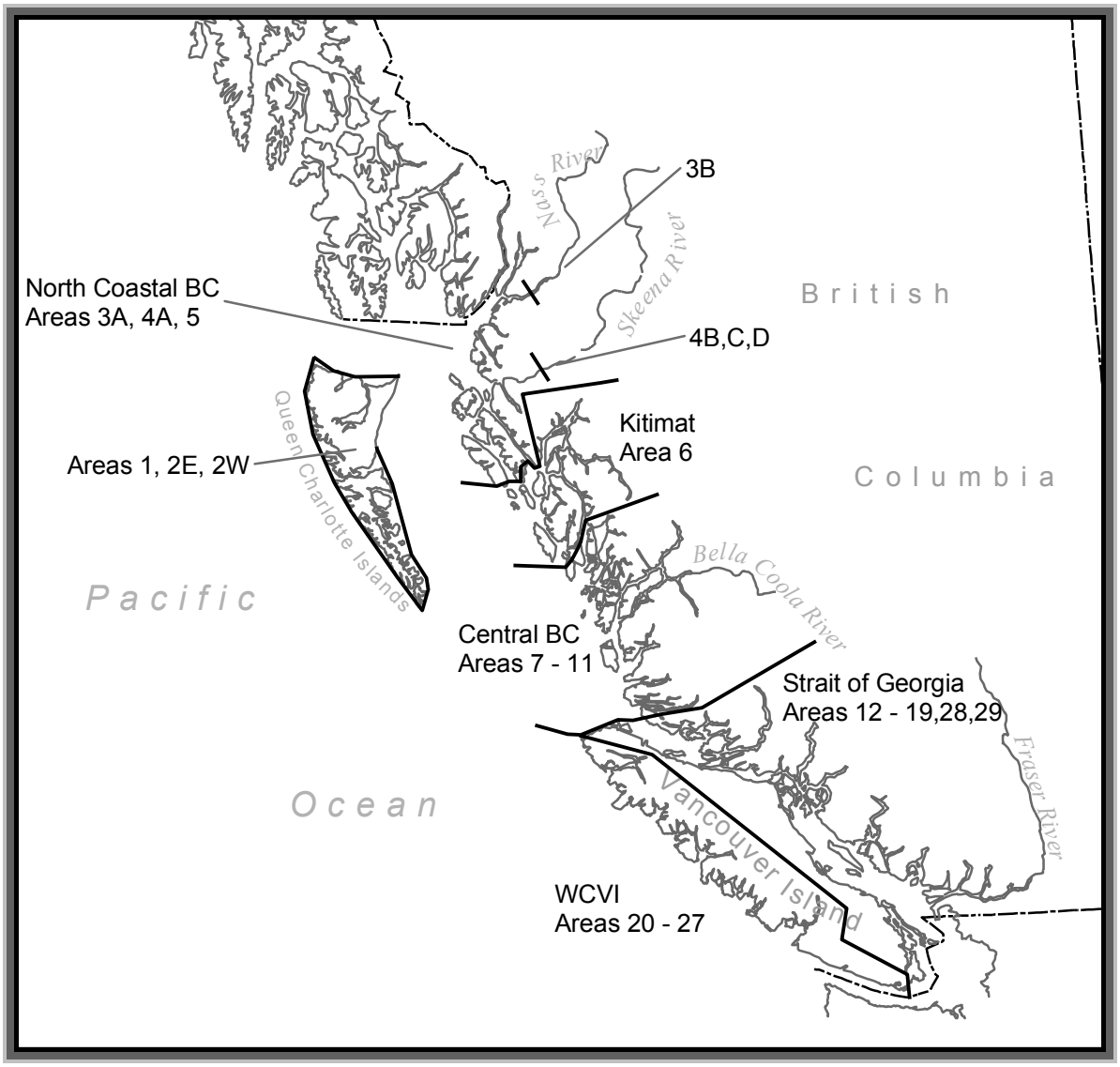
Methods and Data

The material presented in this report has been collated from reports prepared for the Pacific Fisheries Resource Conservation Council[1] (PFRCC 2002) and based on data collected by the Department of Fisheries and Oceans, Canada and the Pacific Salmon Commission (PSC, previously the International Pacific Salmon Fisheries Commission (IPSFC)[2], Roos 1991). Names of the geographic regions in BC are presented in Map 1.

With the exception of pink salmon in the Fraser River, the assessment of pink salmon in British Columbia is limited to distributional observations and trends in numbers of spawners. The numbers of pink salmon spawning in a stream is, in the vast majority of cases, estimated by visual surveys conducted by field staff walking the system or by flights over the systems. Pink salmon spawning can be quite protracted in time and provides the potential opportunity for a few surveys within a year, but the relationship

[1] PFRCC, 590-800 Burrard Street, Vancouver, B.C., Canada V6Z 2G7.
[2] Pacific Salmon Commission, 600-1155 Robson Street, Vancouver, B.C. Canada V6E 1B5 (1957-1985 IPSFC, predecessor to the PSC, collect the catch and spawning escapement data for Fraser pinks).

Map 1. Areas of British Columbia, Canada used to describe the distribution of Pink salmon. Each area is referred to by the labeled name and corresponds to the Canadian Department of Fisheries and Oceans statistical areas). The transboundary rives of northern BC are not shown on this map. Statistical areas my be viewed at: www.pac.dfo-mpo.gc.ca/ops/fm/Areas/areamap_e.htm.



Areas discussed in this report include:
1) **Fraser River** (Statistical Area 29) excluding the outer coastal areas of A29
2) **Strait of Georgia** and Johnstone Strait, Statistical areas 12 to 19, inner area 20 east of Renfrew, area 28 Howe Sound, and outer coastal area 29
3) **West coast of Vancouver Island**, Statistical areas outer area 20, 21 through 27
4) **Central British Columbia**, Statistical areas 7 through 11
5) **Northern British Columbia** including 5 geographic areas: Kitimat, (area 6), Queen Charlotte Islands (areas 1, 2E, 2W), Skeena River (areas 4B,C,D), Nass River (area 3B), and North Coastal areas (areas 3A, 4A, 5) including the outer islands and Portland Inlet.

between individual observations and the final estimate of annual escapement to a stream was usually not documented. Unless otherwise stated, escapement data for pink salmon are considered useful in assessing trends in numbers of spawners in a system over time, but the accuracy of the data is unknown.

Catch data from commercial, sport, and some First Nations fisheries are recorded, but the allocation of catch to pink populations has seldom been done. Consequently, while annual catches in a fishery may be a useful index of changes in pink production over time, the value of the catch data for the assessment of a pink population is also limited. There are limited exceptions to this if catch occurs in a terminal area and can be associated with a pink spawning population or if quantitative methods are used to allocate catch amongst the contributing populations (as conducted by the IPSFC and PSC for Fraser River pink salmon). For some limited pink salmon produced in hatcheries, marking has been conducted to estimate harvest rates on the stock and to estimate the survival rate of these hatchery fish.

Pink salmon in the Fraser River of southern BC is the only pink salmon population that can be assess quantitatively. Following from the 1957 Pink Salmon Protocol (Roos 1991), the IPSFC annually collected quantitative estimates of pink salmon spawning returns to the upper Fraser River (canyon and above), the lower Fraser mainstem, and the late-run pinks returning to the Harrison and Chilliwack rivers in the lower Fraser River. These data were collected using mark-recapture programs from 1957 to 1985. Catch data was collected from all southern BC fisheries and fisheries in Washington State that intercepted Fraser River pink salmon. Catch attributed to the Fraser River pink salmon were initially estimated using "run reconstruction" methods to estimate catch of Fraser pinks, Canadian non-Fraser pinks, or Washington State pink salmon. These methods were later supplemented with genetic stock identification techniques to verify allocations to Fraser River pinks (references to these techniques and the annual analyses are available on the PSC website: www.psc.org, see Shaklee et al. 1991). Following the 1985 Pacific Salmon Treaty, the Canadian Department of Fisheries and Oceans reassumed responsibility for estimation of sockeye and pink salmon escapements in the Fraser River. Escapement monitoring programs were maintained through the 1991 return (Cass and Whitehouse 1993[3], Schwarz and Taylor 1998) but due to budget limitations, the estimation of pink salmon escapements by tributary or region of the Fraser drainage was discontinued in 1993 (Cass et al. 1995). Since 1993, the spawning escapement of Fraser pink salmon is limited to an estimate for the total escapement to the river. Estimation of catch allocation to stock has largely been maintained and continues to be estimated jointly by the PSC and Departmental staff.

All data used in this report are available in a Microsoft Access database or Excel files of the Fraser pink salmon data (Fraser catch and escapement data provided by the PSC).

[3] References to Cass and Whitehouse 1993 and Cass et al. 1995 are both to working papers of the Pacific Science Advice Review Committee and are not citable without permission of the PSARC Secretariat at the Pacific Biological Station, Nanaimo, B.C., Canada V9T 6N7 (these documents are the only statistical descriptions of these mark-recovery programs for Fraser River pink salmon).

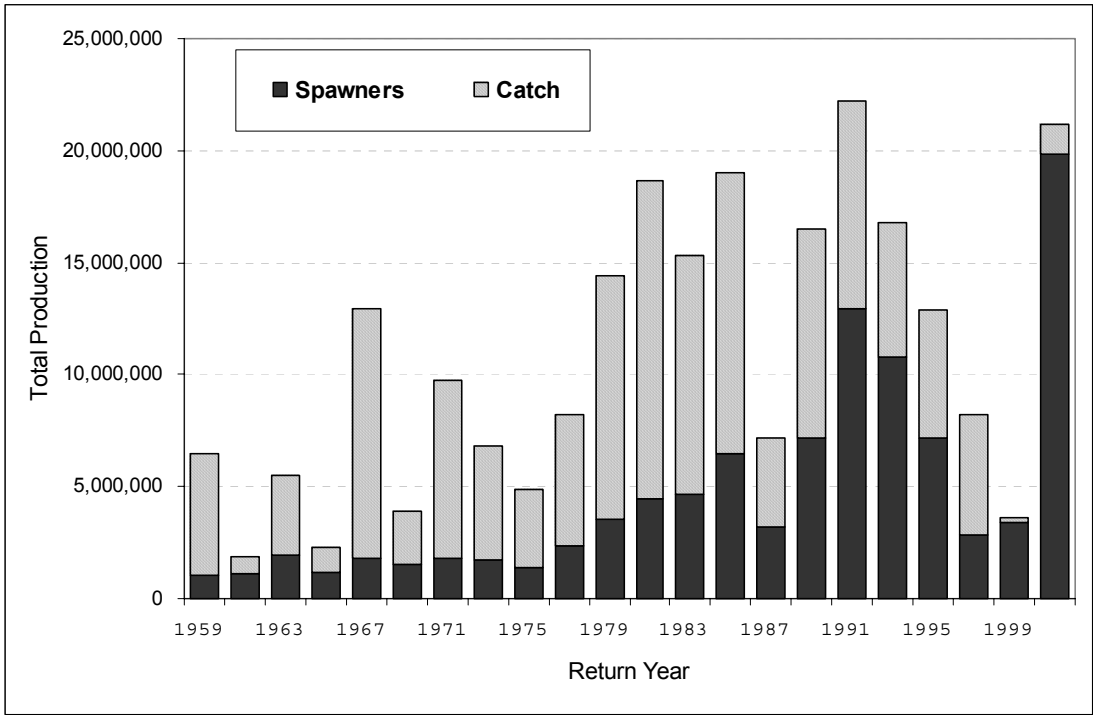
The spawning escapement data is a copy of the Departmental escapement database. Most data has been up-dated through the 2001 escapements in southern BC and the 2002 returns in central and northern BC.

Fraser River Pink Salmon

In the Fraser River, the rigid two-year life cycle for Pink salmon results in odd-year only returns. Spawning can be widely distributed up-stream to the mid-Fraser (Thompson River and north to the Quesnel River) but the major spawning concentrations occur in the mainstem Fraser River and tributaries in the lower river. Pink salmon returning to up-stream tributaries and mainstem spawning areas have been referred to as an early-run, and a later-run largely returns to the Harrision and Chilliwack rivers in the lower Fraser. Fraser pink salmon are also produced in four artificial spawning channels but the proportion of the total return contributed by these channels is small (typically about 5% of the total annual return).

Since 1959 complete catch and spawning escapement records have been maintained. The total production of Fraser River pink salmon has varied over 10 fold from two million to over 22 million pink salmon in a year (Figure 1).

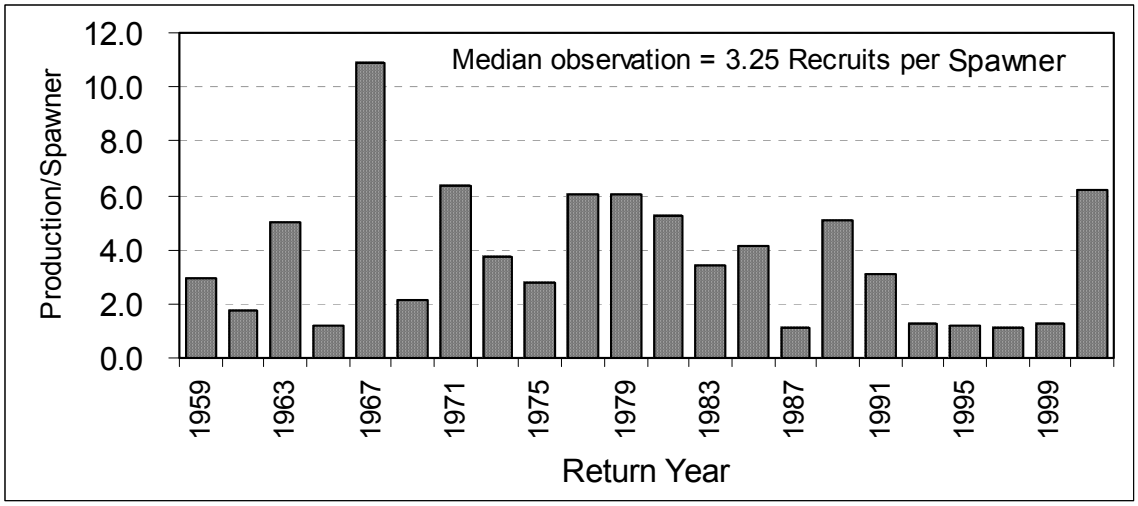
Figure 1. Total production of Fraser River pink salmon returning between 1959 and 2001. The estimated numbers of spawners and catch are summed to determine the total production in numbers of pink salmon. (Data provided by the Pacific Salmon Commission.)



The 2001 return of Fraser pink salmon resulted in the largest spawning escapement and was the second largest recorded return for this stock. The rate of adult return per spawner

in the 2001 return was high (6.2:1) but not exceptional in the time series of data for Fraser pinks (Figure 2). The median rate of return for Fraser pink salmon has been 3.25 adults per spawner over this time period.

Figure 2. Historical time series of total production per spawner for Fraser River pink salmon. Data for spawning year (brood year) 1957 through 1999 and total production estimated for return years 1959 to 2001 (Data provided by the PSC).



A notable feature of the 2001 return was that very few of the pinks were harvested. The estimated harvest rate on the return was only 6.5% and the numbers of spawners in the Fraser River was the largest on record (Figure 1). The low harvest of pink salmon during 1999 and 2001 resulted from conservation programs to limit impacts on interior Fraser River coho salmon and the late-run Fraser River sockeye salmon. Fisheries targeted on Fraser pink salmon would have incidentally caught these coho and sockeye salmon that were to be conserved. In 2001, pink salmon were reported to be well distributed through the South Thompson River system and lower Fraser tributaries. During large escapements of Fraser pink salmon, they have been observed in about 100 streams.

Assessment of Fraser River pink salmon is also unique in that a monitoring program for emigrating pink salmon fry has been maintained in the lower Fraser River since 1962 (Vernon 1966). This program has provided estimates of spawning success and fry production, and subsequently an estimate of survival in the marine environment. Data reported in Roos (1991, Appendix O) indicates freshwater survival rates from 9% to 18% (1961 brood to 1983), and marine survival rates from 0.8% to 5.5%. During the 1990s, return rates of Fraser pink salmon had been less than 2 adult returns per spawner and accounts for their decline in production. This decline was largely attributed to poor marine survival.

Adult pink salmon returning to the Fraser River are also monitored for body size. In general, body size in Fraser pinks has been inversely related to the total production of pinks. The smallest total return (just under 2 million pinks in 1961) had the largest average body size (3.0 kg), but during poor marine survival and declining returns in the

1990s, body size was the smallest (~1.8 kg) since records began in 1959. During the increased returns in 2001, average body sized increased slightly to 1.95 kg.

Strait of Georgia Pink Salmon

Pink salmon have been recorded to spawn in 115 streams from Statistical Area 12 (lower Queen Charlotte Sound) through to Area 20 (southern Vancouver Island around to Renfrew), excluding the Fraser River populations. Unlike Fraser pinks, spawning occurs in both the even and odd years. Essentially all the non-Fraser pink salmon enumerations are based on visual estimation and catches have not been assigned to individual populations since they historically occurred in large mixed-stock fisheries. In odd-years, the Pacific Salmon Commission estimates the catches of Fraser and non-Fraser pinks but the catch of non-Fraser pinks is not allocated to individual spawning populations. Any assessment of an individual pink population is further complicated by unknown accuracy of the visual escapement surveys and inconsistency of inspection methods between years.

In general, pinks are distributed in the northern half of this region and production from the even-year line dominates. Even and odd-year pink salmon utilize streams down to the Englishman River on the east coast of Vancouver Island but the presence of pinks is very limited south of that point. Along the mainland shore, odd-year Pink salmon are obviously abundant into the Fraser River but even-year Pink salmon are limited south of the Phillips River (Phillips Arm, mid-Johnston Strait). Enhancement programs in the Glendale Creek, Kakweiken River, Quinsam River, and Puntledge River[4] are also credited with significant production of pink salmon since the early 1980s.

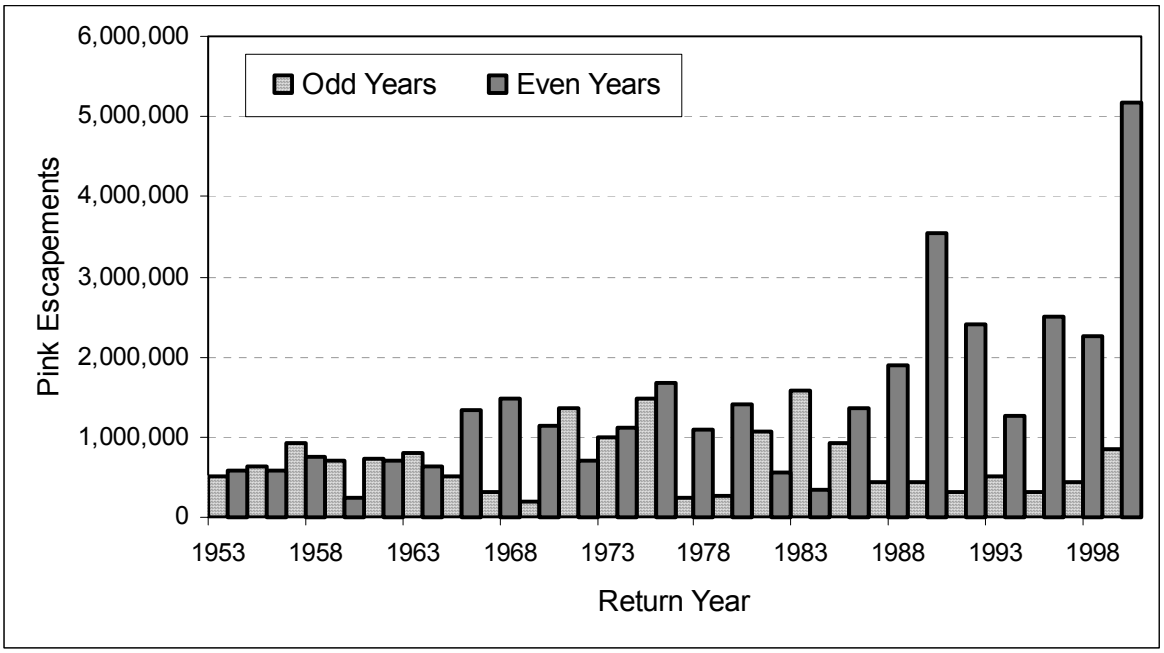
The PFRCC (2002) presented a review of existing spawning escapement records over time (available since 1953) and between rivers. Information on total production or productivity of populations is not currently available, with the exception of some data on survival rates of hatchery-reared pink salmon. The absence of harvest information limits any assessment since:

a) major reductions in harvest rates have occurred since the early years. In recent years, fisheries have been very limited in southern BC, so spawning escapements are the only source of information.
b) harvest rates were larger in odd-years since Strait of Georgia pink salmon are mixed with Fraser River pinks and in fisheries targeted on that stock.

The effect of harvest removals is evident when even and odd-year pink escapements are summed over rivers but within years (Figure 3). For example, catches have been very limited in the most recent years and would certainly exaggerate the difference in stocks sizes over time (i.e., larger escapements since 1990 compared to the 1950s). The absence of catch data, however, is not likely to account for differences between lines within recent time periods (i.e., note the poor escapements of odd-year pinks since 1987 but increased escapements in the even-years since then) when fishing has been very limited.

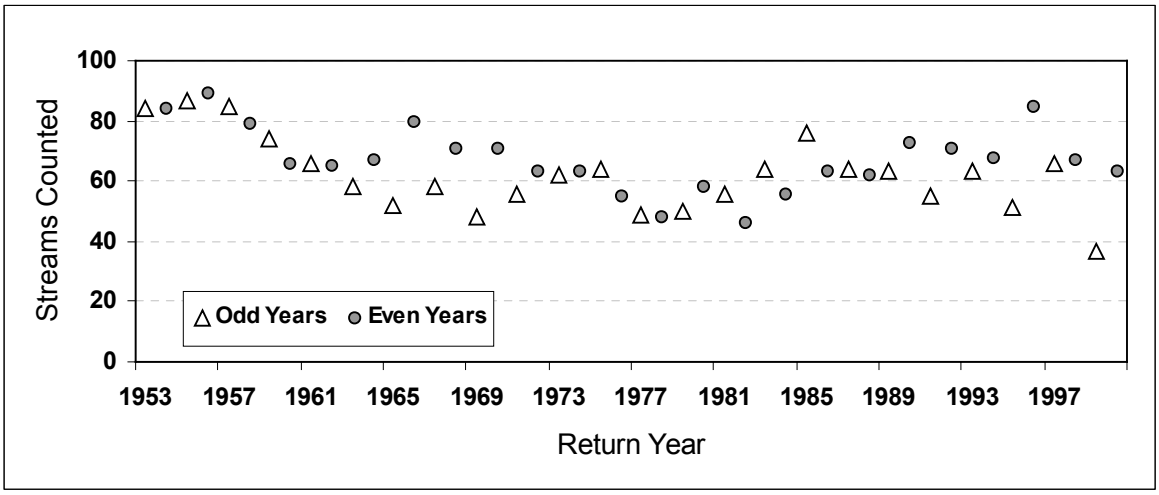
[4] Enhancement projects in the Glendale and Kakweiken rivers are artificial spawning channels, but Quinsam and Puntledge Rivers are major production hatcheries.

Figure 3. Total numbers of pink salmon spawning in the Strait of Georgia region, excluding the Fraser River. Returns are identified by even and odd-years or lines between 1953-2000 (returns for 2001 are not yet available for all rivers in the region).



The differences could be affected by the number of streams that are enumerated annually. If only half of the streams were examined in odd versus even years, then a simple summation over streams would likely be less in the odd-year line. The difference between lines though has not been consistent enough to account for the difference in pink spawning escapements (Figure 4).

Figure 4. Total number of streams enumerated for pink salmon escapements (2001 is not included).

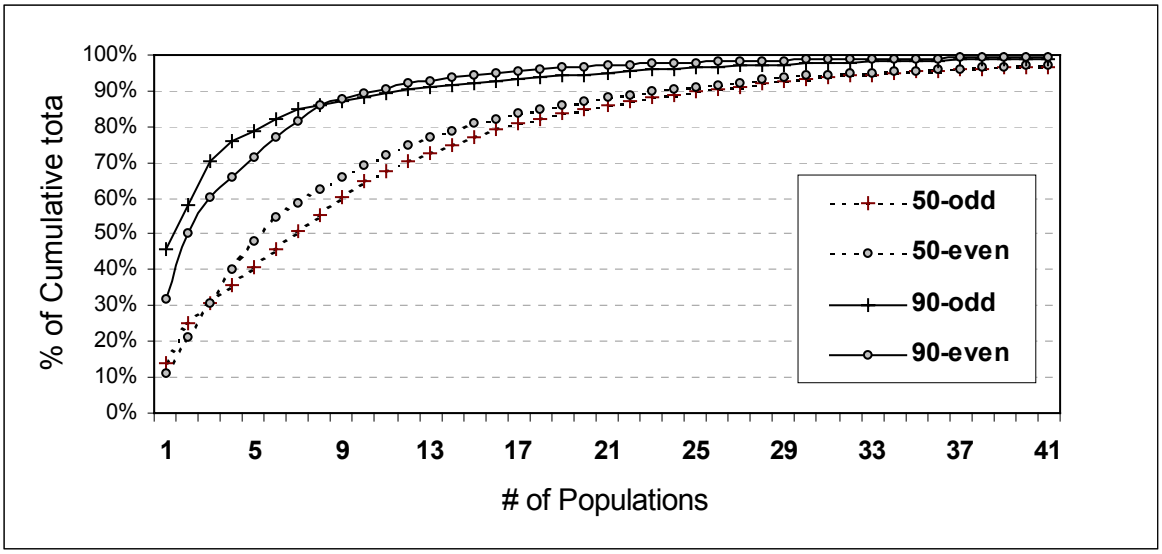


An alternative explanation could be that different streams contribute to the production in the even and odd years. But comparing production by stream in even and odd years indicated that in essentially all cases, the streams contributing are the same. The numbers of spawners though is frequently much greater in the even-year line than in the odd years. However, the importance of specific streams to production within lines has changed over this time period.

To compare streams over 48 years, the average level of spawning escapement by stream during the 1953 to 1960 (4 spawning years per line) was compared to their values in the recent decade (1991-2000). Average numbers of spawners were estimated for even and odd-year lines and each stream then ranked in order from largest spawning escapements to smallest. An individual stream may have a different rank in a time period and line but the intention of this approach was to examine the distribution of spawning escapements between pink salmon streams. If in the past many streams contribute to the total population but now very few streams contribute, then this analysis would reveal a loss of diversity between populations. In Figure 5, this situation would be indicated by the curves moving to the left, relative to the 1950 curves, indicating fewer streams providing most of the spawning pink salmon.

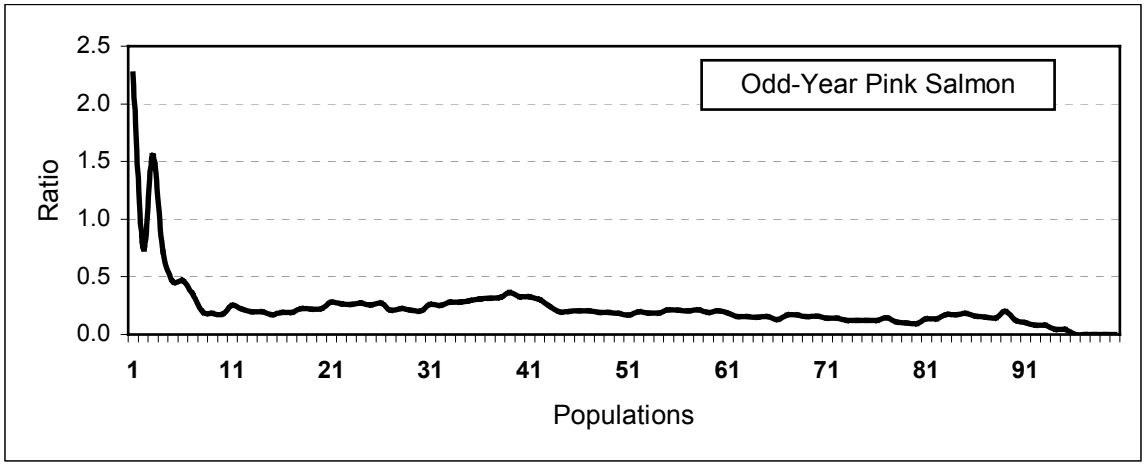
The major difference between time periods is the concentration of production in fewer larger populations during the 1990s, in both the even and odd–year lines (Figure 5). During the 1950s, 25 streams accounted for over 90% of the total pink production in both year-lines. However, by the 1990s only 11 streams accounted for 90% of the total production. During this period, the total abundance of spawning escapements had decreased by 40% in the odd-year line but increased by 500% in the even-year lines.

Figure 5. Cumulative total spawning escapements expressed as % of the total spawners per stream for the 1950s Even and Odd-years versus the 1990s Even and Odd-year lines.



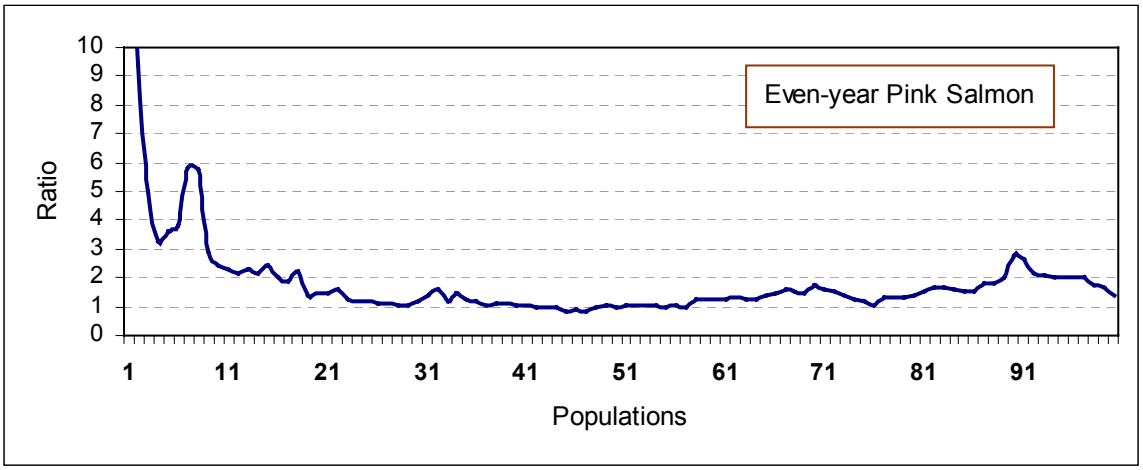
Are the changes in total escapements attributed to a few populations, or are they a more general feature over many pink salmon populations? A simple comparison between escapement sizes for each rank level clearly indicates that the reduction in odd-year escapements occurred across all population sizes, except for two of the largest three populations (Figure 6).

Figure 6. Ratio of changes in spawning escapement levels by rank order and for the odd-year line only (e.g., size of the 10th ranked populations in the 1990 odd-year line divided by the 10th ranked population size in the 1950 odd-year line only).



Values less than 1.0 indicate that the 1990 escapement sizes were less than the size of the 1950 escapement sizes for the same level of ranking. The same comparison for the even-year line demonstrates a distinctly different result, as essentially all levels of ranking involved larger populations during the 1990s (Figure 7). Essentially all of these ratios exceed 1.0 indicating that populations' sizes during the 1990s period were larger than during the 1950s (a general increase across all escapement sizes).

Figure 7. Ratio of changes in spawning escapements levels by rank order for the even-year line only.



During the 1990s, spawning escapements in the 10 largest single populations have accounted for nearly 90% of the total escapement in both the even and odd-year lines (Table 1). However, in terms of numbers of spawners, the abundance of spawners in the odd-year line has only been about 20% of the even-year line abundance.

Table 1. Largest ten spawning populations during the 1990s for even and odd-year pink salmon in the Strait of Georgia region.

Top 10 Even-year Populations	**Area**	**Top 10 Odd-year Populations**	**Area**
1. Kakweiken River (enhanced)	12	1. Glendale Cr. (enhanced)	12
2. Glendale Cr. (enhanced)	12	2. Kakweiken R (enhanced)	12
3. Phillips River	13	3. Quinsam R (enhanced)	13
4. Ahnuhati River	12	4. Puntledge R (enhanced)	14
5. Wakeman River	12	5. Oyster River	14
6. Salmon River	13	6. Ahnuhati River	12
7. Adam River	12	7. Salmon River	13
8. Quinsam R (enhanced)	13	8. Skwawka River	16
9. Kingcome River	12	9. Apple River	13
10. Ahta River	12	10. Tsolum River	14
Per-centage of total production Accounted for …	89.5%	Per-centage of total production Accounted for …	88.5%

Without more detailed examination of total production and productivity, what can we conclude from these analyses? We can at least state that:

- Spawning escapements of non-Fraser **odd-year pink salmon** in the Strait of Georgia region have declined since the 1950s, that the reduction occurred in essentially all populations, and at present over 50% of these populations now have annual average escapements of less than 200 pink salmon (estimates usually based on visual counts only).
- Spawning escapements of non-Fraser **even-year pink salmon** in the Strait of Georgia have increased significantly over time, but approximately 33% of these populations also have annual average escapements of less than 200 pink salmon.
- The total number of streams supporting spawning populations has not declined significantly but the majority of the spawning pink salmon are now concentrated in fewer large populations.

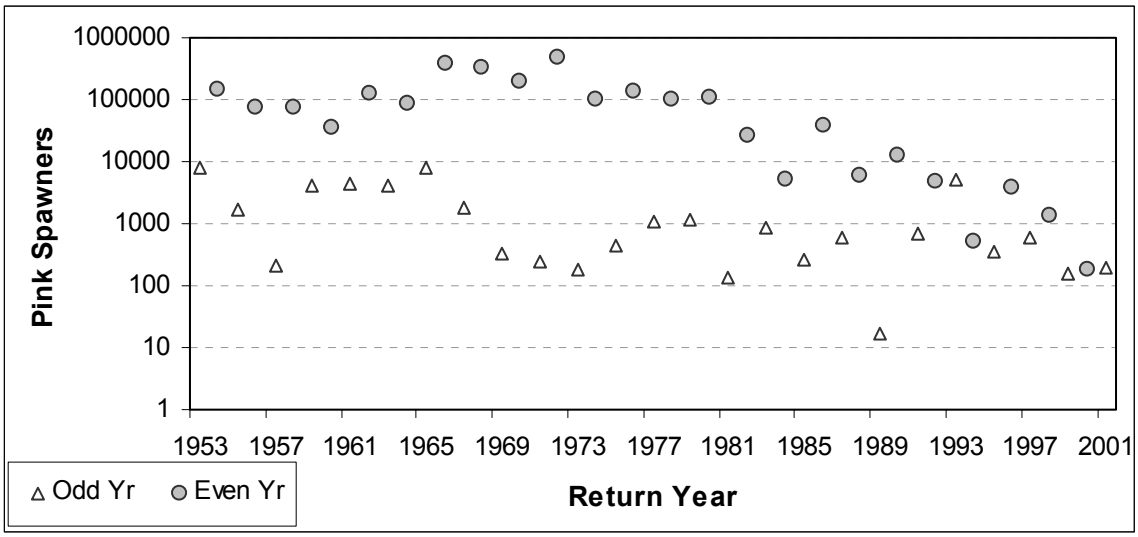
West Coast of Vancouver Island Pink Salmon

Pink salmon along the west coast of Vancouver Island (WCVI) are not a major center of production and escapements are largest in the even-year line. Of the 272 streams with salmon escapements recorded since 1953 in this region, odd-year pink salmon have been recorded in 85 streams and the even-year line recorded in 119 streams. Their spawning populations' sizes are much smaller than in other BC regions (Table 2, Figure 8).

Table 2. Decadal averages for reported spawning escapements of Pink salmon (numbers of pink salmon) along the WCVI (summation of decade averages by stream) and the number of streams recorded with Pink salmon spawning.

Categories:	1953-60	1961-70	1971-80	1981-90	1991-00
Odd-Year Spawners	9,100	9,250	2,100	1,350	2,100
Number of streams	16	48	35	33	63
Even-Year Spawners	102,000	239,000	212,000	19,800	4,700
Number of streams	80	90	84	24	36

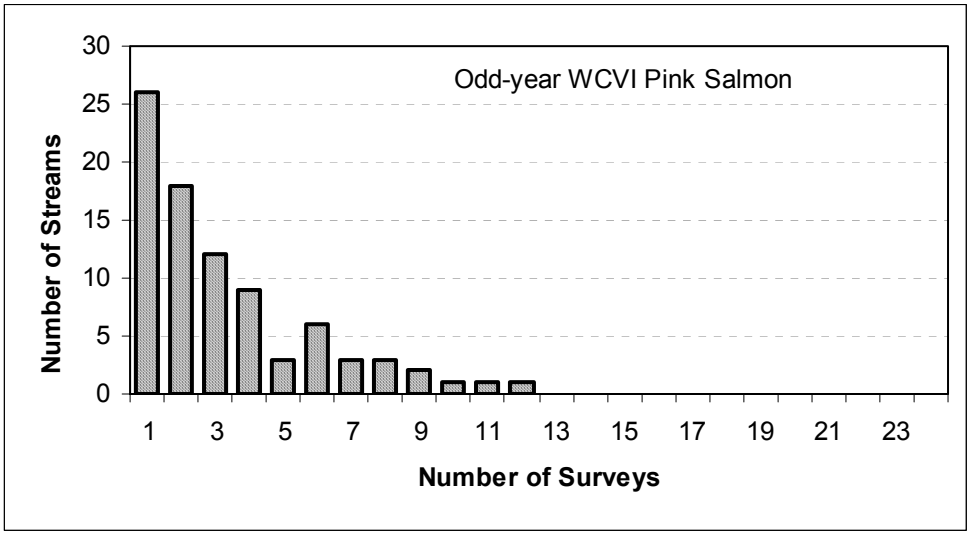
Figure 8. Total spawning escapement of Pink salmon along WCVI as reported in DFO spawning escapements records, 1953-2001 (2000 and 2001 data is incomplete by stream)



Records of pink salmon in the odd-year line are difficult to assess since the occurrence of spawners are almost rare events. There were only 14 streams that had at least one decade average exceeding 100 pink spawners; an extremely small population of pink salmon. These small returns likely also account for the limited number of escapement surveys conducted by Departmental staff. Since 1953 there are 24 years of potential surveys (per line) and 85 streams that have been recorded to support pink salmon. A plot of these possible surveys indicates that 75% of these streams have less than one escapement record for every five return years (Figure 9).

Odd-year pink salmon that have been recorded are mostly distributed in the northern half of WCVI. But there seems to be little that can be concluded about the status of these populations. Of the 14 populations identified above, the average size of the populations declined significantly between decades in nine, showed no trend in four, and increased significantly in one population. However, given the frequency of inspection and small numbers of pinks being assessed, any conclusion on status would be of dubious value.

Figure 9. Frequency of escapement records in streams observed to support pink salmon along the WCVI during odd numbered years (total number of streams, n = 85).

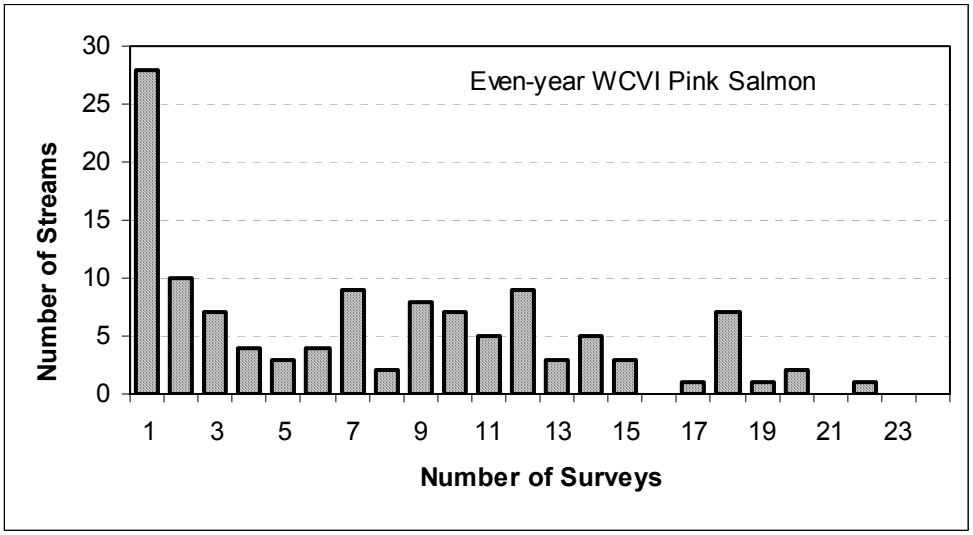


If any conclusion is merited, the need would be for a more rigorous assessment program of odd-year Pink salmon in a few streams along the WCVI. But as DFO has apparently decided, there is little merit in extensive surveys trying to assessment such small Pink salmon populations (although it is notable that the number of streams surveyed actually increased during the 1990s).

The Even-year line is certainly more abundant and surveys have been conducted on a more consistent basis, but there has been a substantial decrease in the number of streams surveyed in the past two decades (Table 2). From 1953 through the 1970s, the number of steams surveyed and the average size of the estimated escapements were quite stable (approx. 2,500 pinks/stream and 2.7 to 3.2 surveys per steam in each decade). However, in the 1980s, the number of streams surveyed was substantially reduced but frequency of surveys per stream maintained at 2.8 surveys per stream. During the 1990s, the number of streams inspected increased slightly but the frequency of survey decreased to compensate (36 streams surveyed at an average frequency of 1.8 inspects in the decade). Overall, however, the survey coverage of Even-year pink salmon was substantially better than for the Odd-year pinks.

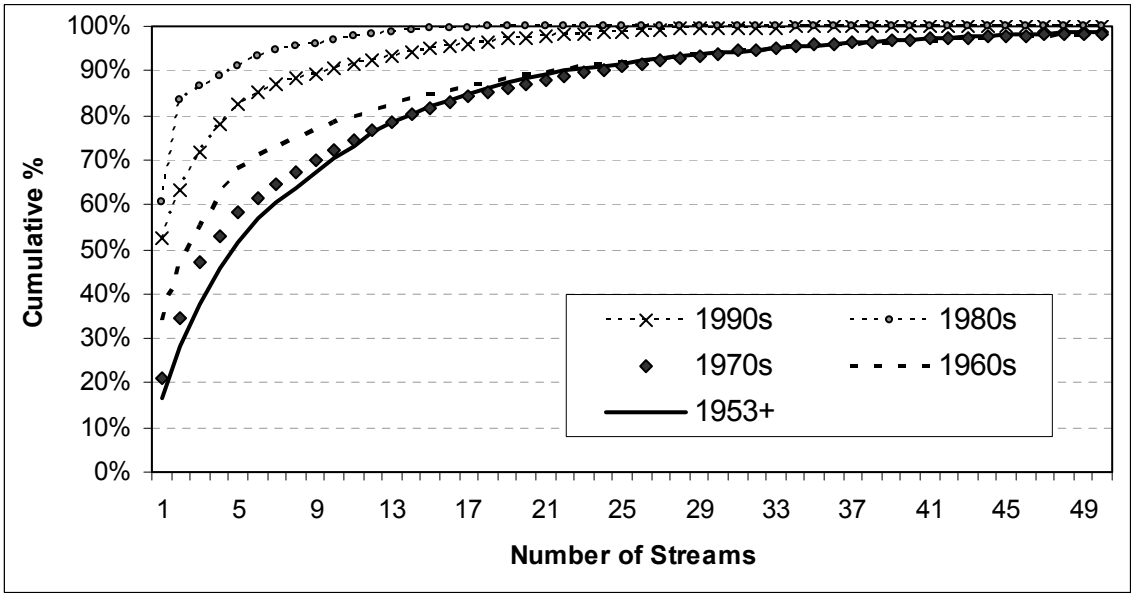
For the Even-year line of WCVI pink salmon, 27% of the stream populations have been surveyed half of the time (i.e., a stream is monitored in 1 of every 2 returns years), and 50% of the populations are surveyed in one of every three return years. While we caution that the accuracy of these surveys is unknown, this sampling intensity should be adequate to detect a trend in the abundance of spawners (catch from each population is unknown). If so, this leads to concern for recent escapements of these pink salmon as returns in the 1990s declined to only 130 spawners per stream, much reduced from the 1980s average of over 800 per stream and the earlier decade averages of over one and two thousand.

Figure 10. Frequency of escapement records in streams observed to support pink salmon along the WCVI during even numbered years (number of streams n = 119).



With the decline in numbers of spawners during the 1980s and 1990s, there has been a reduction in the number of streams contributing to the reported escapement. The distribution of spawners between populations varied a little between the 1950s through the 1970s, but the overall pattern changed very little. However, in the last two decades, there is a noticeable concentration of spawners in fewer streams according to the Departmental records (Figure 11). There are currently fewer streams being enumerated and the population sizes are much reduced from the earlier decades.

Figure 11. Cumulative total spawning escapements expressed as % of the total spawners per stream for Even-year WCVI Pink salmon, one curve for each decade of the escapement records.



The shift in curves from the 1950s to 1990s indicated that very few streams now contribute to the total spawning populations. For example, during the 1950s, about 15 streams provided 80% of the total spawning populations. But in the 1990s, only 2 streams account for 80% of the recorded spawning of pink salmon during the even numbered years. Given the limited number of Pink salmon streams, it maybe useful to identify the major populations in the WCVI even-year pink salmon (Table 3). "Major" populations were determined by ranking every population (stream) according to their average population size per decade and identifying the streams that most consistently were ranked as the 'top ten' populations. The absence of 'top ten' values in some decades indicates how variable the escapements can be between streams and years, but some streams do show a consistent importance over time. It is of concern in the table that seven of the populations listed in the 1990s column averaged less than 100 spawners … a very small pink salmon population. The other streams in the "top ten" for the 1990s were: Coleman Creek, Washlawlis Creek, Goodspeed River, Warn Bay Creek, and the Moyeha River (each of these had average escapements of less than a few hundred spawners).

Table 3. Ranked value for the most significant populations of even-year Pink salmon on WCVI. Streams listed are the top ranked stocks (largest) over the period 1953-2000 based on size of their average spawning escapement by decade (first period only includes 1953-1960), each stream was ranked within each decade. Asterisks (*) note streams that are ranked but have dropped to average escapement values ≤100 reported spawners. NR indicates no records for the stream in a decade.

Stream Name and statistical area	**1953-60**	**1961-70**	**1971-80**	**1981-90**	**1991-00**
Burman River (A25)	4	1	1	2	26*
Waukwaas Creek (A27)	3	4	3	1	1
Kauwich River (A26)	10	2	4	NR	24*
Koprino River (A27)	1	5	15	13*	10*
Kaouk River (A26)	14	6	2	3	28*
Kwatleo River (A27)	2	3	20	6	6
East Creek (A27)	9	19	5	4	4
Leiner River (A26)	20	7	8	14*	11*
Zeballos River (A25)	34	13	7	10	13*
Little Zeballos R. (A25)	39	8	10	NR	35*
Sample size per decade (total # of streams ranked)	80	90	84	24	36

Unfortunately, the trend of reduced population size seems to have been continued in the 2001 surveys with a total of only 188 Pink salmon reported in 21 WCVI streams! This value should be considered preliminary as the completeness of the records is uncertain, but there is a large margin for error for anything to change this assessment.

Pink salmon along the WCVI is clearly not a major resource in terms of production, but there is a wide diversity of populations that seem to have a limited assessment program. Given how small the even-year populations have been and the recent decline in abundance of the odd-year pink salmons, there would appear to be a need for a more careful assessment of these populations. Careful examination of escapement records by stream would be necessary before use of these streams in a monitoring program.

Central British Columbia Pink Salmon

Pink salmon in central coastal BC (statistical areas 7 to 11) have been reported in 125 streams. Spawning records for pink salmon have been maintained since the early 1950s but the streams monitored have varied over time, methods of enumeration have changed, and the effects of fisheries and habitat alterations have undoubtedly affected streams to varying degrees. The vast majority of spawning escapement data for pink salmon is based on visual observations by fishery guardians who conduct walks of streams and/or over-flights at peak spawning times. These data are not likely to be highly accurate on a stream-by-stream basis but efforts are made to conduct annual surveys in consistent manners so that the trends over time are representative of changes over time and areas. Escapements of pink salmon in central BC have been quite stable on a decadal average in both even and odd years (Table 4), but are much more variable on an annual basis.

Table 4. Decadal average spawning escapement values for central coast BC pink salmon (millions of fish) by even and odd-year lines, and the average number of streams surveyed during each decade. The proportion of the total escapement attributed to pink salmon in the Bella Coola/Atnarko rivers is presented to indicate the major contribution from this one system.

Period	Even-Year Pinks (ave. # streams)	Odd-Year Pinks (ave. # streams)	**Bella Coola/Atnarko rivers % of Even Yr.**	**% of Odd Yr.**
1951-1960	1.0 million (81)	0.9 million (81)	50%	**38%**
1961-1970	2.2 million (90)	0.7 million (81)	64%	**50%**
1971-1980	2.0 million (102)	0.8 million (102)	65%	**29%**
1981-1990	3.0 million (111)	1.6 million (118)	47%	**56%**
1991-2000	2.4 million (99)	1.6 million (94)	54%	**75%**
2001 or 2002	**3.3 million (66)**	**4.0 million (53)**	**45%**	**48%**

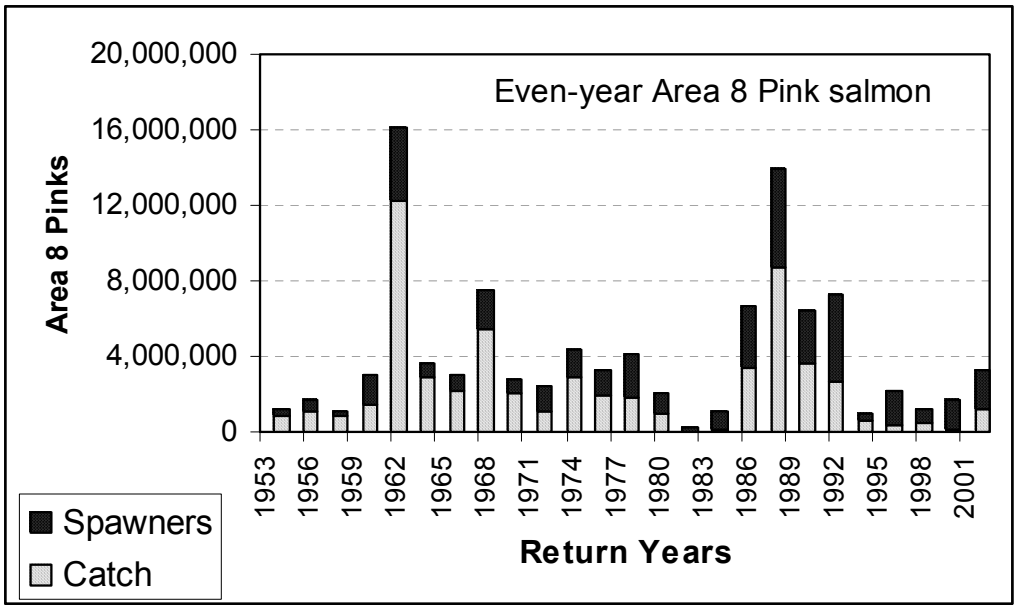
Spawning returns of pink salmon to the Atnarko River have been enumerated by more quantitative methods than is usual in the central coast. Since 1971, visual counts of pink salmon have been conducted from a tower as the fish pass over a white background set across the river bottom. The Atnarko counting tower is located on the Atnarko River, approximately 1km upstream from the confluence of the Talchacko and Atnarko rivers (Bella Coola River system). Virtually all of the pink salmon and coho salmon migrating upstream to spawn in the Atnarko River must swim past the tower. The accuracy of the count was verified by externally marking a large number of pink salmon and then releasing them about 500m downstream from the tower. The marked fish are then

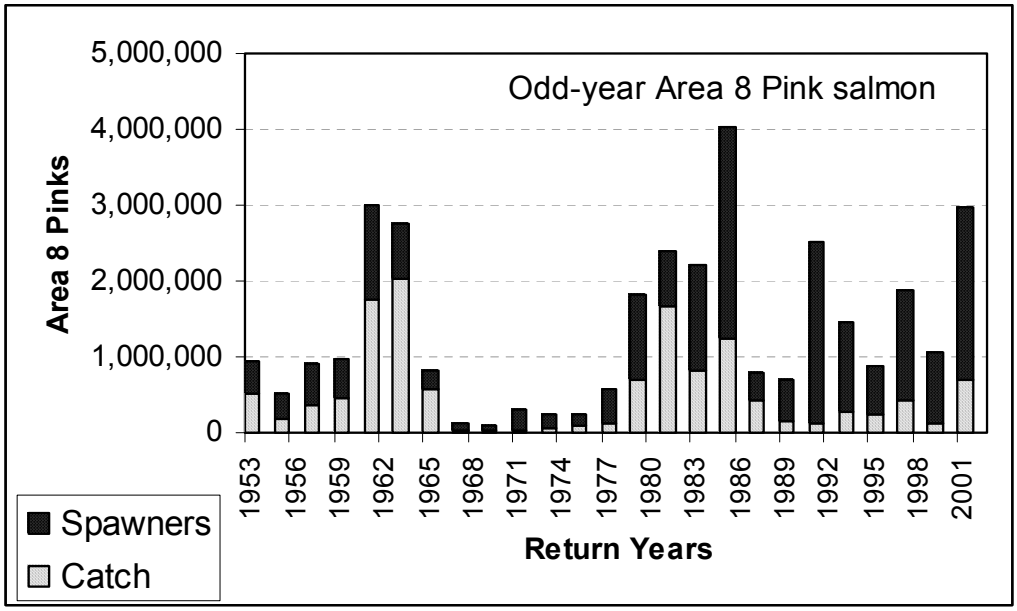
counted as they migrated upstream and over the counting boards. Over 95% of the tags were accounted for when counting from dawn to dusk count (Hilland to West, 1982, DFO Internal memo). More recently, due to financial cut-backs, the duration of the count was reduced and daily migration estimated using statistical methods (Area-Under-the-Curve (AUC) estimates, Cox-Rodgers to Peacock, 1995, internal DFO memo). Several times a year daily estimates are checked against an actual dawn to dusk count, to ensure accuracy and consistency (Willson, 2000). Since 2001, the tower count has been managed by the Nuxalk First Nation, under the supervision of a DFO Fisheries Management Technician.

Pink salmon in the numerous other Area 8 streams are enumerated by over flights and patrolmen counts. Major systems such as the Dean, Kwatna, Koeye rivers are monitored by over-flights, but smaller streams that have complete forest canopy are monitored by patrolmen. The lower Bella Coola River is walked on a weekly basis due to the turbidity of that system. Recently, the Heiltsuk and Kitasoo Bands have also been providing stream counts to supplement the Departmental coverage.

Based on these counts of pink salmon, the catch and spawning escapement to Area 8 (Bella Coola region) has been used as an indicator of pink salmon status in central British Columbia. Catches cannot be identified to individual spawning populations since the fisheries occur in marine channels and outer coast. By summing spawning escapements in Area 8 streams (that are dominated by the Atnarko counts) and catches, a time trend in total production can be established, and harvest rate by the fishery estimated. Figure 12 presents the time series of commercial catches of pink salmon in Area 8 and spawning escapements by even and odd-year lines.

Figure 12. Area 8 (Bella Coola region) Pink salmon commercial catches and spawning escapements for Even (Upper figure) and Odd-year (Lower figure) line pink salmon.





Total production of Area 8 pink salmon has been more consistent in even-years than in the odd-years, but in recent years their production levels have been very similar and both increasing. Harvest rates have been lower on the odd-year line (at only about 20%) and higher on the even-years (between 20-40%), but both significantly less recently than in the earlier years of the time series.

In terms of monitoring pink salmon in other CBC streams, the Department has invested a significant effort in maintaining these surveys, in both the even and odd-year lines. To examine the distribution of escapement surveys, all escapement data for pink salmon in CBC were separated into even and odd-year lines and the frequency of monitoring examine by stream within year-line. Both even and odd-year pink salmon spawn in most streams, but there are some with only one of the lines. As noted above, pink salmon spawning has been recorded in 125 different streams in CBC and between 81 and 118 of these streams have been monitored each decade. If a large number of streams were rarely visited (for example, only once in the 5 spawning years per decade) then these large number of streams may still not provide very informative data on pink salmon status. However, this has not been the case.

Between the 1950s and 1990s, over three quarters (75%) of the streams have been surveyed three or more times in every five years. This is a particularly good record of survey effort given the remoteness of most rivers and the spatial area covered. To demonstrate the frequency of surveys over time, Figures 13 and 14 present the frequency of the streams surveyed per decade (see Table 4 for the number of streams involved) for the Even-year and Odd-year lines, respectively.

Figure 13. Percentage of the streams in the Even-year line of CBC pink salmon that have been surveyed 4 or 5 times (i.e., 80 to 100%), 3 times (60%), or 1-2 times (40% or less) in each decade.

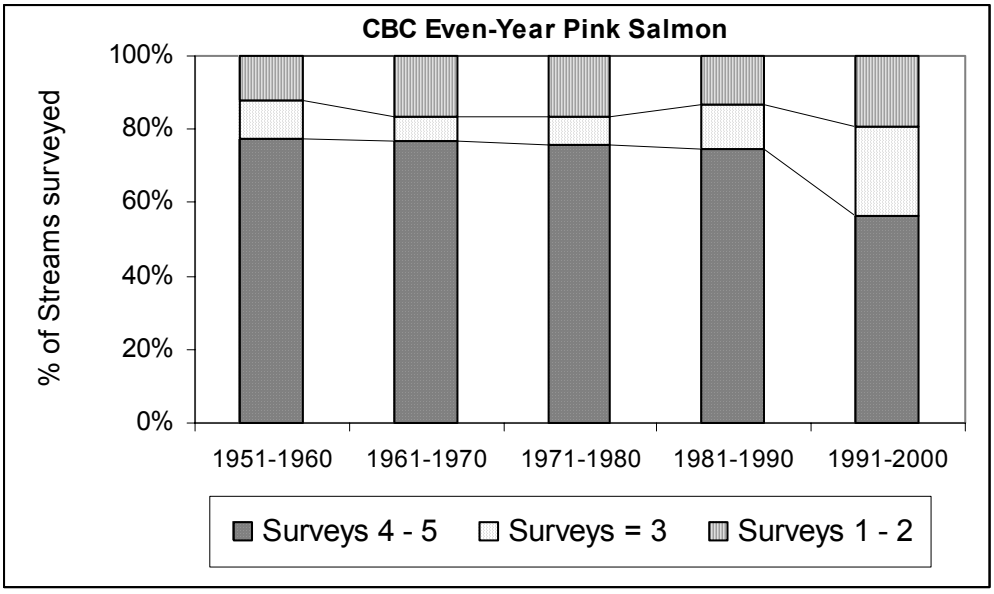
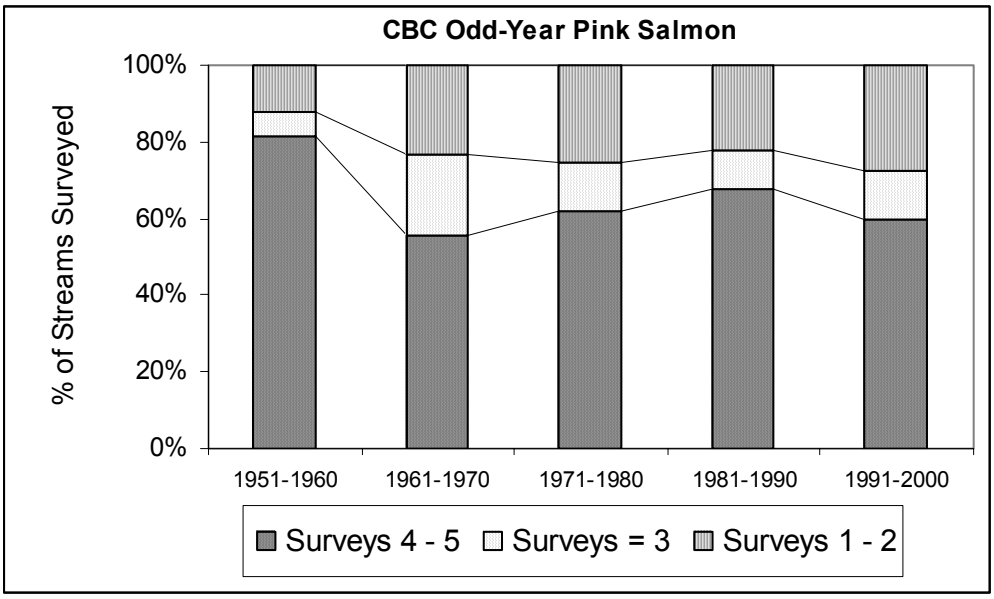


Figure 14. Percentage of the streams in the Odd-year line of CBC pink salmon that have been surveyed 4 or 5 times (i.e., 80 to 100%), 3 times (60%), or 1-2 times (40% or less) in each decade.



Note that the specific streams surveyed do vary over time and the interpretation of blanks or entries of "None observed" can be ambiguous. If there was no data provided for a stream in a decade it was omitted from these calculations.

The frequency of escapement surveys decreased slightly in the 1991-2000 period, but has decreased even more during 2001 and 2002. During 2001, only 53 streams have recorded escapements or visitations, and in 2002 only 66 streams are noted. However, in 125 possible streams with pink salmon, even these survey numbers could provide a reasonable indication of pink distribution and abundance trends depending on how the streams were selected, their frequency of surveys, and their distribution in CBC.

For the Strait of Georgia and west coast of Vancouver Island, to examine changes in the diversity of spawning streams, figures were presented comparing the number of streams contributing to the cumulative total spawners by decade (e.g., Fig. 5 and 11). Curves that rise rapidly but quickly become horizontal lines indicate that a few streams contribute the vast majority of the total spawning population. Curves that rise more slowly and continue to rise over many streams indicate that many streams are contributors to the total spawning population. Curves for CBC pink salmon over the five decades since the 1950s tend to rise rapidly with 85% or more of the total spawning population accounted for by the 15 largest spawning streams in both the Even and Odd-year lines. The curves for each decade are very similar in shape and overlap extensively when plotted. Consequently, these plots are not very informative about changes in stream diversity. The only separation between the curves is due to changes in pink salmon abundances over time. However, if the streams included in the first 15 streams are compared over time, it is apparent that changes do occur. The most direct means to demonstrate these changes is to simply list the 15 largest pink salmon spawning populations in CBC by line and decades (Table 5). In this table, the largest 15 populations during the 1951-1960 decade are compared to the most recent decade (1991 to 2001 or 1992 to 2002).

In both the Even and Odd-year lines, two or three of the larger populations during the 1950s have declined in size, but others have increased substantially. The inclusion of these new large populations has resulted in some populations dropping out of the top groups of streams but their average escapement sizes have actually not declined (e.g., Carter River and Cooper Inlet Creeks, Even-year line). Why these populations changed so much would require a more specific investigation of each watershed, the run timing and fishery impacts in various populations, and the localized pressures on them. The Raincoast Conservation Society report (Harvey and MacDuffee 2002) began to look more specifically at watershed and enhancement[5] records but only related whether logging and enhancement was occurring in a watershed (Appendix 3 of their report). An expansion of this type of analysis would be required if explanations were required.

[5] One pink spawning channel was constructed by the Salmonid Enhancement Program, DFO on the Atrnarko River.

Table 5. Listings of the 15 largest Pink salmon spawning populations in CBC by Even and Odd-year Lines. Within each line, the streams ranked from largest to 15th during 1951-1960 are compared against the most recent decade, and the statistical area of the stream is included in brackets.

Odd-Year Line 1951-1960	**Odd-Year Line 1991-2001**		**Even-Year Line 1951-1960**	Even-Year Line 1992-2002
1. Bella Coola & Atnarko Rivers (8)	1. Bella Coola, & Atnarko Rivers		1. Bella Coola & Atnarko Rivers (8)	**1. Bella Coola & Atnarko Rivers**
2. Koeye River (8)	4. Koeye River		2. Koeye River (8)	**6. Koeye River**
3. Kainet River (7)	5. Kainet River		3. Kainet River (7)	**7. Kainet River**
4. Kwatna River (8)	7. Kwatna River		4. Clatse River (7)	**15. Clatse River**
5. Neekas River (7)	14. Neekas River		5. Neekas River (7)	**8. Neekas River**
6. Mussel River (7)	6. Mussel River		6. Mussel River (7)	**11. Mussel River**
7. Clatse River (7)	9. Clatse River		7. Jenny Bay Creeks (8)	**27. modest decline to several thousand spawners**
8. Dean River (8)	11. Dean River		8. Kwatna River (8)	**4. Kwatna River**
9. Nameless Creeks (7)	Declined to a few hundred spawners		9. Salmon Bay Creek (7)	**24. modest decline to several thousand spawners**
10. Kilbella R (8)	3. Kilbella R.		10. Nekite River (10)	**13. Nekite River**
11. Chuckwalla R (8)	2. Chuckwalla R.		11. Johnstone Cr (9)	**9. Johnstone Cr**
12. Nekite River (10)	15. Nekite River		12. Nootum River (8)	**Significant decline to few hundred spawners**
13. Salmon Bay Creek (7)	Declined to a few hundred spawners		13. Hook Nose Creek (8)	**36. declined to a few thousand spawners**
14. Johnstone Cr (9)	13. Johnstone Cr		14. Carter River (7)	**17. Carter River, no decline in average number of spawners**
15. Carter R (7)	10. Carter River		15. Cooper Inlet Creeks (7)	**21. Cooper Inlet, no decline in average number of spawners**
Kimsquit River … much smaller numbers in Odd-year line.	8. James Bay Creek (7)			**2. Kimsquit River (8)**
	12. Korich Cr (7)			**3. Chuckwalla R (8)**
				4. Kilbella R (8)

In general, most of the rivers that support the largest pink salmon populations have been the same over time, with the exception of the Chuckwalla, Kilbella, and Kimsquit rivers that have substantially increased in numbers of pink spawners. The centre of pink salmon abundance in CBC is the mainland rivers of statistical areas 7, 8 and 9, but 10 to 11 have much lower pink salmon production. Any further investigation of changes in population diversity or habitat impacts would have to investigate the large number of medium to small stream populations through the coastal islands and mainland of CBC.

Northern British Columbia Pink Salmon

Describing the pink salmon resource of northern BC (NBC, Areas 1 -6) is much more difficult than for CBC because of the number of streams involved and the diversity of geographic areas. The PFRCC review of salmon stocks in NBC identifies five sub-areas (Queen Charlotte Islands, Nass River, Skeena River, Kitimat Area 6, and the North Coastal mainland); see Map 1. Overall and since 1950, the number of streams with pink salmon spawning recorded has varied from 235 in 1950 up to 448 (Even-years, 1980s, Table 6). An historical summary of the average number of pink salmon spawners by sub-areas and decade, and the number of streams surveyed, is presented in Table 6. In total, the number of unique streams with pink salmon spawning recorded varied from about 370 streams in the Odd-year line to 450 in the Even-year line.

The numerous pink salmon streams in NBC make a brief summary of Table 6 difficult. But comparing the summary in Table 6 with the detailed escapement records in the escapement database and with the results for the CBC, there are a few notable points:

a) While the number of streams in NBC is substantially greater than in CBC, the total number of pink spawners recorded for NBC, on average, is not proportionately greater than in CBC. Pink returns in CBC are dominated by the major returns to the Bella Coola and Atnarko rivers, but one dominant system does not exist in NBC. There are a few larger rivers with large populations of pink salmon, but production in NBC results from many moderate-sized rivers throughout the region.

b) Like in CBC, pink salmon escapements in Even-year line have been greater than in the Odd-year line but the lines have become similar in size over the past decade. The number of streams involved though has typically been greater in the Even-year line.

c) Two areas of NBC are not typically large producers of pink salmon. Both the Nass River and the Queen Charlotte Islands have much lower levels of pink salmon returns than the other sub-areas of NBC. Even-year returns to the Yakoun River, QCI, is the significant exception to this comment. It is also notable, that like pink salmon along the west coast of Vancouver, pink salmon in QCI have a much more limited return in the Odd-year line and much more diverse use of streams in the Even-year line.

d) Also like in CBC, the number of streams with pink salmon reported during 2001 and 2002 are much lower in NBC than in previous years. The reported escapement numbers, however, were comparable with the past decade and suggest a significant increase in pink salmon returns in the past two years.

Table 6. Average size of pink salmon spawning escapements by decade (5 years per line) presented by Even and Odd-Year Lines, Sub-Areas of NBC, and the number of streams included in each average (i.e., the number of streams with recorded escapements).

Areas	Pink Lines	1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001	2002
Kitimat	Even-Yr Line	204,000	467,000	1,564,000	835,000	988,000	923,000		688,000
	Odd-Yr Line		254,000	621,000	317,000	639,000	514,000	1,611,000	
Nass River	Even-Yr Line	9,000	12,000	18,000	14,000	34,000	5,000		None recorded
	Odd-Yr Line		15,000	31,000	23,000	102,000	18,000	15,000	
North Coastal	Even-Yr Line	495,000	382,000	617,000	600,000	654,000	511,000		1,168,000
	Odd-Yr Line		226,000	342,000	260,000	726,000	745,000	1,382,000	
QCI	Even-Yr Line	918,000	1,153,000	1,532,000	1,005,000	1,549,000	1,870,000		1,626,000
	Odd-Yr Line		86,000	124,000	33,000	26,000	16,000	7,000	
Skeena R	Even-Yr Line	564,000	500,000	1,063,000	791,000	1,462,000	735,000		351,000
	Odd-Yr Line		833,000	967,000	1,136,000	2,691,000	1,899,000	843,000	
NBC	Even-Yr Line	2,191,000	2,513,000	4,794,000	3,246,000	4,687,000	4,044,000		3,832,000
TOTAL	Odd-Yr Line		1,414,000	2,084,000	1,770,000	4,184,000	3,192,000	3,858,000	

Areas	Pink Lines	1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001	2002
Kitimat	Even-Yr Line	93	102	102	107	110	98		75
	Odd-Yr Line		101	104	105	109	95	68	
Nass River	Even-Yr Line	4	5	9	18	20	5		0
	Odd-Yr Line		6	10	19	20	8	2	
North Coastal	Even-Yr Line	68	82	84	99	109	95		60
	Odd-Yr Line		81	87	90	104	101	80	
QCI	Even-Yr Line	43	95	113	123	137	131		87
	Odd-Yr Line		30	46	57	60	45	13	
Skeena R	Even-Yr Line	27	32	51	54	72	50		6
	Odd-Yr Line		31	51	59	78	61	12	
NBC	Even-Yr Line	235	316	359	401	448	379		228
TOTAL	Odd-Yr Line	0	249	298	330	371	310	175	

While there is not a dominant pink population in NBC, there are a number of rivers that have consistently produced large returns over the 53 years of record. These rivers have been identified based on their decadal average escapement being approximately 100,000 pink or more. In the Odd-year line and by sub-area, this list becomes quite small. This definition would identify:

Kitimat sub-area: Quaal River (followed by smaller returns to the Kitimat and Kemano)
Nass River sub-area: no tributaries in the Nass meet this definition, but the Ksi Hlginx (previously Ishkheenickh River, changed May 11, 2000 with Nisga's Treaty) has the most consistent record of pink salmon, approx. 15,000 spawners on average.
North Coastal sub-area: the largest consistent producer is the Kwinamass River in Portland Inlet, followed by the Knukw (Iknouk River in the lower Nass River). Large returns have been recorded in the Khutzeymateen (Portland Inlet) and the Khyex (lower Skeena) rivers but not as consistently as in the Kwinamass River.
QCI sub-area: only the Copper and Tlell rivers have records of consistent pink salmon returns in the odd years. Neither would be consider a large pink salmon system but spawning escapements to the Copper River has decreased to a few thousand from a range of 30,000 to 40,000 in the earlier periods.
Skeena River sub-area: the Skeena River (excluding the coastal area 4A) contains several large pink salmon systems, including the Babine River, Kispiox River, Kitwanga River, and Lakelse River. Lakelse River is the largest Odd-year pink salmon system in NBC. At times, substantial pink escapements have also been recorded to the Morice River (upper Skeena) and in the lower Skeena River (referred to as West Skeena in escapement records).

In the Even-year line, pink salmon returns are more diversified and, historically, were substantially larger. By sub-area, the rivers included would be:

Kitimat sub-area: Kitimat and Kemano would join the Quaal as major producers.
Nass River sub-area: the same comments as above would hold but return numbers are even lower, approximately one-half in the Ksi Hlginx.
North Coastal sub-area: the Odd-year systems noted above would again be the largest pink spawning populations but the average escapement sizes are lower, and the returns to the Knukw (lower Nass R) become negligible in the even years. Two coastal systems in upper Grenville Channel become significant pink producers: Kumealon Creek and Moore Cove Creek.
QCI sub-area: pink salmon spawning number are much greater in the Even-year line and a number of streams become notable producers. The Yakoun River is clearly the major producer on the Even-year line with average spawning estimates ranging from 100,000 to nearly 1 million pink salmon. However a number of other systems typically have 50,000 to 100,000 spawners on average: Brown's Cabin Creek, Copper River, Deena River, Mathers Creek, Naden River, Pallant Creek, and Skedans Creek. It is interesting to note that none of these systems are along the outer west coast of the Queen Charlotte Islands.
Skeena River sub-area: The same systems identified above for the Odd-year line are also the major Skeena pink systems in the Even-year line but the size of the escapements is lower on average. The Lakelse and Yakoun (QCI) rivers are similar in average Even-year returns.

The frequency of spawner surveys in pink salmon streams is a strength in NBC as it was in CBC. As noted previously, the accuracy of the number of spawners is likely low as the vast majority of the NBC surveys are based on visual methods and streams could have been inspected once or several times within a year. However, with a high frequency of surveys each year the Department is able to monitor the distribution of pink salmon, the trends in relative population sizes between streams within a year, and within a stream between years. These visual surveys can also be an important check on the habitat conditions, water levels, etc.

Since NBC has been separated into five sub-areas, two figures are presented for each year-line of pink salmon. Figures 15 and 16 are the same presentation as for the CBC pink salmon (i.e., frequency of surveys to all streams recorded with pink salmon in NBC in each decadal period). However, an examination of the survey coverage shows differences in coverage between sub-areas. Figures 17 and 18 demonstrate the change in coverage over time and within sub-areas.

Figure 15. Percentage of the monitored streams in the Odd-year line of NBC pink salmon that have been surveyed 4 or 5 times (i.e., 80 to 100%), 3 times (60%), or 1-2 times (40% or less) in each decade. Note that the specific streams surveyed do vary over time.

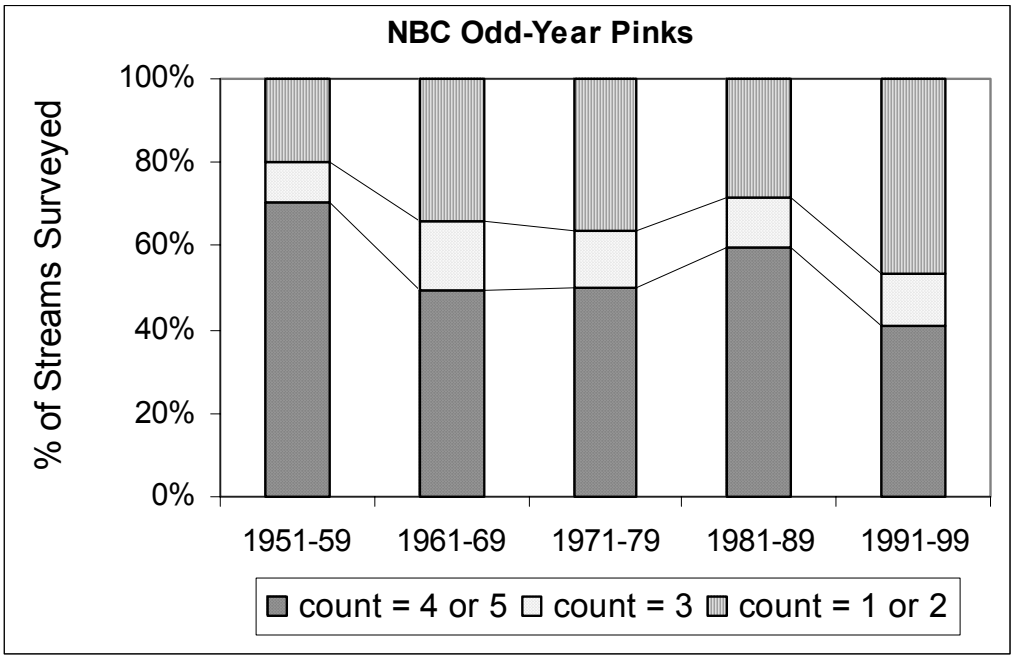
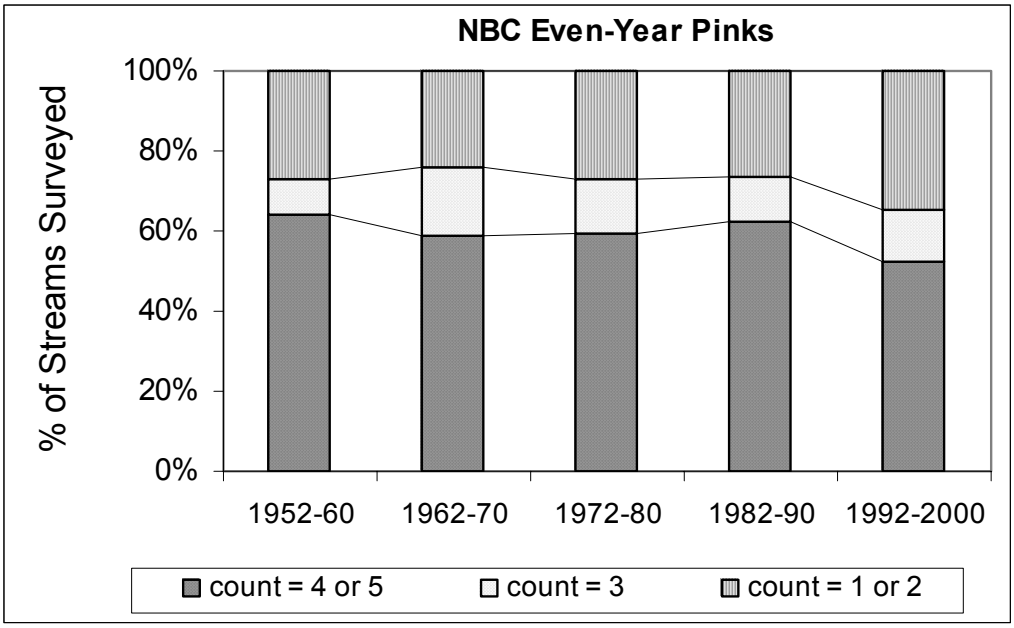


Figure 16. Percentage of the monitored streams in the Even-year line of NBC pink salmon that have been surveyed 4 or 5 times (i.e., 80 to 100%), 3 times (60%), or 1-2 times (40% or less) in each decade. Note that the specific streams surveyed do vary over time.

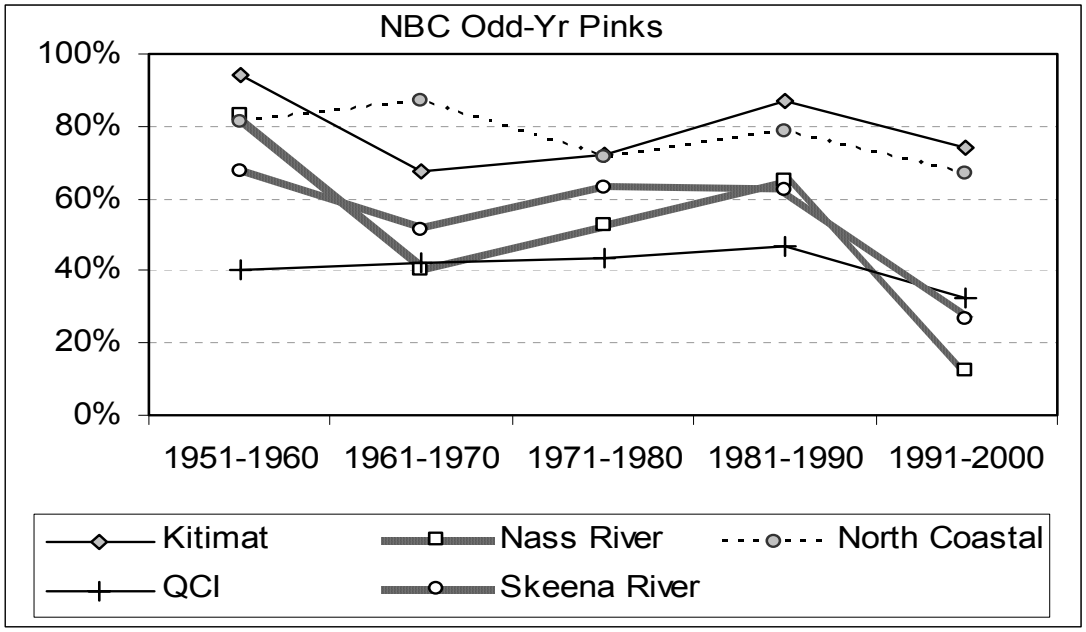


Between 1950 and 1990, about 75% of the pink spawning streams in the Even-year NBC line have been surveyed at least 3 out of every 5 years, but this was reduced to 65% during the 1990s. The frequency of surveys was less and more variable in the Odd-year line but there were still between 63% and 80% of the streams surveyed at least 3 out of every 5 years, and reduced to 53% in the 1990s. As will be shown below, the primary reason for this difference between NBC year-lines is the large number of pink streams on the Queen Charlotte Islands with small numbers of pink salmon estimated to use those streams. As would seem reasonable, the inspections of those streams were less frequent. Overall though, there has been a significant effort invested in monitoring these NBC pink salmon streams.

The frequency of survey coverage does, however, vary between the NBC sub-areas and has generally declined during the 1990 to 2002 period. As noted above, the lower frequency of pink salmon stream surveys in the QCI sub-area during the Odd-year line is evident in Fig. 17 over all five decades. What is also notable though is:

- that there has not been a significant change in the sampling frequencies in the Kitimat or North Coastal sub-areas over this time period, or in the 1990s.
- that the Skeena sub-area maintained about a 60% sampling frequency over the first four decades but has significantly decrease to only 27% during the 1990s.
- that the Nass River sub-area has sampled between 40 and 80% of the streams at least 3 out of 5 years over the first four decades but also allowed a significant decrease to only one in eight streams (12.5%) during the 1990s.

Figure 17. Changes in monitoring frequency by sub-areas and decades in the Odd-year Line of NBC pink salmon. Plot is the percentage of all streams surveyed (i.e., any stream with an escapement record in a decade) in each sub-area that had at least 3 out of 5 visits in a decade.



It should be noted, however, that the Nass River sub-area was only monitoring between 6 and 20 streams for Pink salmon and many of these were very small pink populations. The establishment of the Nisga's Treaty in May 2000, and the programs during the 1990s leading up to this Treaty, may also account for the decline in sampling. New assessment program have been implemented under the Treaty. In 2001, however, only two stream records of pink salmon spawners were reported from the Nass River.

Of more concern than the Nass River sub-area is the decline in survey coverage in the Skeena River. Pink salmon production in the Skeena is significant but frequency of spawning surveys since the early 1990s has decreased substantially. In 2001 only 12 stream records of pink salmon spawners were reported from the Skeena River sub-area (for previous years see Table 6).

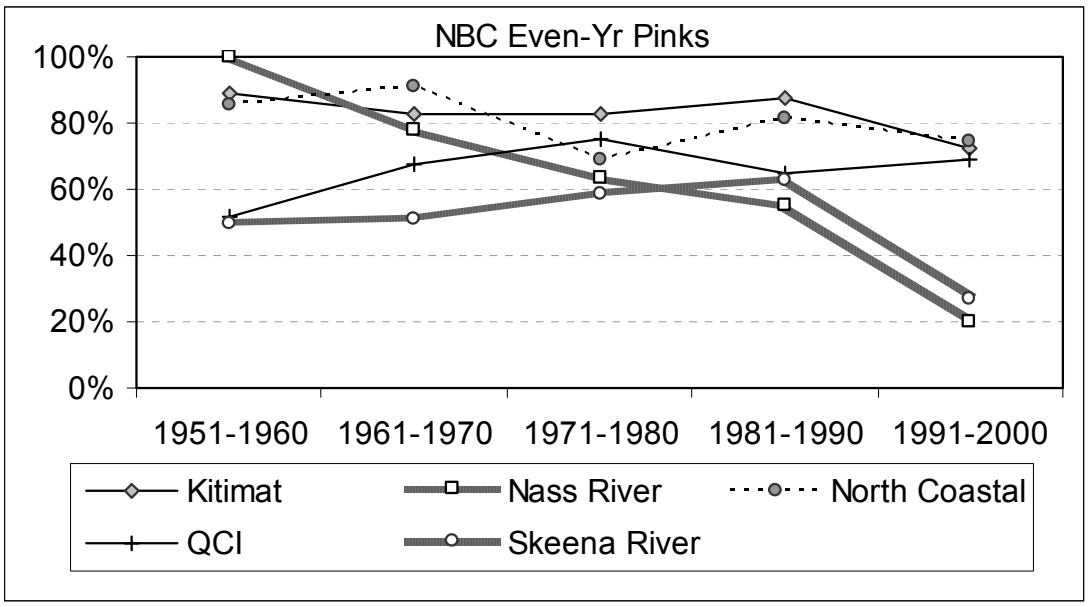
The pattern of change in QCI stream surveys is quite different in the Even-year line for NBC pink salmon (Fig. 18). Rather than a consistent low rate of sampling, the proportion of streams with at least 3 out of 5 years sampled increased to about 75% of the streams and has remained between 65% and 70% during the past two decades. In the Even-year lines of the other NBC sub-areas there:

- has not been a significant change in the sampling frequencies in the Kitimat or North Coastal sub-areas over this time period, or in the 1990s.
- has been a steady decline in the percentage of streams surveyed at least 3 out of 5 years in the Nass River sub-area; but recall the very small number of streams involved in the Nass River (see Table 6).

- had been quite consistent sampling in the Skeena River sub-area (at least 50% of the streams surveyed) until the last decade when the coverage decreased by about one-half.

As noted for the NBC Odd-year line, the most significant concern for changes in the monitoring of pink salmon spawning in the Even-year line is the major decrease within the Skeena River sub-area. The Skeena has substantial pink salmon escapements in both the Odd and Even-year lines, but in both lines assessment coverage of the escapements has decreased substantially.

Fig. 18 Changes in monitoring frequency by sub-areas and decades in the Even-year Line of NBC pink salmon. Plot is the percentage of all streams surveyed (i.e., any stream with an escapement record in a decade) in each sub-area that had at least 3 out of 5 visits in a decade.



Transboundary Rivers (northern BC into SE Alaska)

Six river systems drain from northern British Columbia westward through the southeast Alaskan panhandle. These "transboundary" rivers are (from south to north) the Unuk, Stikine, Whiting, Taku, Chilkat, and Alsek-Tatsensheni rivers. Pink salmon production in these rivers is not well documented but pink salmon are known to use the lower reaches of the Stikine, Taku, and Alsek rivers. Historical records note pink salmon in the lower Canadian portions of the Stikine and a tributary, the Iskut River. Currently, however, there is very little pink production attributed to the Canadian portion of the Stikine River. Similarly, pinks are not reported from Canadian portions of the Alsek or Tatsensheni Rivers. Pink salmon do utilize Canadian portions of the Taku River but the numbers of pinks is relatively small. Records of pink in the Taku River are derived from a fish wheel sampling program at Canyon Island in the lower Taku River and from the Canadian fisheries in that river. The Canyon Island fish wheel is located four kilometers downstream from the international border and has operated as a mark-recapture program since 1984. During that period, the annual catch of pink salmon at the fish wheel has varied from

4.000 to 43,000 during a summer sampling period (Kelly and Milligan 1997). The number of pink salmon spawning in the Canadian portion of the Taku River may be substantial, but the logistics of conducting monitoring programs in this large, glacially-turbid river system are daunting. It may be that a clear water tributary with pink salmon spawning exists in the lower river, but that information was not readily available.

Pink Salmon Summary

Pink salmon are widely distributed through out most of coastal British Columbia. Table 7 summarizes the details presented above.

In recent years there has been an increase in spawning escapements recorded in most of the pink salmon streams that were surveyed. In some areas though, these results are confounded with a significant reduction in the number of streams surveyed (particularly during 2001 and 2002) and the frequency of surveys between years (i.e., during the 1990s). These reductions are in contrast with substantial effort that the Department had directed to maintaining stream surveys during the 1950 to 1990 period. The exact year of reductions will have undoubtedly varied between streams and the 1990 date is only used here as it defines the end of the 1980s decade. Since there is very little quantitative data on pink salmon (outside of the Fraser River and the Atnarko rivers), these historical spawning escapement surveys are the heart of the assessment information on Pink salmon. Changes in the relative size of spawning populations between streams, and within a stream but between years, are the best available indicators of changes in Pink salmon status. The recent changes in escapement monitoring are of particular concern to a long-term monitoring program but in most cases there has been sufficient coverage to allow selection of a sub-sample of streams for future surveys.

Discussion

Pink salmon in British Columbia cover a significant latitudinal range and exist in hundreds of coastal watersheds. This paper has simply identified the diversity of these populations, commented on the annual survey methods used to monitor these streams and the variation in monitoring effort over time. However, it has not considered annual survey methodologies in detail (i.e., number in visits per year, inspection methods, calibration efforts, repeatability of surveys between years within a stream, or the comparability of surveys between geographic areas) or specific habitat issues in watersheds that may affect the suitability of a stream for monitoring. If monitoring the production, or at least the spawning escapement trends, of pink salmon were to be developed as a monitoring tool to study changes in ocean climate and productivity in the subarctic Pacific, these are only a few of the more detailed questions that would have to be considered.

Over time, production in a pink salmon population will be a function of the freshwater and estuary habitats, fishery impacts and density dependent effects in the spawning populations, and variation due to changes in marine environmental conditions. An initial question then is how detailed an assessment is required for one population.

Table 7. Summary comments on distribution of Canadian pink salmon in British Columbia, escapements in Even and Odd-year lines, and methods used for escapement surveys.

Geographic Area and statistical areas	Even Year Line	Odd Year Line	**Survey methods and comments**
Fraser River, Area 29 (100+ spawning sites in Odd-year)	None	**Largest Canadian pink stock. This complex of populations has been the best monitored pink stock in Canada and has estimates for catch, escapement, and population dynamic parameters since 1959. There will be no assessments conducted in 2003.**	
Strait of Georgia and Johnstone Strait (Areas 12-20, 28, and outer 29, 115 streams)	Numerous populations in both lines, most production in northern half of region. Some enhanced production of pink salmon.		**Vast majority of escapement surveys based on visual methods. Recently Koegh River (north east Vancouver Island) has an electronic fish counting system, Province of BC.**
West Coast Vancouver Island (Areas 20-27, max. 85 streams in Odd-years and 119 in Even-years)	Pink salmon mostly distributed in northern half of region and more abundant in Even-year line. Pinks spawning escapements much smaller than in other BC areas.		**Visual escapement surveys and significant reduction in survey effort relative to other BC areas.**
Central BC (Areas 7-11, maximum number of streams noted was 125)	Widely distributed pink spawning populations from areas 7-9, but limited in areas 10-11. Production dominated by Atnarko River pink salmon. Even-year and Odd-year lines approx. equal in production recently.		**Majority of surveys based on visual methods but excellent survey coverage over years. Atnarko River pinks counted since 1971 (see text). Opportunity for developments with local community programs.**
NBC – Kitimat (Area 6, up to 110 streams)	Widely distributed pink spawning populations in both year lines. Contains three of the largest pink populations in recent years.		**Visual methods, Annual survey coverage have been maintained in recent years.**
NBC – QCI (Areas 1, 2E, 2W, up to 137 streams)	Widely distributed spawning populations in the Even-year line, much more limited in Odd-year.		**Visual methods in Odd-years, similar in Even-years, accept that mark-recapture and fences have been used for some Even-years in the Yakoun River. Annual survey coverage has been maintained in Even-years.**
NBC – Nass River (Area 3B, river portion, max. of 20 streams)	Limited pink production in both Even and Odd-year lines.		**Very few streams and surveys. New programs under the Nisga'a Treaty agreement may be implemented.**
NBC- Skeena River (Areas 4B, C, D river portion, up to 78 streams)	Widely distributed pink spawning populations in both year lines. Several streams with large pink salmon escapements. Lakelse River in lower Skeena River is the largest producer in NBC region.		**Visual surveys with the exception of pink salmon counts at the Babine fence. Major reductions in numbers of streams surveyed in recent years.**
NBC – Coastal	**Widely distributed pink spawning**		**Visual surveys with good coverage**

streams (Areas 3A, 4A, 5, up to 109 streams)	**populations in both year lines. Several streams with large pink salmon escapements. Highly diversified habitats in this region.**	**in both Even and Odd-year lines. Annual survey coverage has been maintained in recent years.**

In Canada, stock assessments may be referred to as intensive (e.g., an indicator stock that is monitored quantitatively) or as extensive. The latter involve multiple population assessments that are less quantitative but place higher priority on spatial coverage of many populations and the assessment of spawning trends. The choice of an option depends on the objectives of the assessment, will have very different costs, and need not be mutually exclusive. However, given the broad spatial coverage over the north Pacific, we will initially presume that extensive surveys designed to detect change in trends is most desirable. However, if the freshwater and fishery components are not assessed, this implies the use of multiple streams within a geographic area to "average" the effect of those sources of variability.

For an extensive monitoring program to provide reliable assessments of trends or changes over time, survey and sampling designs still need to be considered. For example, there is an obvious progression of sampling from within a stream to over a large geographic area. The sources of variability in the extensive survey would include:

- precision about the estimation method(s) within a stream and its repeatability between years,
- variability in spawning escapements between streams within a year,
- geographic range of covariation in escapement trends over time and between populations,
- the choice of sampling protocols between years (Would streams be annually selected at random from the full set of streams or should a suite of streams be initially selected and monitored annually?),
- what are the objectives of the monitoring program and how will compatibility of surveys be assessed between agencies?

Over a large geographic area involving many agencies and environments, establishing a common objective for each monitoring program is essential. The procedures used in an area may differ but their monitoring program should strife to meet the common objectives. For example, the objective of the monitoring program throughout the north Pacific could be to detect a 50% change in marine survival within a specified level of confidence (say, with 80% confidence). This level of confidence in the annual assessments will be a major determinant as to whether it is more cost effective, and informative, to develop fewer indicator stocks as compared to the number of extensive surveys needed to detect change.

While British Columbia has a rich diversity of pink salmon populations along the coastal regions, and approximately a fifty-year time series, we have not presumed to recommend a sampling design or conducted any assessment of what may be an achievable objective. Those analyses will require a substantially greater effort than simply this description of pink salmon populations and escapement trends in British Columbia. However, with the continuing reduction of budgets for the Department of Fisheries and Oceans and recent reductions in stream surveys for pink salmon, the need for a careful review of monitoring programs and their objectives is becoming increasingly important.

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