Review & Assessment of

Adult Pink Salmon Enumeration Programs

on the Fraser River

Final Report
for the
Department of Fisheries and Oceans

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1.0 INTRODUCTION

Fraser River pink salmon (*Oncorhynchus gorbuscha*) are an important component of the commercial salmon fishery on the Pacific coast of Canada. The management of stocks of pink and sockeye salmon (*O. nerka*) was, until 1986, the responsibility of the International Pacific Salmon Fisheries Commission (IPSFC). Since that time, the IPSFC has been reorganized into the Pacific Salmon Commission (PSC), and the responsibility for management of Fraser River sockeye and pink salmon escapement goals has been part of the mandate of the Canadian Department of Fisheries and Oceans (DFO).

An important part of the management of salmon stocks is enumeration of adult spawners. The Pearse Commission on Pacific fisheries policy indicated a strong need for new and consistent methodologies to improve estimates of salmon escapements to British Columbia streams, suggesting that a 20% increase in the long-term yield from salmon fisheries could potentially result from more precise escapement data (Pearse 1982). Waldichuk (1984) summarized the management uses of escapement data, and Symons and Waldichuk (1984) recommended that research on the accuracy and cost of various methods for monitoring escapement should be undertaken as soon as possible. Programs to enumerate adult Fraser River sockeye and pink salmon are the product of many years of development by the IPSFC (historical perspectives for sockeye salmon are given in Howard and Chapman (1948) and Schaefer (1951), and for pink salmon are given in Ward (1959) and Hourston et al. (1965)). Enumeration programs considered appropriate to individual populations at different locations have included a variety of methods (e.g., Petersen mark-recapture, and live and dead counts). To facilitate decision-making and planning by DFO as to how to best continue enumeration of pink salmon stocks, IPSFC procedures must be reviewed and assessed. Until recently, there has been little need for extensive documentation of enumeration methods used by the IPSFC. A review and assessment of adult sockeye salmon enumeration programs was conducted recently (Andrew and Webb 1987). At present, there is little documentation on the methods for enumeration of pinks used at different locations in different years, nor on the precision and accuracy of these methods.

The IPSFC has maintained a comprehensive database of all its adult pink enumeration work in the form of summary record cards and paper files of the raw data. For pink salmon, these files span the period from 1957 to the present. The major data source for escapement estimation is the record cards which contain a summary of all the data used to form the estimate, including daily records of live counts, dead pitches, tag application and recovery, and an indication of the methods used to produce the estimate. There is one card for each estimate produced -- for each stream and year; in addition, there are master cards which contain an estimate for a whole system of streams. At present, there are approximately 600 cards for pink salmon, and each card has between 25 and several hundred items of data on it depending on the frequency of visits. In 1985, the data were entered onto Lotus spreadsheets and some simple formats for calculation of estimates were developed.

In this project we provide an unbiased review of the programs for enumeration of adult pink salmon conducted by the IPSFC. This documentation will facilitate the planning of policy direction and budget allocation for enumeration programs by the Management Biology - Operations Unit, DFO.

1.1 Objectives

The overall objectives of this project are to:

1) enter the complete pink salmon enumeration summaries from 1957 to the present into a computer-

ized database which is compatible with both current management practices and future analytical requirements;

2) review and summarize the enumeration methods used;

3) review and summarize the enumeration data contained in the dataset, focusing on the most recent years;

4) examine the precision and accuracy associated with the different methods used; and

5) review experimental design considerations and recommend steps to be taken to attain greater statistical confidence in future enumeration estimates for pink salmon spawners in the Fraser River system.

This report follows the same format as the previous report for sockeye salmon (Andrew and Webb 1987). Since this report will often be read and used independently of the sockeye report, it contains a complete description of the methods, analysis, and computer programs used for pink salmon, although the two reports are very similar in content and repetitive where procedures for the two species were identical. In this report, the differences between the procedures used for pinks and sockeye are indicated where appropriate.

The body of this report is organized into four sections to meet the objectives. The first section is a summary of enumeration procedures used by the IPSFC. The next section is a description of methods used to produce the computerized database and refers to the appendices, which provide documentation of codes used in the database as well as a description of software and data file formats. Following sections provide descriptive and statistical analyses of the enumeration data. The final section provides conclusions regarding experimental design for enumeration of pink salmon, particularly for allocation of effort between streams in the Fraser River system.

2.0 ADULT PINK ENUMERATION IN THE FRASER RIVER SYSTEM

2.1 IPSFC Field and Analysis Procedures

A wide range of salmonid escapement estimation methods have been used by the IPSFC. These range from very simple counting methods to complex tagging programs. The methods can be broken into those based on:

1) counting fish through a fence, fishway, or weir;

2) tagging live fish and recovery of tags on dead fish;

3) visual counts of live fish in the system;

4) dead pitches and counts of carcasses; and

5) other miscellaneous methods.

Generally, the most effective method of enumerating adult fish is to count each one through a facility at a fence or weir. The main drawback of this method is the expense of the permanent facilities required. In some smaller streams, it is possible to use temporary fences which are relatively inexpensive and do not have to be maintained through high flow periods. Although fence counts are the best approach to obtaining accurate estimates, some potential sources of bias include misidentification of species or sex, avoidance of the counting facility, and recirculation back over the fence or weir leading to double counting of some fish.

It has been assumed that tagging live fish and the recovery of tags from carcass surveys provides the most statistically defensible estimates. The general approach of the IPSFC has been to conduct tagging programs on streams with relatively large populations. In order to minimize costs on streams with smaller populations, however, the general approach of the IPSFC has utilized relatively low cost indexing methods and then calibrated these with more intensive tag recapture programs.

Prior to the pink salmon spawning season each year, IPSFC personnel plan which methods to use for enumeration of pink populations in streams of the Fraser River system, and then plan allocation of effort by field crews between spawning streams.

2.1.1 Choice of Method

Pre-season planning of which enumeration method to employ at each stream is dependent mainly upon the method used in previous years. Previous years' data are used to predict the size of the spawning runs in the various streams. Petersen methods are generally chosen if the population is predicted to be greater than 25,000 fish. If the population is lower than this level, live and/or dead counts are used to enumerate the population. Streams are divided into general classifications based on the predicted size of the run, and the enumeration method is chosen based on the general classification system of streams given in Table 1. A second reason for using the Petersen method on streams with high escapement is that these streams are usually major rivers within the Fraser River system in which live counting of pink salmon is often relatively difficult.

The basis for the decisions on which enumeration method to use for pink salmon is similar to that for sockeye salmon. In the case of pink salmon, the methods used from year to year on individual streams are more consistent than for sockeye salmon, due to the relatively consistent size of the escapement of pink salmon to individual streams. This is due to differences in the lifecycles of these species. Pink salmon have a two year lifecycle, and spawning occurs in the Fraser River system every second year. Therefore, populations spawning in individual streams are composed of offspring of the previous spawning population at that location. In the case of sockeye salmon, there is a four year lifecy-

Table 1. Enumeration methods used for particular classes of streams.

Stream type	Enumeration method
Large population (> 25000), closed system	Petersen, sexes separate
Large population	Petersen, sexes separate for males and females
Large population, strays to other streams	Petersen, sexes separate, but subtract stray tags from tags available
Large populations in a complex of streams where it is not possible to perform tagging study on separate streams due to high degree of straying	Petersen, sexes separate on the complex, subtract out populations of streams with separate enumeration
Medium population, or large population but limited access to stream	(Peak live count + cumulative dead) x factor
Medium population, closed system	Dead recovery x factor
Spawning channel	Total dead recovery

cle, which results in a four year cycle in the size of escapement to individual streams as well as the method of enumeration employed.

Once data are collected and submitted for analysis, population estimates are made based on standard calculations. Observations made by field crews, however, regarding presence of predators in the vicinity of the spawners, the weather conditions, or other factors that influence live counts or dead recovery may affect the calculations and/or the confidence the biologist has in the calculated estimate. These observations are based on the experience and intuition of personnel, and may affect opinion as to whether the estimate based on calculations from data is too high or too low. For example, flooding may produce an artificially low dead recovery by washing carcasses out of the stream prior to counting. Water conditions may affect live counts; for example, live counts in turbid or wind-rippled water will be lower than in calm water. When water or weather conditions render certain enumeration methods less reliable, an estimate from a method generally considered to be less reliable may be accepted to be the best. Under very poor conditions or in remote areas, a visual estimate by field crews, other agencies, or local residents may be accepted as the best estimate.

2.1.2 Choice of Sex Ratio Method

Several different methods of determining the sex ratio of the spawning populations have been used by the IPSFC. The sex ratio method usually paralleled the method of enumeration. In sexes separate Petersen estimates, the sex ratio was calculated by separate population calculations. In live and dead count methods or for populations with low dead recovery due to predator activity or other factors, the sex ratio was often accepted to be the same as the sex ratio for another area nearby that was enumerated by Petersen estimate or a composite of areas nearby. In dead recovery methods and live count plus cumulative dead methods, the sex ratio was often determined by relative dead recovery of males and females. The sex ratio was usually assumed to be 50:50 for males and females in populations where there was little or no dead recovery, or where no other nearby areas provided sex ratio.

2.1.3 Planning and Scheduling of Field Crews

During pre-season planning, a preliminary schedule is set for the field crews. This schedule incorporates the predicted timing of spawning runs based on past years' data, and the amount of effort required to enumerate the various streams according to the planned enumeration methods. The number of fish to be tagged in the various tagging programs is determined to be 1% of the predicted run size. This schedule is altered during mid-season when the timing or size of runs is not as predicted. The field season commences in July to enumerate the early runs in the Stuart district.

The effort required by field crews in different districts varies with the number of streams in each district and the escapement to those streams. Specific numbers of field personnel are given in Section 2.2.

2.1.4 Petersen Method

The formula used by the IPSFC for calculating Petersen estimates is as follows (Ricker 1975):

$$\text{Population estimate} = \frac{\text{Total dead recovery} \times \text{Tags available}}{\text{Tag recovery}}$$

The IPSFC corrects the number of tags available for tagged fish straying to other streams by subtracting the number of strays recovered from the number of tags applied. Stray tags are estimated when the number of strays is assumed to be greater than the number of stray tags recovered, perhaps due to a relatively low dead pitch, as follows:

$$\text{Calculated tags strayed to stream A} = \text{Population of stream A} \times \frac{\text{Tag recovery in streams composite}}{\text{Dead recovery in streams composite}}$$

Or, where it was too difficult to live count pink salmon (e.g., Adams River), as follows:

$$\text{Calculated tags strayed to stream A} = \text{Population of stream A} \times \frac{\text{Tag recovery of sockeye}}{\text{Dead recovery of sockeye}}$$

The calculated number of strays is then used in place of the actual number of stray tags recovered.

The proportion of tags recovered among the pitched fish may vary between field crews, depending mainly on the experience of the crew and the condition of the fish (e.g., heavy fungal infections). The number of missed tags among the pitched fish can greatly affect the Petersen population estimate. To determine the proportion of missed tags, repitches were often conducted. This procedure involved rechecking the pitched fish for tags on a regular basis (when tags are found initially they are removed from the fish). Among fish with heavy fungal infections, tags are often more readily seen on older carcasses due to drying out of the fungus. The number of missed tags is calculated as follows:

$$\text{missed tags} = \frac{\text{tags recovered in repitch}}{\text{repitched fish}} \times \text{pitched untagged fish (uncorrected for repitch)}$$

The missed tags are then added on to the tag recovery.

On the data card for each stream, recoveries of both local tags and Glen Valley tags are recorded. Local tags are from tagging on that stream or a nearby stream, and Glen Valley tags are from tagging on the Fraser River mainstem. On almost all cards, except the Fraser River mainstem cards, the number of dead untagged includes the number of Glen Valley tag recoveries. In other words, Glen Valley tagged fish are accounted for twice on the backs of the cards. Similarly, tagged fish straying from other systems are accounted for in untagged dead columns. Any fish listed in the local tagged fish columns on the cards are not accounted for in the dead untagged columns as well. In the case of the Fraser River mainstem cards, Glen Valley tagged fish are not included in untagged dead columns.

Although most streams were enumerated separately, some streams were enumerated together using pooled tags available (applied on the main stream), dead recovery, and tag recovery in one Petersen calculation. For this report, we have called such groups of streams "complexes". The streams that were often handled in this way were the Chilliwack-Vedder River and Sweltzer Creek, the Harrison River and the Chehalis River, Seton Creek and Cayoosh Creek, and the Thompson River with Nicola, Bonaparte, and Deadman creeks. Usually the streams other than the main stream were also enumerated independently by peak live count plus cumulative dead. The population estimate for the main stream (where tagging was performed) was then calculated by subtracting independent estimates of the other streams from the Petersen estimate for the complex.

The method of enumeration used on the Fraser River mainstem is described in Section 2.2.1.

2.1.5 Live and Dead Count Methods

Most pink salmon spawning populations in the Fraser River system are enumerated using live and dead count methods. The method most commonly used by the IPSFC is based on the following algorithm:

1) regular live counts are made in the spawning areas as fish move in;

2) as carcasses start to occur they are pitched regularly;

3) the peak live count is selected; and

4) this peak live count plus the cumulative dead pitched to that date are multiplied by a factor determined from tag recapture experiments to produce an estimate of the escapement.

This type of calibrated method is a practical approach to the problem of obtaining defensible estimates at a minimum expenditure of effort. If carcasses are "locked into" particular streams, only a small effort is required to recover a large proportion of the carcasses. Partial live counts from separate days may be summed to produce a "peak" live count. Field crews often choose days for live counts when visibility is best.

The calibration factors used in this method were determined through comparison of peak live count plus cumulative dead pitch with separate sexes Petersen estimates, as follows:

$$\text{factor} = \frac{\text{Petersen estimate}}{\text{peak live count + cumulative dead}}$$

During 1957, from studies on the Chehalis River (Ward 1959), the factor was determined to be 2.6. This factor was applied to other streams in 1957. In 1959, studies in Jones and Seton creeks confirmed the magnitude of this factor. With few exceptions, it has been used on pink salmon spawning streams throughout the Fraser River system. A similar study on the Coquihalla River in 1959 determined the factor to be 5.2, and this factor was used on the Coquihalla River populations in 1959, 1961, and 1963. The factor 5.3 was applied on the Nicola and Stave rivers in 1959.

The pink salmon factor 2.6 was larger than the ones derived for sockeye salmon (usually 1.8 for sockeye; Ward 1959). Reasons for this difference may include lesser visibility of pinks in turbulent water resulting in a lower percentage of those present being live counted, or the number of fish present at any one time formed a smaller proportion of the total run. The prolonged character of pink salmon spawning runs indicates that there are probably fewer fish relative to the total escapement on the spawning grounds at any one time compared to sockeye salmon.

For accurate estimates of pink salmon spawners, the factors 2.6 to 5.3 are high for some streams and low for others. Some streams retain a higher portion of their carcasses; therefore, the peak live count plus cumulative dead provides a count of virtually all fish in the population, and application of a factor causes the estimate to be too high. On other streams, carcasses may be washed out resulting in a low dead pitch and low population estimate. In either case, the error should be consistent from year to year and the continued application of these factors ensures that the trends in population estimates of individual streams are the same as those in the real populations.

2.2 Pink Spawning Streams

Each year, the IPSFC enumerates pink spawner populations in approximately 50 streams in the Fraser River system. These streams are grouped into eight geographic districts (Table A.1, Appendix A). The purpose of this section is to give a brief overview of the major features of the enumeration districts, including the major streams, special structures such as spawning channels, most commonly used enumeration methods, and considerations for operations of field crews. Much of the information in this section is from personal communication with R. Kent and F.J. Andrew. Methods used for escapement estimation and resulting escapement estimates of all streams from 1957 to 1985 are listed in Tables C.1 and C.3 (Appendix C), respectively.

2.2.1 Lower Fraser District

In the Lower Fraser District, the stream with the greatest number of spawners is the Fraser River mainstem. Since 1963, these spawners have been enumerated by tagging at Glen Valley and/or Duncan Bar and dead pitched throughout the Fraser system (Davis 1967). The number of available tags is calculated by subtracting lost and stray tags from the tags applied, and the Petersen calculation is performed on separate sexes dead pitched in the Fraser River system. Sources of lost and stray tags include biased tag loss, losses to the commercial and Indian fisheries, and stray tags recovered in tributaries of the Fraser River. Biased tag loss is assumed to be 5% of the tags applied. The commercial fishery usually removes less than 100 tags per year. Prior to the mid 1970s, there was an insignificant Indian fishery for pink salmon in the Fraser River. Since that time, however, fishing intensity by Indians has increased and tags removed by the Indian fishery have been accounted for in the tag losses. (In some years, the Indian tags were included in the Petersen calculation, but then the portion of the spawner population was subtracted from the final population estimate.) The main source of lost tags from the Fraser River is "straying" of tagged fish to tributary rivers and streams. Either the number of stray tags recovered or the calculated number tags recovered are subtracted from the tags available. The method of enumeration of Fraser River pinks from 1957 to 1961 was similar to the method used in later years, but stray tags to other streams were not subtracted from the tags available, and the Petersen calculation was performed on the dead pitch throughout the Fraser system. To estimate the number of spawners in the mainstem, the separate estimates for all other streams were then subtracted from the overall estimate. The field crews enumerating the Fraser mainstem use the Harrison cabin and boat launch. Crews are composed of approximately eight persons and include fishermen from the Fraser River fishery.

The expertise of the fishermen in boat handling on the Fraser River is a valuable asset the crew.

Numerous streams in the Lower Fraser District have smaller populations than the mainstem and are enumerated by the peak live count plus cumulative dead count method. These streams are enumerated by a roving crew of two to three persons working out of the New Westminster office. This crew also covers the Fraser Canyon and Upper Fraser District streams.

2.2.2 Chilliwack-Vedder District

The most important streams in the Chilliwack-Vedder District are the Chilliwack-Vedder River and Sweltzer Creek. The Chilliwack-Vedder River is enumerated using the Petersen method. This method is used due to the high escapement (over 25,000 fish), but also because the high turbidity of the water would preclude live counting of spawners.

In some years, Sweltzer Creek is included with the Chilliwack-Vedder River in the Petersen estimate instead of subtracting the stray tags recovered, but in most years, Sweltzer Creek is enumerated by peak live count plus cumulative dead. Other streams in the Chilliwack-Vedder District are enumerated by peak live count plus cumulative dead pitch.

Field crews of three to four persons are employed for tagging and dead pitching of the Chilliwack-Vedder River. The crews used the Sweltzer cabin in past years, but now use the Cultus Lake laboratory as a service area for the Chilliwack-Vedder River and Sweltzer Creek enumeration.

2.2.3 Harrison District

The most important stream in the Harrison District is the Harrison River, and secondarily the Chehalis River. There is a spawning channel at Weaver Creek. Due to the relatively high escapement to the Harrison River, enumeration is by the Petersen method. The Chehalis River and other small streams in the district are enumerated by peak live count plus cumulative dead. Weaver Creek proper is enumerated by dead recovery multiplied by the sockeye recovery rate, and the Weaver spawning channel is enumerated by total dead recovery.

The field crew enumerating the Harrison River shares the cabin at Harrison Mills with the Fraser River crew. The Weaver Creek area is enumerated by a separate crew of one to two persons. Until recently, this crew used the Weaver cabin located at the spawning channel, but now the cabin is used only for spawning channel work. Other streams in the district are covered by the roving crew out of the New Westminster office.

2.2.4 Fraser Canyon District

The most important streams in the Fraser Canyon District are the Coquihalla River and Jones Creek. There is a spawning channel and cabin at Jones Creek. The Coquihalla River is usually enumerated by peak live count plus cumulative dead, but due to a recent increase in population size, in future years the escapement may be enumerated by the Petersen method for a more accurate estimate of the population. The numerous small streams in the district are enumerated by peak live count plus cumulative dead, with the exception of the Jones Creek spawning channel which is enumerated by total dead recovery.

The streams in the Fraser Canyon District are covered by a roving crew of two to three persons working out of the New Westminster office.

2.2.5 Seton-Anderson District

Seton Creek is the most important stream in the Seton-Anderson District. Portage Creek and Bridge River also have relatively large spawning populations. There are two spawning channels on Seton Creek, which were installed in the 1960s. The lower channel has a larger escapement than the upper channel. Seton and Cayoosh creeks are usually enumerated as a complex by the Petersen method. Strays from the tagging program for this complex (mainly to Portage Creek and Bridge River) are subtracted from the tags available and the Petersen calculation is performed on dead and tag recovery in Seton and Cayoosh creeks. In most years, the estimate for the Seton-Cayoosh complex is apportioned between the two creeks by subtracting out a separate estimate for Cayoosh Creek obtained from peak live count plus cumulative dead, but in years when Cayoosh Creek is too turbid to live count, the estimate for the complex is not apportioned between the creeks. The spawning channels are enumerated by total dead recovery.

Although Bridge River has a relatively high escapement, access to this stream is difficult; therefore, the population is enumerated by live count plus cumulative dead. In future years, the Petersen method may be used to more accurately estimate the escapement. Other streams in the district are enumerated by peak live count plus cumulative dead.

The migration and spawning location of pink salmon in the Seton-Anderson District is determined, in part, by hydroelectric developments on Seton Creek and Bridge River. There is a B.C. Hydro dam on Seton Creek, and water is diverted from Seton Lake above the dam to a powerhouse. Fish migrating upstream in the Fraser River to the Seton-Anderson District aggregate in the powerhouse tailrace due to attraction to their diverted homestream water (Fretwell 1984). Tagging for the Seton-Cayoosh complex is conducted in the tailrace. After the construction of the Seton Dam, Cayoosh Creek was diverted into Seton Lake for power production at Seton Dam. The diversion, which contributes only minor flows, was halted in the 1960s following the construction of the Bridge River Dam which discharges into Seton Lake. Studies of migration patterns of pink salmon with respect to the Seton powerhouse diversion prompted the reactivation of the Cayoosh diversion into Seton Lake (Fretwell 1984). The Cayoosh water tends to attract pink salmon to the fishway at Seton Dam and to their spawning grounds in the above-dam areas of the Seton-Anderson District to homestream water and away from the powerhouse tailrace (Fretwell 1984).

There is an electronic fish counter located on the fishway at Seton Dam. Although the counter was installed with the intention for enumerating pink and sockeye salmon, it is not appropriate for enumeration of pink salmon because a high proportion of the pink salmon passing upstream are swept over the dam and recounted when they pass upstream through the fishway again.

Many pink salmon that spawn above the Seton Dam drift back to the dam as fatigued or dead fish. Often these fish become lodged against the screens at the canal intake. These screens must be cleaned periodically by back flushing while the Seton powerhouse is shut down. Pink salmon are often washed out of the above-dam area through the fishway or over the spillway of the dam, and are recovered for enumeration purposes in Seton Creek below the dam.

There is a crew of six persons working in the Seton-Anderson District. Field crews working in the Seton-Cayoosh area oversee the adequacy of fish passage past the Seton Dam, maintenance of stipulated minimum flow requirements in Seton Creek below the dam, and adequacy of flows through the Cayoosh diversion tunnel to Seton Lake. The relatively small population of pink salmon in Gates Creek is enumerated by the operator of the Gates Creek spawning channel (the channel is for sockeye salmon). There is a cabin at Lillooet which is used by field crews working in this area.

2.2.6 Thompson District

The Thompson River mainstem is the most important spawning location in the Thompson District. This stream is usually enumerated in a complex with Nicola, Bonaparte, and Deadman creeks by the Petersen method. Tagging is conducted in the Thompson Canyon, approximately seven miles upstream of Lytton. Carcass recoveries are made from Kamloops Lake downstream to Spences Bridge. Nicola, Bonaparte, and Deadman creeks are enumerated separately by peak live count plus cumulative dead, and the population of the Thompson mainstem is calculated by subtracting the creek populations from the estimate for the complex. Other streams in the Thompson District (e.g., Adams River, Little River, and South and North Thompson rivers) are enumerated by peak live count plus cumulative dead.

In some years, the Thompson River and other streams in the complex were enumerated by live counts from towers constructed at Big Horn. Big Horn is located upstream of the Thompson Canyon. Towers on each bank were 15 feet high, and the river was illuminated for night counts by lights on 25-30 foot booms which swung out over the river. Although counts were made every second 15 minute interval, counts were unreliable due to fish skirting the illuminated area. This method of enumeration was abandoned for this reason as well as the expense of the operation.

Enumeration in the Thompson District is conducted by a crew of six persons, which works out of Cache Creek or local motels in the district. Crews survey the Thompson River by boat from road access points at Savonna at the upstream end, as well as Walhatchen, Juniper Beach, Spences Bridge, and other locations.

2.2.7 Upper Fraser District

There are numerous streams in the Upper Fraser District with relatively small escapements (e.g., the Stein, Churn, and Quesnel rivers). Streams in this district are enumerated by peak live count plus cumulative dead, or estimates of escapement are provided from DFO helicopter surveys. In 1967, the small number of pink salmon in the upper Fraser River mainstem were enumerated by a tagging program at Bridge River Rapids fishways, and strays to the Seton-Anderson system were subtracted from the total tags available.

Enumeration throughout the Upper Fraser District is conducted by roving crews of two to three persons out of the New Westminster office.

2.2.8 Burrard Inlet District

The Indian River in the Burrard Inlet District was surveyed in 1957 and, although there was a relatively high escapement, since then populations have been insignificant and surveys were not continued. The Burrard Inlet is not part of the Fraser River system.

3.0 METHODS OF DATA ENTRY AND MANAGEMENT

The importance of data management is frequently underestimated in fisheries studies. In projects such as this, however, data management is one of the most important considerations. It is extremely important that the database be validated, verified, and maintained in an accessible form; otherwise it would be of little utility for data analyses in this and other studies. A total of 15 years of pink salmon escapement data (1957 - 1985) were entered and verified. Data entered to the database included raw data from daily summaries, the method used to calculate the population estimate, the final population by sex and total estimates, as well as other information pertinent to the population, such as run timing. By including the raw data in the database, the population estimate could be recalculated once the data were entered, thereby checking both the original calculations on the data card and the accuracy of the data entry. Described below are data sources, methods of data coding and entry, coding and entry of streams in complexes and the Fraser mainstem, verification, storage, and analyses.

3.1 Data Sources

The main data source for the database was IPSFC data cards. Cards were for individual streams and years, and contained daily summaries of live counts, dead pitch, and numerous other data. In cases where data were ambiguous, arithmetic discrepancies occurred, or where data were missing, daily summary sheets and raw data forms (filed in binders) written by field personnel were checked to validate the data. In addition, meetings with key personnel from the former IPSFC provided information for this report, particularly regarding IPSFC procedures in the field and in analysis of the data.

3.2 Coding

Prior to data entry, all cards were reviewed by the project biologist and certain data were coded for purposes of brevity in the computer files. Codes were assigned to the district, stream, substream, and the method used to calculate the population estimate. These codes are listed in Appendix A. The coding of the method of escapement estimation was critical since there were many variants of the basic methods. The approach used was to first determine the basic method and any factors that were used directly with the method of calculation (a maximum of three were allowed), and then determine what adjustments, if any, were made to account for various special conditions. The procedure for coding the methods of enumeration for streams enumerated in a complex are discussed later.

Several types of adjustments were made in the calculations of enumeration estimates. These adjustments were applied to totals of dead recovery, tags available, tags recovered, or the final population estimate. Adjustments were often sex-specific. In data entry, adjustments were entered as the letter code of the appropriate adjustment shown in Table A.3 (Appendix A) concatenated with a numerical suffix in the amount of the adjustment.

Codes were also assigned to species, sex ratio source, live count source, and common words used in the remarks fields (Appendix A). Comments recorded in the remarks fields included points that were relevant to the population estimate, such as coverage by helicopter, high or low water (affecting dead recovery), and poor visibility (producing high counts).

3.2.1 Stray Tags

One way in which the pink salmon data were coded and entered that differed from the procedure for sockeye salmon is the way that stray tags were coded. In the case of pink salmon, the recovery of stray tags was coded with the data for the recovery location, and the number of male and female tags was entered in the format "m__f__". The number of strays recorded was the number used in calculations, whether this was the actual number recovered or the estimated number recovered (i.e., the number recovered x dead pitch rate). In the case of sockeye salmon, strays were coded as an adjustment with the data for the stream where tags were released.

3.2.2 Stream Complexes

Streams in the same complex were coded with the district, stream, and substream of the main stream where tags were released. This location code indicated where "local" tags recovered at each stream were released. The streams in one complex were then identified by first identifying the main stream (i.e., district, stream, and substream were the same as the location codes for the release stream), and then searching through the data for streams coded with the same release stream.

3.2.3 Fraser River Mainstem

The Fraser River mainstem was enumerated by Petersen estimate independently from other streams and not as a complex. There were numerous strays from the mainstem to other streams, however, which reduced the number of tags available for tag recovery in the mainstem. Special methods were used to record the strays from Glen Valley tagging. Glen Valley tags recovered were recorded in columns labelled as such, and if the card showed that the number of tags was estimated (i.e., total number of tagged strays = recovered tags x dead pitch rate), then the total number was entered as adjustment "X". Where repitches of Glen Valley tags were conducted, an adjustment ("RG") was applied to the number of tags recovered, but where the card indicated that an expansion of the number of tags recovered in addition to a repitch, the number of tags recovered in the repitch was accounted for in the "X" adjustment.

3.3 Data Entry System

The data entry system constructed used the Lotus (Version 2) software package for data entry. One spreadsheet was used for the entry of each data card (each stream and year), but the data from each data card was then saved into a flat file rather than as a Lotus worksheet to facilitate analysis. The format of the data entry program is given in Appendix B. The major advantage of using Lotus spreadsheets for data entry was that the system was designed to be menu-driven to allow easy access to the different sections of the spreadsheet, cursor movements were restricted to labeled fields for data entry, and saving of data in standard formats was handled automatically. In addition, streams with special cases of data adjustments were handled easily. A more complete description of the data entry system is given in Appendix B.

3.4 Data Storage

Once data entry for each stream was complete, data from the Lotus spreadsheet were saved in flat files. Although data were erased from the spreadsheet once saved in flat files, the data entry system allowed retrieval of data for a specified stream back onto the spreadsheet for further viewing, as well as replacement of the records for that stream in the flat file. Data from the spreadsheet were grouped into five different line types in the flat files. The formats of the flat files for data storage are given in Appendix B. For each year of data, two files were created -- one for the raw data and another for summary data. The major advantage of using flat files rather than spreadsheets for data storage is that it is much easier to produce summaries of streams across years and to compile summaries of annual data. Other advantages are that flat files have a much lower storage requirement than Lotus spreadsheets and are more accessible by other computer systems and Fortran programs. The data occupy less than 100 kilobytes per year resulting in a total storage requirement on the order of 1.5 megabytes.

It is important to recognize that the inclusion of raw data in this database makes it somewhat unique among escapement databases, and it provides the advantage that population estimates may be reconstructed from the data. If decisions are made in the future regarding availability factors or calibration factors between Petersen estimates and estimates from live and dead counts, new estimates are easily reconstructed with minor changes to the program "chekpink".

3.5 Verification

Verification of data pertaining to population estimation was performed by reconstructing the population estimates from the raw data entered and comparing the values to the final estimates from the data cards by sex and total. A program (called "chekpink"; see Appendix B) was written in Fortran 77 that read in the raw data from the database and reconstructed the population estimates according to the data and method codes that were input. This allowed checks for errors in data entry, the understanding of the method of estimation, and in the original data cards.

Once this verification step was completed, summary tables for each year were produced from the raw data files, and these were used to produce data summaries and to carry out the analysis of the levels of precision and accuracy in the estimates of escapement to streams, districts, and the whole Fraser River system.

Data not pertaining to population estimation were not verified. It should be recognized that prior to analyses of timing of arrival and peak dates of spawning, percent spawn, temperature (particularly with respect to location and time of the measurement), water gauge levels, and marine tags, these data should be verified.

3.6 Analyses

Descriptive analyses were conducted using the summary files and the Lotus system. Statistical analyses were conducted using Fortran 77 programs to access data in the summary files. The Lotus graphics package was used to produce figures.

4.0 DESCRIPTIVE ANALYSIS OF THE DATA

Fifteen years of pink escapement data were entered into the database (a total of 674 separate escapement estimates). In several cases during verification of the data, it was not possible to reconstruct the population estimate for individual streams exactly. In estimates of small populations, discrepancies were often due to rounding of integers. In streams with larger escapements, the average deviation of the reconstructed estimates from the estimate on the data cards (deviation of one stream = absolute value ((reconstructed population estimate - estimate from card) x 100/estimate from card)) was only 1.33%. All reconstructed estimates were within 10% of the value entered from the data card.

The purpose of this section is to summarize important parts of the database and provide examples of the types of information contained in the data. Using the computerized database, such summaries are produced easily. Data that have been analyzed in this section include escapement estimates, methods used for estimation, strays, and mark rates. In some of the analyses, only the most recent two years (1983 and 1985) and two earlier years (1959 and 1961) were used. We did not use 1957 in these analyses because it was the first year of enumeration of pink salmon by the IPSFC and some procedures may have been different than those used in later years. In some of the analyses, the ten streams with the largest overall escapement (over the 15 years of data) were used.

4.1 Escapement

Virtually all the escapement of pink salmon to the Fraser River system each year spawns in less than ten streams (Figure 1). In 1985, the escapement to the Fraser River mainstem comprised over 80% of the total escapement, and the combined escapement to the Fraser River mainstem,

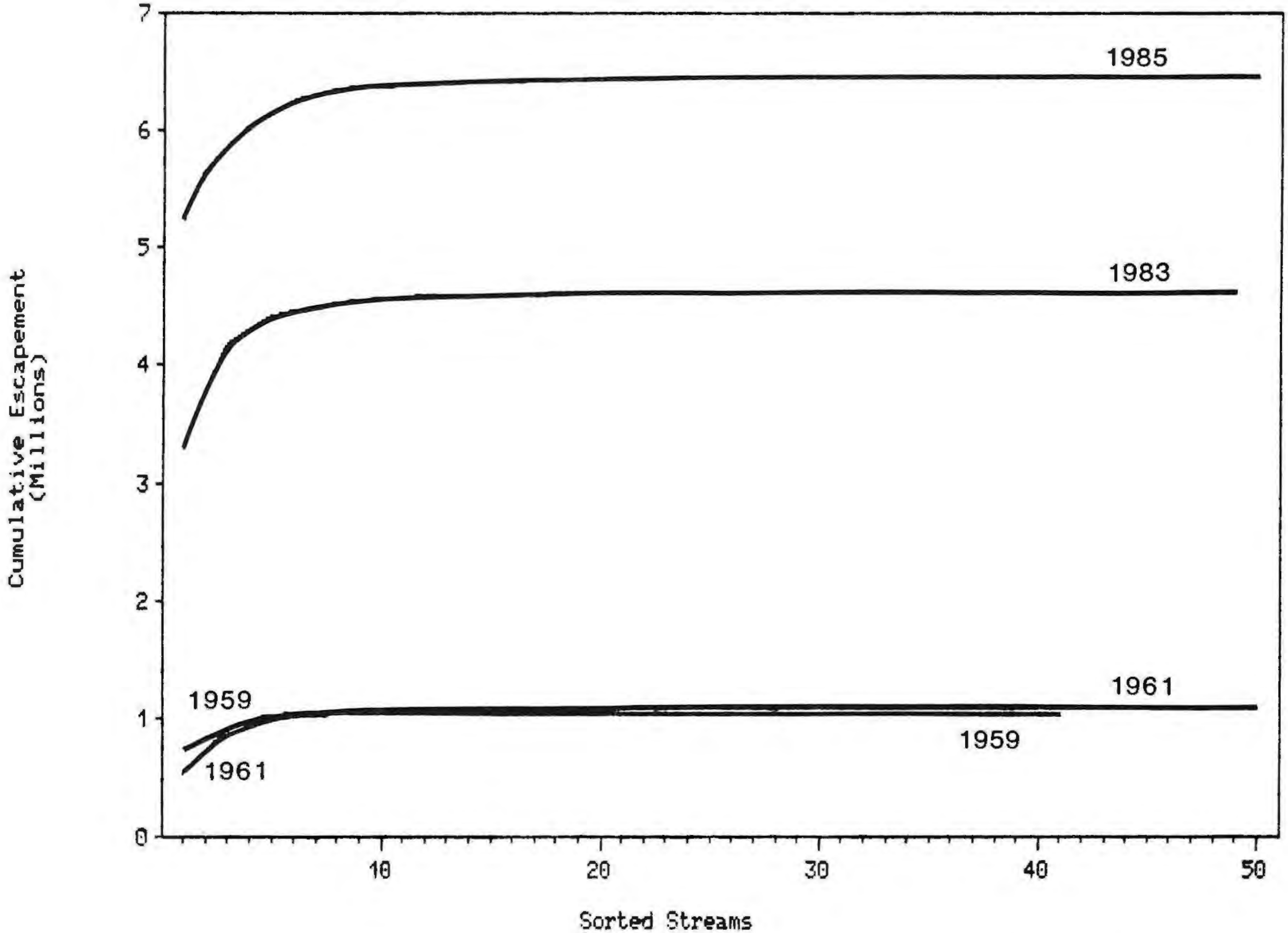


Figure 1. Cumulative escapement of pink salmon to streams in the Fraser River system for selected years. (Streams are sorted in descending order of population size. The first stream is the Fraser mainstem.)

the Harrison River, the Thompson River, Seton Creek, the Coquihalla River, and the Chilliwack-Vedder River comprised over 95% of the total escapement (Figure 2; Table C.3 in Appendix C). In recent years, the total escapement has increased markedly from the escapement in 1959 and 1961 (Figure 1), although the trend in relative abundance between streams has remained the same (Figures 2 and 3).

4.2 Methods of Escapement Estimation

In the database, methods of escapement estimation were coded according to the specific method used out of a possible 30 methods used for pink salmon (Table A.2, Appendix A), according to criteria outlined above in Section 2.1. A summary of these methods is given for all streams and years in Table C.1, Appendix C. These methods were categorized into seven groups of method types for purposes of analysis (Table C.2, Appendix C). There was a trend with population size in method type used for enumeration (Figures 4 and 5). Large populations (usually > 25,000 fish) in single streams (method group 1) or complexes (method group 2) were enumerated using Petersen tag recapture programs. Most streams with intermediate population sizes were enumerated using live and dead count combination methods (mainly method 12, as well as other methods in method group 3). Live count methods (method group 4) and dead count methods (method group 5) were used at weirs and spawning channels, respectively. Each year, a few streams observed by field crews had no fish present (method 20, method group 7). The same method (Table C.1) or a method from the same method group (Table C.2) was used on individual streams from 1957-1985. Many streams in the comprehensive list of streams enumerated (given in Table A.1, Appendix A) were only enumerated in one or a few years from 1957 to 1985.

4.3 Tag Recoveries and Stray Tags

Several tagging programs are conducted each year in the

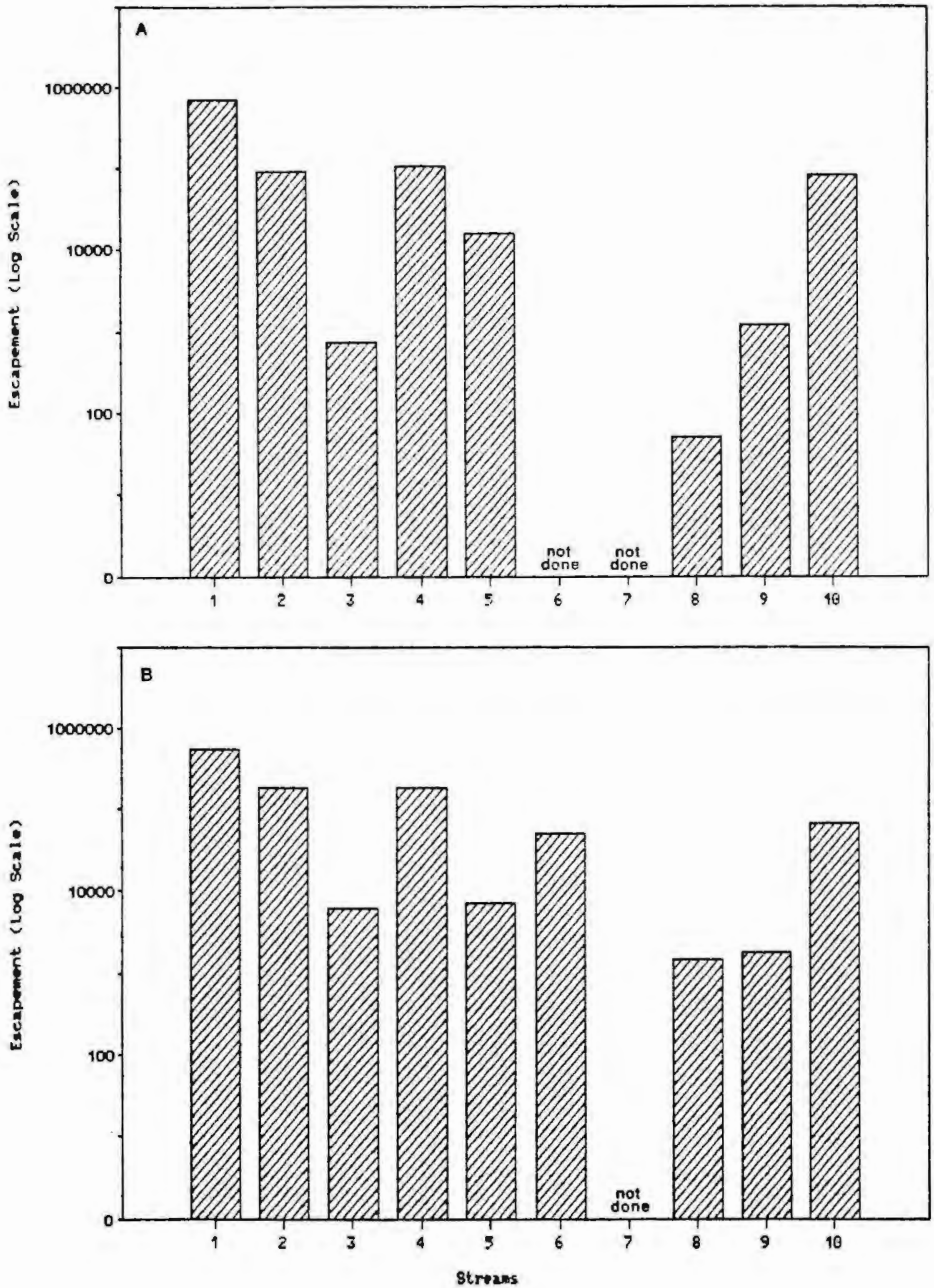


Figure 2. Pink salmon escapement to some major streams in the Fraser River system; 1959 (A), 1961 (B). (For stream names, see legend on page32. Note log scale.)

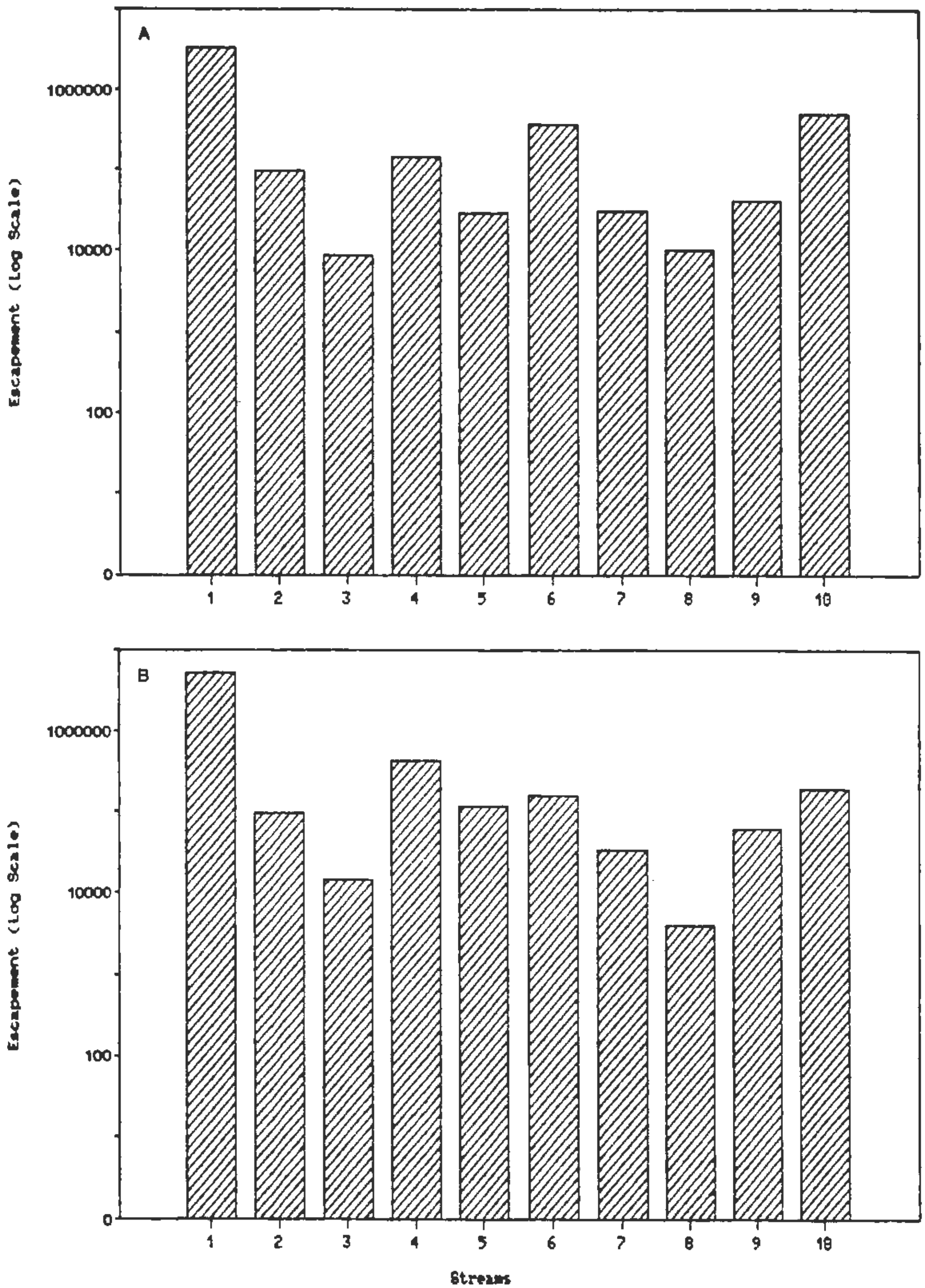
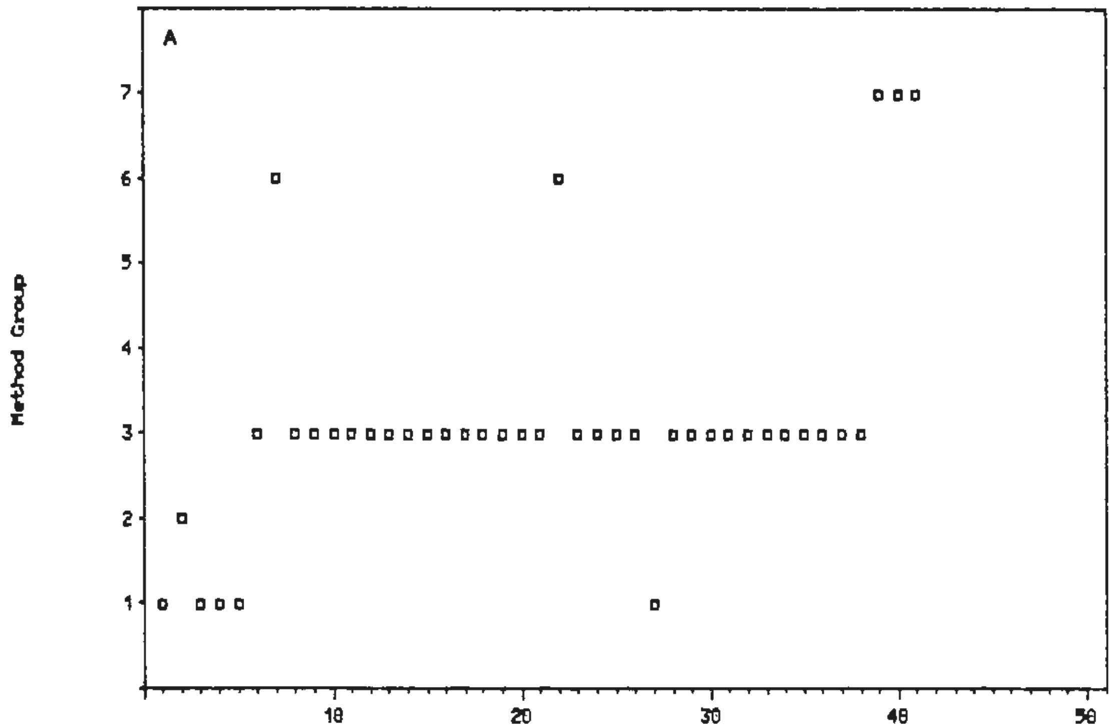


Figure 3. Pink salmon escapement to some major streams in the Fraser River system; 1983 (A), 1985 (B). (For stream names, see legend on page 32. Note log scale.)

Legend for Figures 2 and 3.

1	Fraser River mainstem
2	Chilliwack-Vedder River
3	Sweltzer Creek
4	Harrison River
5	Coquihalla River
6	Seton Creek proper
7	Seton Lower Channel
8	Portage Creek
9	Bridge River
10	Thompson River



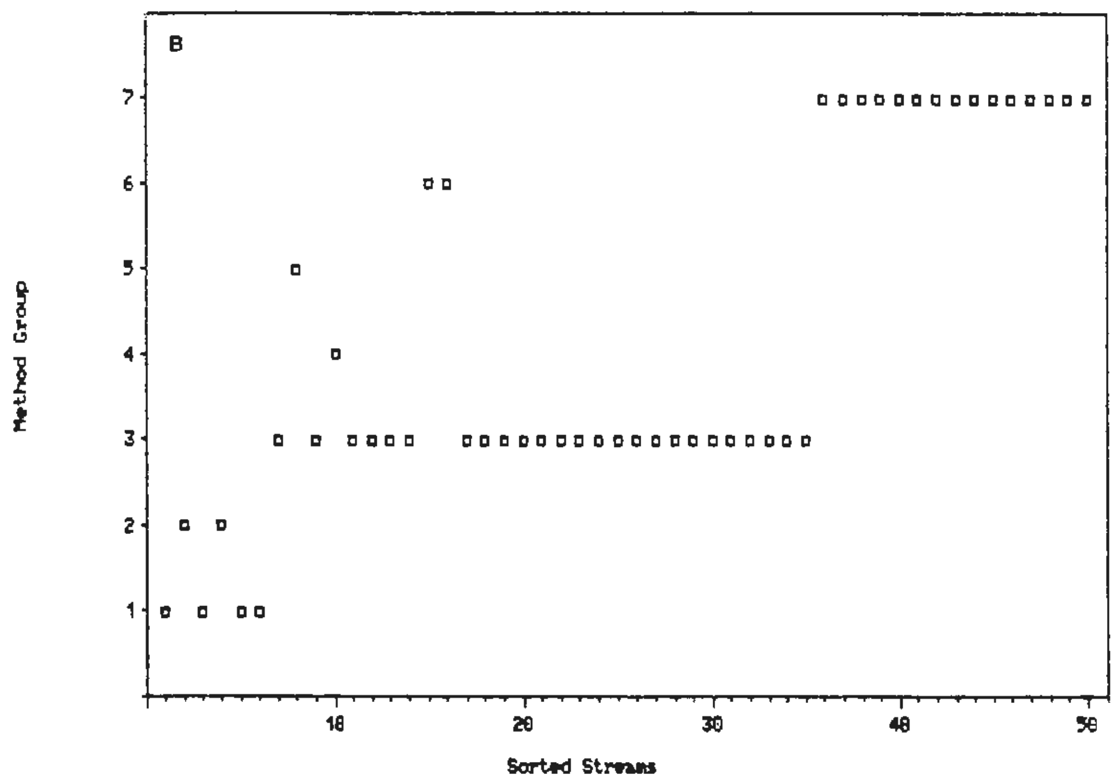


Figure 4. Method of escapement estimation for streams in the Fraser River system; 1959 (A), 1961 (B). (Streams are sorted in descending order of population size. The first stream is the Fraser mainstem. Method group 1 = Petersen, simple stream; 2 = Petersen, complex streams; 3 = live and dead count methods; 4 = live count methods; 5 = dead count methods; 6 = miscellaneous methods; 7 = not done.)

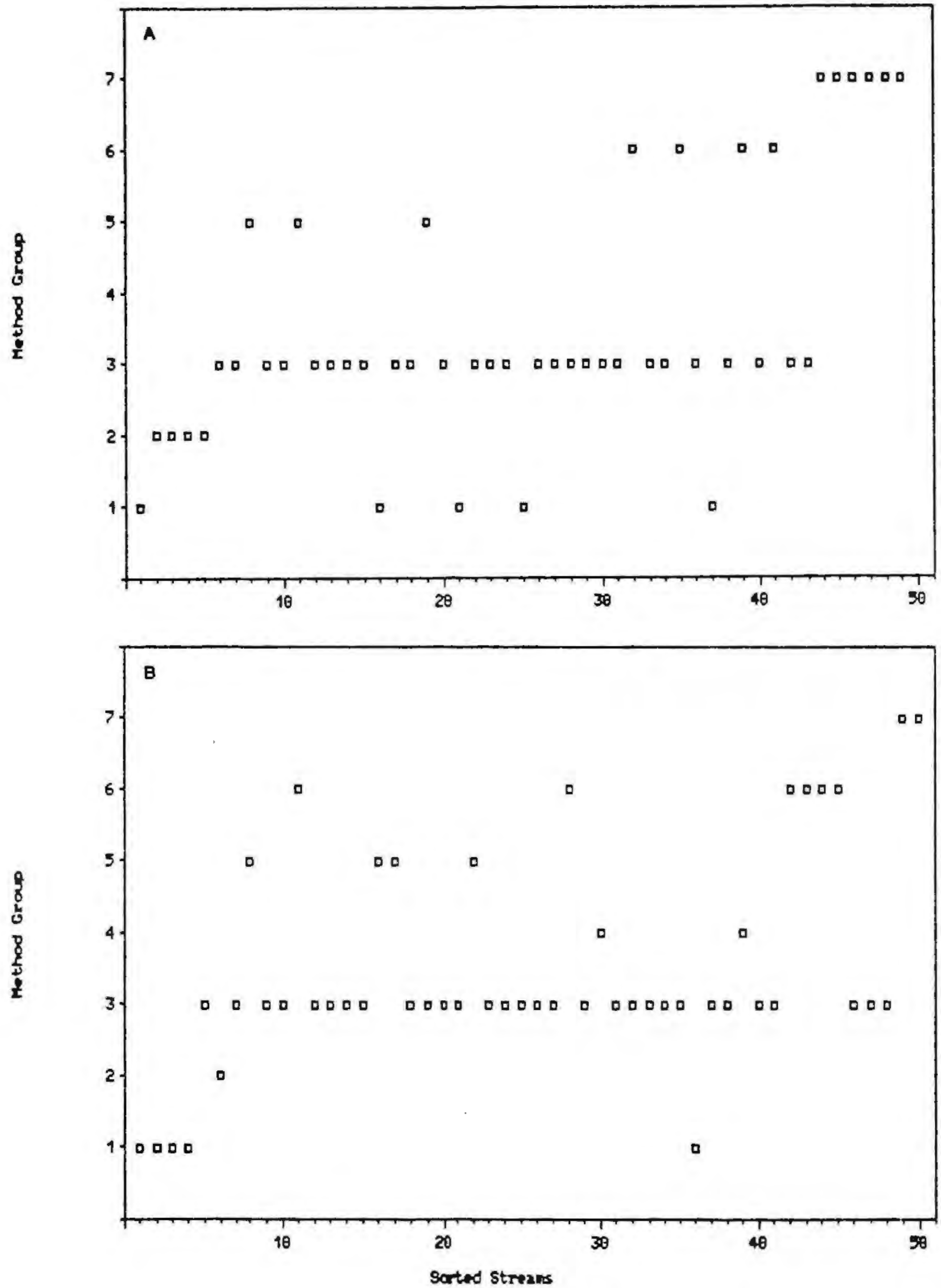


Figure 5. Method of escapement estimation for streams in the Fraser River system; 1983 (A), 1985 (B). (Streams are sorted in descending order of population size. The first stream is the Fraser mainstem. See Figure 4 for method group codes.)

Fraser River system for enumeration of pink salmon. In 1985, tagging programs were conducted in the Fraser River (tagging at Glen Valley), Chilliwack-Vedder River, Harrison River, Seton Creek, and Thompson River. There are numerous tagged strays from these tagging programs. In 1985, stray tagged fish from the Fraser River were recovered mainly in the Harrison River, the Chilliwack-Vedder River, the Coquihalla River, and Seton Channels, as well as numerous other smaller streams (Table 2). Tagged fish from the Chilliwack-Vedder River tagging program were recovered as strays only in Sweltzer Creek. Most strays from the Harrison River tagging program in 1985 were recovered in the Fraser River and, secondarily, in Weaver Creek and Weaver Channel. Most strays from the Seton Creek tagging program were recovered in the Seton channels, and, secondarily, in Portage and Cayoosh creeks. There were no tagged stray recoveries from the Thompson River tagging program in 1985 with the exception of one female tag recovered in the Adams River dead pitch.

4.4 Mark Rates of Glen Valley Tags

Among the Glen Valley tagged fish recovered as strays, the Glen Valley tag recoveries comprise varying proportions of the dead pitch in the numerous streams where they are recovered. The proportion of tags recovered in the dead pitch is called the "mark rate" (tags recovered/total dead recovered). In 1985 in streams with five or more Glen Valley tags recovered, the mark rates varied from 0.05 to 0.78 (Table 3). Such differences may affect population estimates calculated by different methods; these effects are discussed in Section 5.0.

Table 2. Recovery of tagged pink salmon in the Fraser River system, 1985.

Location of Tagging	Location of Recovery	Tags Recovered1			Stray Tags Estimated2		
		M	F	T	M	F	T
Fraser River mainstem (Glen Valley)	Fraser River	388	692	1080			
	Ruby Creek	1	1	2	12	14	26
	Johnson Slough	15	25	40	26	43	69
	Squawkum Creek	0	0	0	2	1	3
	Maria Slough	0	0	0	2	1	3
	Chilliwack-Vedder River	56	54	110	323	282	605
	Sweltzer Creek	1	3	4	4	10	14
	Harrison River	87	92	179	793	647	1440
	Weaver Creek	1	1	2	2	2	4
	Weaver Channel	16	5	21			
	Coquihalla River	8	11	19	220	303	523
	Jones Creek	0	0	0	1	2	3
	Jones Channel	5	2	7			
	Lorenzetti Creek	0	1	1	1	1	2
	Silverhope Creek	7	10	17	25	36	61
	Hunter Creek	0	0	0	2	3	5
	American Creek	1	0	1	9	12	21
	Spuzzum Creek	3	3	6	23	27	50
	Nahatlatch River	0	0	0	3	3	6
	Anderson Creek	0	0	0	4	5	9
	Emory Creek	1	1	2	40	50	90
	Kawkawa Creek	10	7	17	18	12	30
	Yale Creek	0	1	1	4	5	9
	Seton Creek	48	16	64	256	70	326
	Seton Channels	55	19	74			
	Cayoosh Creek	5	0	5	15	0	15
	Portage Creek	2	0	2	14	0	14
	Bridge River	3	2	5	33	22	55
	Thompson River	5	2	7	71	24	95
	Stein River	0	0	0	1	1	2
Chilliwack-Vedder River	Chilliwack-Vedder River	64	75	139			
	Sweltzer Creek	10	5	15	39	16	55
Harrison River	Harrison River	119	132	251			
	Fraser River	3	4	7	41	68	109
	Weaver Creek	7	4	11	17	10	27
	Weaver Channel	9	14	23			
	Steelhead Creek	1	1	2			
Seton Creek	Seton Creek	238	266	504			
	Fraser River	0	1	1	0	17	17
	Weaver Channel	0	1	1			
	American Creek	7	0	7			
	Seton Channels	319	381	700			

	Cayoosh Creek	11	12	23	27	30	57
	Portage Creek	10	16	26	38	61	99
Thompson River	Thompson River	56	74	130			
	Seton Creek	4	0	4			
	Adams River	0	1	1			

[1]In the case of Glen Valley tagging, listed on IPSFC data cards and in the dataset in columns for Glen Valley tags.
[2]Estimated Glen Valley tags in the population, equal to tags recovered expanded by the dead pitch rate (population estimate/dead recovery).
[3]M = Males; F = Females; T = Total.

Table 3. Mark rate of Glen Valley tags in the Fraser River system, 1985.

Location of Tagging	Location of Recovery	Glen Valley Tags Recovered	Glen Valley Tags Estimated	Mark Rate[1]
Fraser River mainstem (Glen Valley)	Fraser River	1080		0.45
	Ruby Creek	2	26	0.44
	Johnson Slough	40	69	0.57
	Squawkum Creek	0	3	0.00
	Maria Slough	0	3	0.00
	Chilliwack-Vedder River	110	605	0.63
	Sweltzer Creek	4	14	0.10
	Harrison River	179	1440	0.32
	Weaver Creek	2	4	0.15
	Weaver Channel	21	21	0.44
	Coquihalla River	19	523	0.44
	Jones Creek	0	3	0.00
	Jones Channel	7	7	0.29
	Lorenzetti Creek	1	2	6.67
	Silverhope Creek	17	61	0.45
	Hunter Creek	0	5	0.00
	American Creek	1	21	0.16
	Spuzzum Creek	6	50	0.78
	Nahatlatch River	0	6	0.00
	Anderson Creek	0	9	0.00
	Emory Creek	2	90	3.51
	Kawkawa Creek	17	30	0.52
	Yale Creek	1	9	0.60
	Seton Creek	64	326	0.15
	Seton L. Channel	68	68	0.20
	Seton U. Channel	6	6	0.13
	Cayoosh Creek	5	15	0.19
	Portage Creek	2	14	0.18
	Bridge River	5	55	0.09
	Thompson River	7	95	0.05
	Stein River	0	2	0.00

[1]Mark rate in Stream A = (Glen Valley tags recovered in Stream A/Total dead recovery in Stream A)

5.0 EXPERIMENTAL DESIGN CONSIDERATIONS

The objective of this section of the report is to examine the levels of precision and accuracy expected with the different methods of escapement enumeration described above.

Methods of estimating precision will be examined and the potentials for bias in different methods discussed. Precision estimates for the enumeration data in the database will then be presented for streams aggregated into districts and the total escapement in a year.

In considering the level of confidence (degree of belief) to place in an estimate of escapement, it is essential to understand the difference between precision and accuracy.

Precision - is measured by the reciprocal of the variance of an estimate and is an indication of the degree of scatter around a mean value that could be expected if the estimation procedure were carried out a number of times.

Accuracy - is a measure of bias in the estimate; that is, if the estimation procedure were carried out a number of times, the difference between the mean estimate and the true (parametric) value. The accuracy of an escapement estimate might be reduced due to such things as tag loss in a Petersen procedure, a counting fence washing out, or poor counts due to turbid water conditions.

Accuracy is frequently difficult to estimate but must always be considered since just specifying the precision can be very misleading. An intensive Petersen estimate may have a very high precision with large numbers of tags released and recovered, but due to undetected tag loss, it may be a serious overestimate of the true value and consequently inaccurate.

The escapement estimates in the database fall into four categories based on how the estimates were formed and recorded:

A) estimates based on tagging in some form of Petersen estimate, possibly with corrections for various factors including strays to other systems;

B) estimates based on complete counts of live or dead fish at weirs, counting fences, and total dead pitches;

C) estimates based on a range of techniques utilizing partial counts of live and/or dead fish as indexes of escapement and applying calibration factors determined at some time in the past; and

D) estimates produced from some source other than the IPSFC, so there is no detailed information on the way in which the estimate was produced, and other estimation methods for which no estimate of coefficient of variation was calculated.

There are formal methods of estimating the precision of only those estimates which fall into category A (tagging estimates). If we wish to determine the precision (and accuracy) of the index and total count methods, then we must develop appropriate methods for doing this. There is insufficient information to assess precision for estimates in the fourth category, but, fortunately, this category is relatively uncommon in the database.

All methods of escapement estimation are susceptible to bias in one way or another; if, however, the same estimation technique is used every year in a particular stream, then the trends over time should not be affected.

Methods for estimating the precision of escapement estimates in these categories have been described in detail in a previous report which examined the estimation of sockeye escapement to the Fraser River (Andrew and Webb 1986); these descriptions will not be repeated here in detail. In summary, the methods of precision estimation used were:

A) for tagging estimates, the equation described in Ricker (1975) for Petersen estimates was used;

B) for estimates based on complete counts of either live or dead fish, a coefficient of variation of 5% was assumed;

C) for estimates based on the expansion of partial counts, it was assumed that the coefficient of variation of the estimate was related to the number of entries made into the system; for a single entry, the coefficient of variation was assumed to be 39% and this was decreased by the square root of the inverse of the number of entries; and

D) levels of precision were not calculated for this category which represented a very small percentage of the overall estimates for districts and years; in all 15 years of pink data, only 39 estimates fell into this category -- these streams had average escapements of 1,171 and contributed an average escapement of 3,046 a year.

The one major aspect pink escapement the estimation that is different from sockeye is the estimation of the mainstem pink spawners through the use of systemwide tagging and the subtraction of either "stray" tags or tributary population estimates. The analytical methods associated with this approach will be examined here.

5.1 Estimation of Mainstem Spawning

The estimation of mainstem pink spawning is based on the application of tags at or near Glen Valley in the lower Fraser River. These tags are recovered in dead pitches in the mainstem and many of the tributaries. Over the years in which pink escapements have been estimated, there have been two methods used to form the estimate of mainstem spawning from these data. In summary, these methods are to:

I. estimate the total number of Glen Valley tags that have gone to the tributaries, subtract these from the tags available in the mainstem, and then use the tags available along with the dead recovery and tag recovery in the mainstem to form a Petersen estimate of mainstem spawning; the tags in the tributaries are estimated by expanding the observed number of tags by the ratio of the total estimate in each tributary to the number of carcasses dead pitched (coded as method 53 in the database); and

II. use the total dead pitch tag release and tag recovery in the whole Fraser system to produce a Petersen estimate of the total system escapement, and then subtract out the tributary populations which are estimated independently (coded as method 61 in the database).

5.1.1 Accuracy

The two methods of estimating mainstem escapement would be equally applicable and unbiased if one of two conditions were held:

1) if the tagging were carried out proportionately on the whole run of pinks so that the mark rate of Glen Valley tags was the same in all tributaries; or

2) if the proportion of total escapement dead pitched were the same in all tributaries.

A quick review of the data in the database reveals that neither of these conditions is true in the majority of years. In general, the mark rate tends to be slightly lower outside the mainstem and the proportion of total escapement dead pitched is substantially higher in the tributaries. This combination of a lower mark rate and higher rate of dead pitching in the tributaries means the estimate produced by method II will frequently be biased upwards.

The results from the mainstem tagging in 1985 can be used to illustrate the relative magnitude of these problems. Table 4 shows a comparison of statistics for 1985 for the mainstem versus the sum of the tributaries. Note that while 54.3% of the total Glen Valley tags recovered are observed in the tributaries only, 14.7% of the estimated tags are to be found in the tributaries. This reflects the much lower rate of dead pitching in the mainstem and the larger expansion factors used. Both male and female tag rates are substantially lower in the tributaries. Figure 6 shows the confidence intervals on the mark rates for the 26 streams with the highest escapement in the Fraser system in 1985. Mark rates are significantly lower than the mainstem (0.45) in six of the top ten tributaries; these are (in order of total escapement):

1) Harrison River (mark rate = 0.32);

2) Thompson River Mainstem (mark rate = 0.05);

3) Seton Creek Proper (mark rate = 0.15);

4) Bridge River (mark rate = 0.09);

5) Seton Creek Lower Spawning Channel (mark rate = 0.20); and

Table 4. Comparison of a range of statistics for the mainstem Fraser and the sum of the tributaries, 1985.

	Mainstem	Tributaries	Percent in Tributaries
Observed G.V. tags	1080	586	54.3
Estimated G.V. tags	24382	3584	14.7
Male Mark Rate	0.54%	0.34%	-
Female Mark Rate	0.41%	0.22%	-
Escapement Estimate I	5.26 million	1.21 million	23.1
Escapement Estimate II	6.28 million	-	-

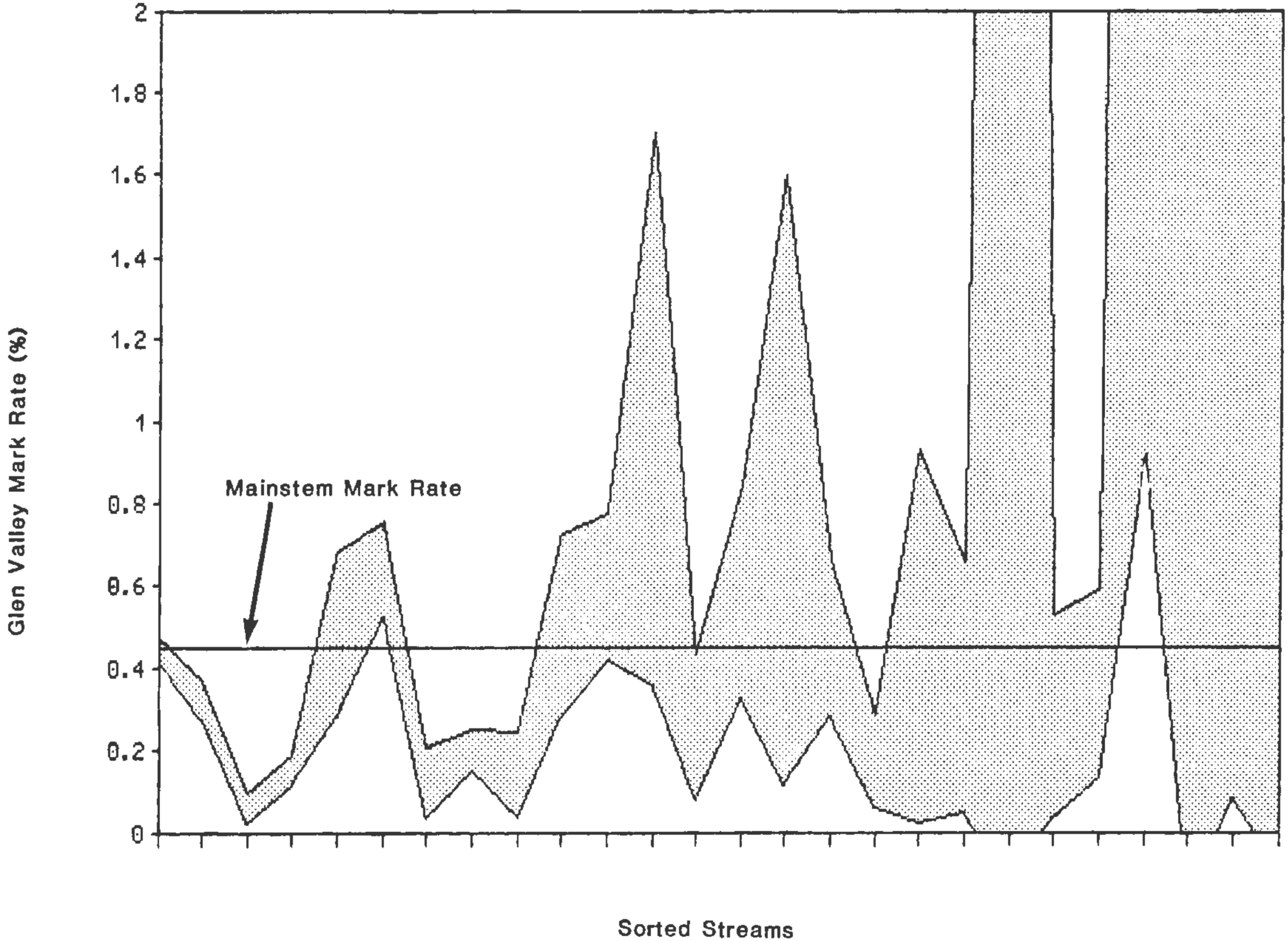


Figure 6. Percentage of the escapement of pink salmon marked with Glen Valley tags in the Fraser River system, 1985. (The shaded area represents the 95% confidence intervals or the mark rate. Streams are sorted in descending order of population size. The first stream is the Fraser mainstem.)

6) Sweltzer Creek (mark rate = 0.10).

In contrast, the Coquihalla and Chilliwack-Vedder rivers, which are also quite large, have mark rates of 0.44 and 0.63, respectively, which are quite similar to the Fraser mainstem. In general, streams smaller than these top ten have mark rates whose confidence intervals include the rate in the mainstem (Figure 6).

In summary, the differential mark rates and dead pitch rates in the tributaries mean that a systemwide Petersen estimate will tend to overestimate the total escapement. The best way to produce an unbiased estimate is to estimate the number of Glen Valley tags that stray to the tributaries and subtract these from the tags available in the mainstem. The IPSFC used this method of subtracting stray tags from 1961 to 1985.

In all years, the IPSFC have assumed a 5% tag loss of Glen Valley tags prior to any recovery. This number has had relatively little justification. Some tag loss is quite likely in any tagging program of this kind and could range from a very low level to 10%, 20%, or more depending on the situation. This factor represents a potential problem in the accuracy of the overall escapement estimate.

5.1.2 Precision

The precision for estimates produced using method II described above can be calculated simply by adding together the variances produced using the standard formula (see Andrew and Webb 1986) for the systemwide estimate with the variances on the estimates for each of the tributaries subtracted out. The precision for method I, the preferred method, is less straightforward to estimate correctly.

In a normal Petersen estimate, only the variance in the number of tags recovered needs to be considered; it is assumed that the number of individuals sampled (dead pitched) and the number of marks applied is known without error. When the number of marks available is estimated from the number applied minus the number estimated to have gone to the tributaries, this is no longer the case; the error in the estimate of the number of tags in the tributaries must also be taken into account.

Using this method, we will derive here the equations required to estimate the variance of the estimate. Standard equations for the variances of products and ratios are used (Goodman 1960 and Topping 1962).

Let: N = total escapement to mainstem;

M = total marks applied;

R = marks recovered in mainstream;

N_s = total escapement to tributaries;

M_s = estimated number of marks in tributaries (strays);

R_s = marks recovered in tributaries; and

C_s = number dead pitched in tributaries.

The basic equation for estimating mainstem escapement is:

$$\hat{N} = \frac{(M - M_s)\ C}{R} \tag{1}$$

We assume here that the number of marks straying to the tributaries is estimated from the number of marks in the dead pitch and the population estimate:

$$M_s = \frac{N_s R_s}{C_s} \qquad (2)$$

The estimate of the variance of $\hat{N}$ can be produced using the same approach as for a normal Petersen estimate (Ricker 1975), except the variance in the estimated number of strays must be taken into account. We make two assumptions here:

1) C and M are known without error; and

2) the errors in R are independent of the errors in M_s.

The second assumption means that the covariance of R and M_s can be ignored, so the equation for the variance of $\hat{N}$ is:

$$\mathrm{VAR}\ (\hat{N}) = C^2 \cdot \frac{(M - M_s)^2}{R^2} \left[\frac{\mathrm{VAR}(M_s)}{(M - M_s)} + \frac{\mathrm{VAR}(R)}{R^2} \right] \qquad (3)$$

Assuming a binomial process we can estimate the variance of R:

$$\mathrm{VAR}\ (R) = C \cdot \frac{R}{C} \cdot \left(1 - \frac{R}{C}\right) \qquad (4)$$

$$= R \left(1 - \frac{R}{C}\right)$$

Assuming the precision of N_s is known (as some coefficient of variation), then the variance of Ms can be estimated based on equation 2:

$$VAR(M_s) = \left(\frac{1}{C_s}\right)^2 \left[R_s^2 \,.\, VAR(N_s) + N_s^2 \; VAR(R_s) - VAR(N_s) \,.\, VAR(R_s)\right] \quad (5)$$

N_s is estimated by a range of different techniques. We assume here that its coefficient of variation is known:

$$VAR(N_s) = (CV(N_s) \,.\, N_s)^2 \quad (6)$$

The variance of Rs can be estimated in the same way as for R in equation 4:

$$VAR(R_s) = R_s\left(1 - \frac{R_s}{C_s}\right) \quad (7)$$

Substituting equations 6 and 7 into equation 5 gives:

$$VAR(M_s) = \left(\frac{1}{C_s}\right)^2 \left[R_s^2 N_s^2 CV^2(N_s) + N_s^2 R_s\left(1 - \frac{R_s}{C_s}\right) - N_s^2 R_s\left(1 - \frac{R_s}{C_s}\right) CV^2(N_s^2)\right]$$

Since the mark rate on recovery is low, we can ignore the $(1 - R_sC_s)$ terms as being insignificant. Rearranging gives:

$$VAR(M_s) = \left(\frac{N_sR_s}{C_s}\right)^2 \left[CV^2(N_s) + \frac{1}{R_s} - \frac{CV^2(N_s)}{R_s}\right]$$

Simplifying this further and neglecting the product of the variances as being insignificant in comparison to the other terms gives:

$$VAR(M_s) = M_s^2 \left(CV^2(N_s) + \frac{1}{R_s}\right) \tag{8}$$

Substituting equations 7 and 8 into equation 3 and simplifying gives:

$$VAR(\hat{N}) = C^2 \cdot \frac{(M - M_s)^2}{R^2} \left[\frac{M_s^2\left(CV^2(N_s) + \frac{1}{R_s}\right)}{(M-M_s)^2} + \frac{\left(1 - \frac{R}{C}\right)}{R}\right] \tag{9}$$

$$= \left(\frac{CM_s}{R}\right)^2 \cdot \left(CV^2(N_s) + \frac{1}{R_s}\right) + \frac{C \cdot (M - M_s)^2(C - R)}{R^3}$$

Thus, equation 9 gives the equation for the variance of an estimate made using the subtraction of estimated strays. If there are no strays, then this simplifies to the formula for the simple Petersen estimate (Ricker 1975):

$$VAR(\hat{N}) = \frac{C\ M^2(C - R)}{R^2}$$

If the strays are actually estimated in a series of streams and then added together, then equation 9 can be modified to:

$$VAR(\hat{N}) = \left(\frac{C}{R}\right)^2 \cdot \sum_{i=1}^{t} \left(M_{si}\left(CV^2(N_{si}) + \frac{1}{R_{si}} \right)\right) + \qquad (10)$$

$$\frac{C\left(M - \sum_{i=1}^{t} M_{si}\right)^2 (C - R)}{R^3}$$

where t is the number of tributaries (i = 1...t).

The effect of the additional term in equations 9 and 10 can be estimated by substituting values taken from the 1985 pink estimate:

$$M = 24{,}382$$

$$C = 220{,}000$$

$$R = 1{,}080$$

$$M_s = 3{,}584$$

$$R_s = 586$$

$$CV(N_s) = 0.10 \text{ (estimated)}$$

Substituting these into equation 9 gives:

$$VAR(\hat{N}) = 6.24 \times 10^9 + 16.54 \times 10^9$$

given $\hat{N} = 5.256$ million

$$CV(\hat{N}) = 2.9\%$$

Thus, including the first term, which allows for the error in the estimation of the number of tags in tributaries, increases the variance estimate by 38% and raises the coefficient of variation on $\hat{N}$ from 2.4% to 2.9%.

In earlier years in the pink database, the relative effect of the first term is likely to be smaller as it will remain at approximately the same magnitude (the CV(Nsi) will remain approximately the same), while the number of recoveries in the mainstem will be less, increasing the second term.

In view of the predominant effect of the second term, the simpler and more standard form has been used in estimating precision here:

$$\mathrm{VAR}(\hat{N}) \cong \frac{C\left(M - \sum_{i=1}^{t} M_{si}\right)^2 (C - R)}{R^3} \tag{11}$$

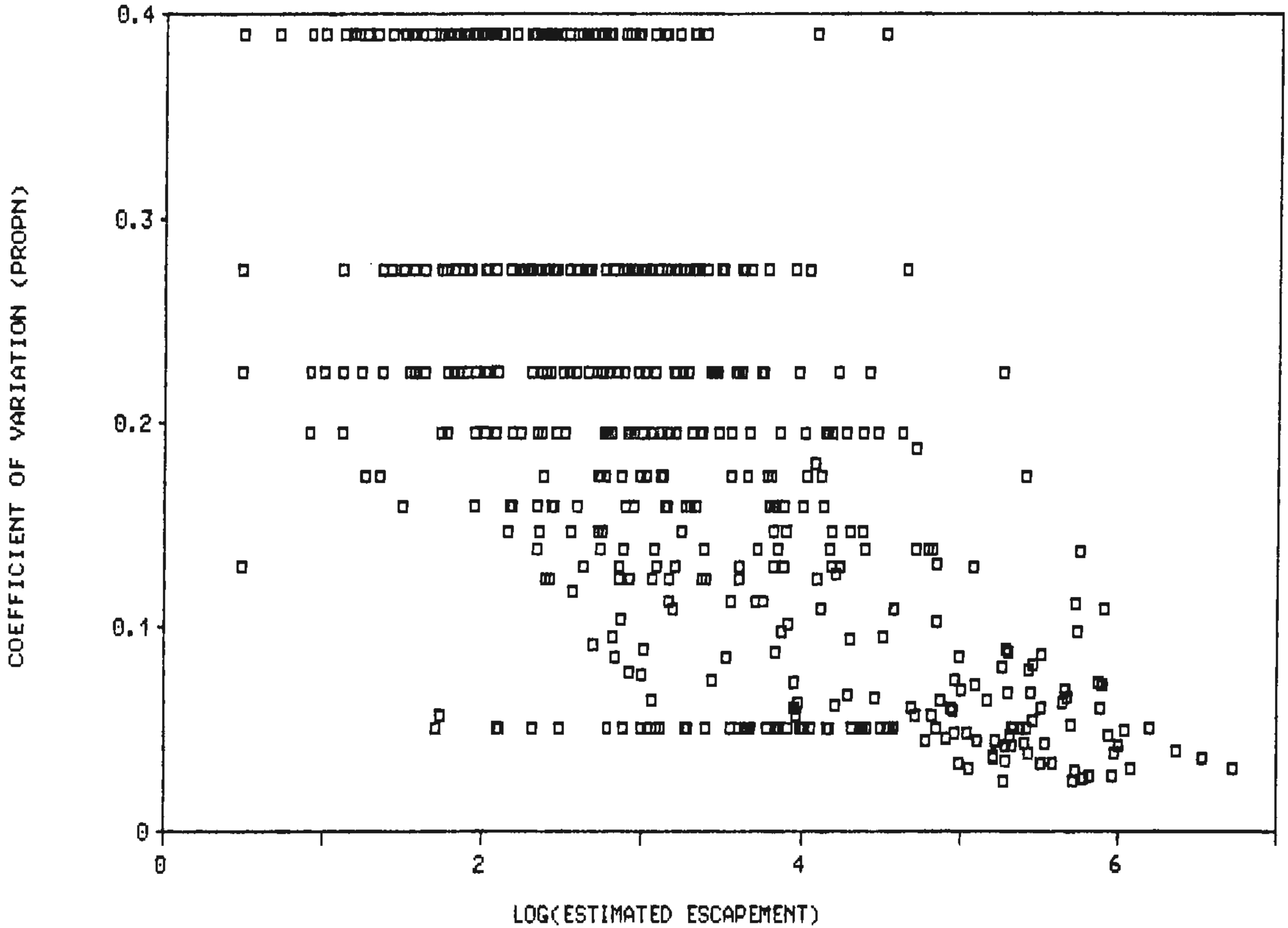


Figure 7. Coefficient of variation plotted against the log (base 10) of the estimated escapement for all streams, 1957 to 1985.

5.2 Calculated Coefficients of Variation

All estimates of pink escapement in the 15 years of the database were reviewed and the coefficients of variation and variances were calculated using the methods described above. In general, it would be logical that more effort was applied to systems with greater escapement such that these had lower coefficents of variation. Figure 7 shows the results of plotting the estimated CV against the log of estimated escapement for all 15 years of data for all streams. The systems with the highest escapements are generally estimated with the highest level of precision. However, for escapements below about 100,000 (log(escapement) = 5), the levels of precision attained are very variable. Other points to note on this plot are the large numbers of estimates with CVs of 39% and bands below this representing the estimates formed using index type methods. The band of estimates with CVs of 5% represent estimates formed from total counts.

In addition to examining the levels of precision on individual estimates it is possible to look at the precision of aggregates of streams such as the escapement to a district. This is simply done by adding up the total escapements and variances for each stream and then dividing the square root of the total variance by the total of the estimates to produce the CV of the aggregate.

Tables 5 and 6 show the results summed by district for all districts within a particular year and all years for a particular district. These tables are included here as examples of what can be produced; more complete tables of all districts and years are included in Appendix C (Tables C.4 and C.5). Note that these numbers may differ from those reproduced elsewhere to a small extent for two main reasons:

1) they only include estimates for which the precision could be estimated; and

Table 5. Escapements and coefficients of variation of pink salmon for the Lower Fraser District, 1957 to 1985.

Year	Escapement	Variance	Coefficient of Variation
1957	1081965	2747425000	4.8
1959	735987	2823571000	7.2
1961	552681	5658308000	13.6
1963	518764	3267503000	11.0
1965	544246	2793465000	9.7
1967	786297	7255710000	10.8
1969	848532	1583734000	4.7
1971	929185	1296639000	3.9
1973	767114	3000144000	7.1
1975	315049	732390200	8.6
1977	755016	2072750000	6.0
1979	1523458	5930301000	5.1
1981	2255753	7996520000	4.0
1983	3310999	13634680000	3.5
1985	5258311	26136240000	3.1
MEAN:	1345557		6.9[1]

[1]Simple unweighted arithmetic mean of coefficients of variations.

Table 6. Escapements and coefficients of variation of pink salmon in all districts in the Fraser River system, 1985.

District	Escapement	Variance	Coefficient of Variation
1	5258311.	26136240000.	3.0
2	110602.	70248040.	7.5
3	446377.	766486100.	6.2
4	164437.	248738500.	9.5
5	274120.	130815000.	4.1
6	193448.	289672400.	8.7
7	530.	10733.	19.5
YEAR TOTAL:	6447825.	27642200000.	2.5

2) there is some double counting of fish where streams are estimated independently using one method (e.g. an index method) but are also part of a complex which is estimated using a Petersen method on the whole group.

Caution should be used in interpreting the coefficients of variation in these tables. It should be remembered that these reflect the estimated precision in the estimate and do not include the effects of biases. In general, biases might tend to cancel out when the estimates of many streams are combined. However, it is possible that all of the index method estimates within a district (or even within the whole Fraser River system) could be negatively biased in a particular year due to high rainfall leading to high carcass washout rates and low dead pitch counts. Similarly the 5% tag loss factor used for mainstem enumeration or the factors used in index methods could be consistently incorrect.

6.0 SUMMARY AND CONCLUSIONS

This study of pink salmon enumeration techniques on the Fraser River has produced three major products:

- the database of complete Fraser River pink escapement data from 1957 to 1985 and software which allows the reconstruction of the estimates from the raw numbers;

- a description, classification, and implementation in software of the methods used in this period to produce escapement estimates; and

- an analysis of the levels of precision and accuracy which these methods can be expected to provide.

The database constructed contains a wealth of information of which the analyses in this report give only a few examples. The data in this database have been verified for the purposes of recreating the estimates based on the method coded. Time constraints in the course of this study have not allowed complete verification of other types of information such as timing of arrival and peak dates of spawning, percent spawn, temperature, water gauge levels, and marine tag data.

The examination of the different methods used in the Fraser River has revealed a large number of variations on a relatively small number of basic themes. The underlying approach has depended on using variations on the Petersen method as the ultimate yardstick against which to calibrate the other methods, and the alternate methods are then seen as less expensive ways of estimating escapement in lower priority streams.

Petersen methods provide objective estimates (if the number of subjective adjustments on their components is not too great) against which to measure other, more subjective methods. Petersen estimates can, however, be subject to systematic biases which may be hard to detect due to such factors as incomplete mixing of tags and tag loss. With the data available to this study, it has not been possible to assess the level of accuracy of the Petersen methods used and, consequently, it is not possible to assess the accuracy of the other methods calibrated using the Petersen method.

The index methods using peak live count plus cumulated dead pitch counts are used extensively on streams in the Fraser River system, and create some concern for accuracy of population estimates. In escapement estimates for whole districts, the method would seem reasonable although it is likely that further calibration of the factors used would considerably improve confidence in the estimates. In producing estimates for individual streams, a single global factor will inevitably lead to positive or negative biases due to the characteristics of the streams to which the method is applied. Thus, considerable care should be exercised in interpreting the relative magnitudes of populations of individual streams estimated using these index methods.

6.1 Recommendations

In line with the discussion above, we make six main recommendations on how the process started with this study should be continued:

1) The method of estimating the mainstem Fraser River escapement should continue to be based on subtracting out the number of tags estimated to have gone to the tributaries to calculate the tags available to the mainstem;

2) The single largest potential source of consistent bias in the total pink escapement estimate is the level of loss of Glen Valley tags. The only way

in which this can be resolved is through the implementation of a double tagging study to assess tag loss. If a more accurate total estimate of escapement is required then such a study should be carried out.

3) The potentials for other sources of bias in the escapement data should be further reviewed. Specifically, the factors extensively used in the index method of peak live count plus cumulative dead pitch multiplied by a factor should be assessed.

4) The uses of the Fraser River pink escapement data should be reviewed and the levels of precision and accuracy required by those uses should be determined. If appropriate, the effort allocation algorithm described in the sockeye report (Andrew and Webb 1986) should be implemented to provide a tool to aid in the objective assignment of enumeration effort among streams.

5) The database produced by this study should continue to be expanded as data are collected for enumeration in the future.

6) The software for accessing and analysing the enumeration data should be further refined to produce more useful, integrated and user-friendly tools.

7.0 REFERENCES

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APPENDIX A

CODES USED IN THE DATABASE

Table A.1. Codes for districts, streams, and sub-streams used in the database for pink salmon.

District	Stream	Substream
1 Lower Fraser		
	1 Fraser River	
	2 Ruby Creek	
	3 Johnson Slough	
	4 Stave River	
	5 Coquitlam River	
	6 Kanaka Creek	
	7 Whonnock Creek	
	8 Silverdale Creek	
	9 Suicide Creek (Norris)	
	10 Salmon River	
	11 Beaver Creek (Nathan)	
	12 West Creek	
	13 Silver Creek (Pitt Lake)	
	14 South Alouette River	
	15 North Alouette River	
	16 Squawkum Creek	
	17 Scott Creek	
	18 Lagace Creek (Hatzic Lake)	
	19 Upper Sumas Creek	
	20 Alouette River	
	21 Maria Slough	
	22 Hoy Creek	
	23 Upper Pitt River	
	24 Deboville Slough	
2 Chilliwack-Vedder		
	1 Chilliwack-Vedder River	
	2 Liumchen Creek	
	3 Sweltzer Creek	
	4 Paleface Creek	
	5 Depot Creek	
	6 Dolly Varden Creek (Upper Chilliwack River)	
	7 Slesse Creek	
	8 Tamihi Creek	
	9 Foley Creek	
	10 Borden Creek	
	11 Middle Creek	
	12 Centre Creek	
	13 Chipmunk Creek	
	14 Chilliwack Lake and tributaries	
	15 Ryder Creek	
	16 Little Chilliwack River	
	17 Brown Creek	
3 Harrison		
	1 Harrison River	
	2 Chehalis River	
	3 Weaver Creek	
		1 Creek proper

2 Spawning channel
4 Birkenhead River
5 Big Silver Creek
6 Steelhead Creek

4 Fraser Canyon
1 Coquihalla River
2 Jones Creek
1 Creek proper
2 Spawning channel
3 Areas below the channel
3 Lorenzetti Creek
4 Silverhope Creek
5 Hunter Creek
6 American Creek
7 Spuzzum Creek
8 Nahatlatch River
9 Anderson Creek
10 Emory Creek
11 Stoyama Creek
12 Kawkawa Creek (Sucker Creek)
13 Texas Creek (Choate Creek)
14 Nine Mile Creek
15 Yale Creek
16 Hawkes Creek
17 Popkum Creek
18 Flood Creek
19 Sawmill Creek

5 Seton-Anderson
1 Seton Creek
1 Creek proper
2 Upper spawning channel
3 Lower spawning channel
4 Creek proper above dam
5 Creek proper below dam
6 Spawning channel
2 Cayoosh Creek
3 Portage Creek
4 Bridge River
5 Gates Creek
6 Seton Lake
1 Lake and creek above dam
7 Yalakom River

6 Thompson
1 Thompson River mainstem
2 Nicola River
3 Bonaparte River
4 Deadman Creek
5 Bear Creek
6 Adams River
7 Little River
8 South Thompson River
9 North Thompson River
10 Lower Shuswap River

11 Nicoamen River

7 Upper Fraser
1 Stein River
2 Churn River
3 Quesnel River
4 Williams Lake Creek
5 Chilcotin River
6 Fraser River proper (Bridge River Rapids to Quesnel)
7 Watson Bar Creek
8 Gaspard Creek
9 Canoe Creek
10 Big Bar Creek

8 Burrard Inlet
1 Indian River

Table A.2. Codes for enumeration methods used in the pink salmon database. (M = males, F = females, DR = dead recovery, DRm = dead recovery of males, TA = tags available, TR = tag recovery, PLC = peak live count, PLCt = peak live count of sexes combined (total), CD = cumulative dead. Note that Glen Valley tag recoveries are included in dead untagged data unless stated otherwise.)

Method Code	Description of Method and Factors
A. PETERSEN METHODS	
a. Petersen method on closed systems, or streams with strays to other areas. (METHOD GROUP 1)	
3	Petersen estimate, sexes separate. Subtract stray tags to other streams from tags put out.
50	Petersen estimate, sexes separate. Calculate population estimate by dead recovery x sockeye recovery rate. M:50 A:M recovery ratio B:F recovery rate
51	Petersen estimate, sexes separate. Calculate population estimate by dead recovery x recovery rate from another area or composite of areas. M:50 A:M recovery ratio B:F recovery rate
52	Petersen estimate, sexes separate. Tagging program is in addition to Glen Valley and other local tagging programs. Total tag recoveries are coded as "strays" from the stream of tag release.
53	Petersen estimate, sexes separate for Fraser River mainstem. Subtract Glen Valley tags that strayed to other streams in the watershed, and tags taken in the Indian fishery. (This method is like Method 3 only it is on Glen Valley tagging.) M:53 A:.05 tag loss B:M tags C:F tags to Indians
b. Petersen method on complex systems (METHOD GROUP 2)	
4	Petersen estimate, sexes separate. Calculate population estimate of the main stream (and possibly other streams in the complex if coded as "Method 4") by subtracting populations of other streams according to their separate population calculations based on their method codes.
22	Petersen estimate, sexes separate. Petersen calculation was performed on the sum of dead recovery of all streams. The population is allocated entirely to the main stream and the remaining streams are coded "not done".
59	Petersen estimate, sexes separate. Calculate male and female estimates for the complex by dead recovery x ratio to sockeye jack population, then subtract out populations of tributaries. M:59 A:M factor B:F factor
61	Petersen estimate, sexes separate for Fraser River

mainstem. Calculate male and female estimates for the Fraser system based on Glen Valley tagging and composite dead recovery and tag recovery for the system, then calculate estimate for the mainstem by subtracting populations of all other streams according to their separate method codes. In some years, the Indian catch was subtracted out from the estimate using K adjustment. (This method is like Method 4 only it is on Glen Valley tagging.)
M:53 A:.05 tag loss (if required)

B. LIVE AND DEAD COUNT METHODS

a. Live and dead count combinations (METHOD GROUP 3)

12 Sum dead pitch (in columns for untagged and tagged fish) up to and including the day of the peak live count, then calculate the population by (peak live count + cumulative dead) x factor (1.8). This was the most commonly used method of enumeration.
M:12 A:factor

25 Counts through weir plus enumeration below weir performed as in Method 12. Count through weir + [(Peak live count below weir + cumulative dead) x factor (1.8)]. The fortran code is the same as in Method 7, and counts below the weir are coded as an adjustment.
M:25 A:factor

60 Same as Method 12 but the factor used accounts for areas not covered by live count plus cumulative dead.
M:60 A:factor

b. Live count methods (METHOD GROUP 4)

7 Live count at weir. Sum live counts and counts by sex which were entered into tags applied columns. Same fortran code as Methods 9, 25, and 28.

8 Live count at bridge. Sum counts entered into partial counts column. Same fortran code as Method 40.

9 Live count by splitter. See Method 7.

28 Live count through fence or transferred (e.g., Gates Creek). See Method 7.

40 Count at dam or fishway. See Method 8.

54 Calculate estimate for Thompson River by live counts at Big Horn less population estimates of tributaries.

58 Peak live count x factor.
M:58 A:factor

c. Dead count methods (METHOD GROUP 5)

14 Total dead recovery. Sum dead untagged and dead tagged for population estimate then apportion to sexes using sex ratio method entered. ZQ adjustment may be used as substitution for dead recovery.

16 Assuming a partial dead recovery, sum dead recovery of untagged and tagged fish and multiply by a factor (e.g., a factor of 10 assuming 10% recovery).
M:16 B:factor

30 Assuming a partial dead recovery, for each sex sum dead recovery of untagged and tagged fish and multiply each total by sex-differentiated factors. The factor for one sex may be tags applied divided by tag recoveries to give a Petersen calculation.
M:30 A:M factor B:F factor

C. MISCELLANEOUS METHODS (METHOD GROUP 6)

19 Present. This method was used when the data indicated presence of spawners but enumeration was not performed.

21 Not done. Most streams for which enumeration was not performed do not have computer records associated with them. Many streams that were coded as "not done", however, had live counts or dead pitch performed on them but these data were used in estimates with other streams (e.g., data from the north end of Chilko Lake was used with the Chilko River data to estimate the combined systems, but the population was recorded as being from the river).

27 Estimate. Some estimates were provided by DFO (previously called the FFS) or local residents. In these cases, this information was recorded in the remarks lines of the database.

46 Estimate based on redd count.

48 Estimates based on a variety of enumeration methods which were too complicated to code. This method of coding was used infrequently since it resulted in a loss of information regarding the actual method of enumeration.

55 Same proportion (% dead recovery) of another population as previous year(s). Same fortran code as Method 48.

56 Assume % dead recovery is the same as for another stream. Calculate the population estimate by dead recovered x (Population from another area/dead recovery from that area).
M:56 A:PE from other area/DR from that area

57 Pink population by ratio of pinks to sockeye in the dead recovery after estimating the sockeye population by Petersen estimate. Same fortran code as Method 48.

D. NOT PRESENT (METHOD GROUP 7)

20 Not present.

Table A.3. Codes for adjustments used in the sockeye and pink salmon databases.

Code	Reason for Adjustment and Correction Made
A. Population Estimate	
B	Egg, milt, or experimental samples were taken. Add to estimate.
C	Males wrongly identified as jacks. Add to males and subtract from jacks. Adjustment appears in PE/J.
D	Racoon or Indian kills. Add to estimate.
IA	Iteration factor (e.g., Birkenhead River 1984). Add to total.
IB	Iteration factor (e.g., Birkenhead River 1984). Subtract from total.
J	Same as D.
K	Indian fishery catch above Glen Valley.
O	Indian fishery catch below Glen Valley.
P	Proportion of jacks in total population estimate (e.g., P.0004). Apportion population to jacks using adjustment factor and apportion remainder to males and females according to sex ratio entered.
Q	Cumulative dead. Use in formula for estimate. Adjustment is found in PEt.
S	Addition factor due to variety of reasons, for example, the correction made to Adams River population due to the Little River tagged carcass correction. Add to population estimate total. If the Little River correction is to be done but has not been calculated, enter the adjustment S without a numerical suffix.
T	Subtraction factor due to a variety of reasons, for example, the correction made to Little River due to the Little River tagged carcass correction. Subtract from population estimate total. If the Little River correction is to be done but has not been calculated, enter the adjustment T without a numerical suffix.
V	Live count or peak live count. Use in formula for estimate. Adjustment is found in PEt.
ZA	Multiply total.
ZB	Spawned out before tagging. Add to total.
ZC	Dead retrieved below weir or after weir removal, or weir counts of live fish. Add to total.
ZG	Jacks wrongly identified as males. Subtract from PEm, add to PEj. Adjustment appears in PEj.
ZQ	Total dead recovery. Adjustment is used in Method 17.
ZV	Number of days of dead recovery. Adjustment is used in Method 17.
B. Total Dead Recovery	
C	Same as C above but appears in DRj.
E	Availability of jacks relative to males and females. If adjustment appears in DRj, multiply DRj by

	adjustment (e.g., 1.26), but if adjustment appears in DRm, divide DRm by adjustment.
F	Male tag recovery ratio (TAm/TRm). Multiply DRj by adjustment.
G	Unknown sex. Add to total. Fish of unknown sex are not coded as an adjustment if fish are already entered into columns for tags applied or dead pitch because the program sums the numbers along with the fish of known sex.
J	Racoon kill. Add to total.
L	Males wrongly identified as jacks. Multiply DRj by adjustment, add product to DRm, and subtract from DRj. Adjustment appears in DRj.
U	Population from another substream. Subtract from total.
W	Males wrongly identified as jacks. Subtract from DRj and add to DRm. Adjustment is found in DRj.
ZD	Subtraction factor due to variety of reasons (e.g., dead tag counted twice). Subtract from total.
ZE	Addition factor due to variety of reasons (e.g., for extra dead recovered). Add to total.
ZH	Incomplete dead recovery (e.g., Chilko River 1970). Add to total.
ZJ	Availability of males relative to females. Multiply total.

C. Total Tags Put Out

A	Strays to other stream (e.g., into channel). Subtract from total.
H	Tags recovered by fishing (e.g., Indian fishery). Subtract from total.
M	Tags eliminated. Subtract from total.
ZD	Tags added. Add to total.
ZH	Males wrongly identified as females. Subtract from females and add to males. Adjustment appears in TAm.

D. Total Tags Recovered

R	Missed tags recovered in repitch (local). Add to total.
RG	Missed tags recovered in repitch (Glen Valley). Add to total.
N	Recoveries eliminated. Subtract from total.
ZF	Males wrongly identified as females. Subtract from females and add to males.
ZI	Incomplete tag recovery (e.g., from another area). Add to total.
X	Calculated number of Glen Valley tags in the population.
Y	Calculated number of local tags in the population.

Table A.4. Codes for species, sex ratio source, live count source, and remarks used in the sockeye and pink salmon databases.

Code	Coded Item
A. Species	
1	Sockeye
2	Pink
3	Chum
B. Sex Ratio Source	
1	Dead recovery (use dead recovery after adjustments and special factors (e.g., Method 38) are applied)
2	Other stream nearby
3	Estimate (often 50:50)
4	Egg and milt samples
5	Multiple year average or past years' ratio on the same stream
6	Other
7	No source
8	Petersen population estimates, sexes separate (separate population calculation)
9	Count (e.g., weir)
10	Population estimate calculated values
11	Composite of other streams nearby
12	Other species
C. Live Count Source	
C	Expanded from partial visual or fish counter counts
E	Estimated
F	Fence
I	Interpolated
P	Partial or subsection count
R	Seined or fished (e.g., captured to transport to channel)
S	Splitter count
T	Total from fish counter
W	Weir count (if counts are by sex, put into "tags applied" columns)
D. Partial Counts (only bridge and dam counts were used in the partial counts column; these may be partial or complete counts)	
B	Bridge count
D	Dam count
E. Remarks	
M	Male
F	Female
J	Jack
T	Total
PE	Population estimate
DR	Dead recovery
TA	Tags available
TR	Tags recovered

DFO	Department of Fisheries and Oceans
FFS	Federal Fisheries Service

Table A.5. Gazeteer codes for pink salmon spawning streams in the Fraser River system enumerated by the IPSFC (not used in the database).

Stream	Gazeteer Code
A. Lower Fraser District	
Fraser River	00-0000
Ruby Creek	00-0750
Johnson Slough	not available
Stave River	00-0400
Coquitlam River	00-0180
Kanaka Creek	00-0290
Whonnock Creek	00-0370
Silverdale Creek	not available
Suicide Creek (Norris)	not available
Salmon River	00-0300
Beaver Creek (Nathan)	00-0360
West Creek	00-0330
Silver Creek (Pitt Lake)	not available
South Alouette River	00-0200-050
North Alouette River	00-0200-050-020
Squawkum Creek	01-0100
Scott Creek	00-0180-100
Lagace Creek (Hatzic Lake)	00-0500-060
Upper Sumas Creek	not available
Alouette River	00-0200-050
Maria Slough	00-0700
Hoy Creek	00-0180-100-020
Upper Pitt River	00-0200
Deboville Slough	not available
B. Chilliwack-Vedder District	
Chilliwack-Vedder River	00-0600-020-000-000 -000-991
Liumchen Creek	not available
Sweltzer Creek	00-0600-020-020
Paleface Creek	00-0600-020-240
Depot Creek	00-0600-020-250
Dolly Varden Creek	00-0600-020-000-000 -000-993
Slesse Creek	00-0600-020-130
Tamihi Creek	not available
Foley Creek	00-0600-020-160
Borden Creek	00-0600-020-120
Middle Creek	00-0600-020-170
Centre Creek	not available
Chipmunk Creek	not available
Ryder Creek	00-0600-020-050
Little Chilliwack River	not available
Brown Creek	not available
C. Harrison District	
Harrison River	01-0000-000-000-000 -000-993

Chehalis River	01-0400
Weaver Creek	01-0500-010
Birkenhead River	01-4100
Big Silver Creek	01-1800
Steelhead Creek	00-0400-140
D. Fraser Canyon District	
Coquihalla River	00-0800
Jones Creek	00-0735
Lorenzetti Creek	00-0736
Silverhope Creek	00-0790
Hunter Creek	00-0760
American Creek	00-0815
Spuzzum Creek	00-0900
Nahatlatch River	00-1200
Anderson Creek	00-1000
Emory Creek	not available
Stoyama Creek	not available
Kawkawa Creek (Sucker Creek)	00-0800-010
Texas Creek (Choate Creek)	not available
Nine Mile Creek	not available
Yale Creek	00-0860
Hawkes Creek	00-0552-020-015?
Popkum Creek	not available
Flood Creek	not available
Sawmill Creek	not available
E. Seton-Anderson District	
Seton Creek	00-1800-000-000-000 -000-992
Cayoosh Creek	00-1800-050
Portage Creek	00-1800-000-000-000 -000-991
Bridge River	00-1900
Gates Creek	00-1800-650
Yalakom River	00-1900-150
F. Thompson District	
Thompson River	02-0000
Nicola River	02-2500
Bonaparte River	02-5000
Deadman Creek	02-7000
Bear Creek	00-6300
Adams River	03-1800-000-000-000 -000-991
Little River	03-0000-000-000-000 -000-992
South Thompson River	03-0000-000-000-000 -000-991
North Thompson River	04-0000
Lower Shuswap River	03-5400-000-000-000 -000-991
Nicoamen River	not available
G. Upper Fraser District	
Stein River	00-1400

Churn River	not available
Quesnel River	06-0000
Williams Lake Creek	not available
Chilcotin River	05-0000
Watson Bar Creek	not available
Gaspard Creek	not available
Canoe Creek	not available
Big Bar Creek	not available
H. Burrard Inlet District	
Indian River	90-0500

APPENDIX B

DESCRIPTION OF SOFTWARE AND DATA FILES

In this appendix, the software and data files produced in this project are described. Some parts of this appendix may be repetitive to other sections of the report (particularly Section 3), because software and data files were intentionally described only briefly in the report. This appendix, however, is intended to be a more complete description of the software programs (and their use) and data file formats.

Data Entry System

The data entry system used for the pink salmon database was constructed by modifying the Lotus (Version 2) program developed for entry of sockeye data. The data entry system for pink salmon was, therefore, very similar to the sockeye program, with minor revisions to accommodate the differences in the type of data unique to pink salmon enumeration (e.g., Glen Valley tagged strays).

One spreadsheet was used for each data card (each stream and year). The spreadsheet was organized into three windows (Table B.1). Windows A and B provided labelled fields for most data from the front of the IPSFC data card (year, codes for stream identifiers, IPSFC card number, sex ratio, percent spawn, dates of spawning, etc.), as well as codes for the method of population enumeration, adjustments, and linking codes when streams were enumerated in a complex or when stray tags were collected. The sex ratio entered was the actual sex ratio of the population estimate as shown on the card although several sex ratios were shown for some streams. On window B, four remarks lines were provided for remarks that pertained directly to the population estimate, such as the source of the estimate (e.g., FFS or DFO), and water and weather conditions that may have affected the quality of certain counts (e.g., turbidity may cause low live counts). Window C provided fields for raw data counts. Each row was labelled with consecutive dates spanning the field season. Only the raw data were entered; no totals or

Table B.1. Format of Lotus spreadsheet for data entry to pink salmon database.

A. Window A

```
Input  Save  Erase  Read  Overlay  New  Dos  Quit
Input/edit data on one of the three screens
        A        B        C        D        E        F        G        H        I        J
1    RECORD NUMBER:                FILE NAME:
2              year:               !         POPULATION ESTIMATE
3          district:               !  total:                     method used:
4            stream:               !   male:              factors          A:
5         substream:               ! female:                               B:
6           species:               !                                       C:
7              card:               !
8    ------------------------------|------------------------------------------------
9    ADJUSTMENTS USED     MALE          FEMALE          TOTAL
10                  ------------- ------------- -------------
11    popn estimate
12    dead recovery
13   tags available
14   tags recovered
15   -------------------------------------------------------------------------------
16   TAG DATA         local   stray1 stray2 stray3 stray4 stray5
17           district
18             stream
19          substream
20   number recovered
12-Mar-87  11:25 AM                        CMD        CALC
```

B. Window B

```
        A        B        C        D        E        F        G        H        I        J
22
23              SEX RATIO                       PEAK SPAWNING   MONTH       DAY
24                  source:                              from:
25                   males:                                to:
26                 females:
27
28            MISCELLANEOUS                      ARRIVAL DATES
29                biologist:                    first observed:
30      card completed by:                                25%:
31        weighted % spawn:                               50%:
32     biosamples obtained?                               75%:
33                                                       100%:
34
35                             REMARKS
36     |-------------------------------------------------------------------|
37     | LINE 1:                                                           |
38     | LINE 2:                                                           |
39     | LINE 3:                                                           |
40     | LINE 4:                                                           |
41     |-------------------------------------------------------------------|
                                           CMD        CALC
```

C. Window C

```
      L    M    N        O        P        Q        R        S        T        U
 43
 44   DATE      LIVE COUNT          TAGS APPLIED            UNTAGGED DEAD
 45             CODE  COUNT      MALE FEMALE UNKNOWN     MALE FEMALE UNKNOWN
 46             -----------      ------------------      ------------------
 47                       0        0       0       0       0       0       0
 48             -----------      ------------------      ------------------    ...
 49  SEP   1
 50  SEP   2
 51  SEP   3
       :
164  DEC  25
165  DEC  26
166  DEC  27
```

```
     V        W        X        Y        Z       AA      AB      AC      AD      AE      AF      AG      AH      AI
            LOCAL                       G.V.                                PERCENT SPAWNED SAMPLES
         TAGGED DEAD                TAGGED DEAD         BRIDGE/DAM            0%             50%            100%
    MALE FEMALE UNKNOWN         MALE FEMALE UNKNOWN     LOCN COUNT        F       TR      F       TR      F       TR
    ------------------          ------------------      ----------    ---------------------------------------------
      0        0       0          0        0       0             0        0       0       0       0       0       0
... ------------------          ------------------      ----------    ---------------------------------------------  ...
```

```
     AJ     AK    AL    AM      AN      AO      AP      AQ      AR      AS      AT      AU        AV
                                          REPITCHED CARCASS RESULTS
     WATER TEMP          UNTAGGED DEAD          LOCAL TAGGED DEAD          G.V. TAGGED DEAD
    LOCN TEMP TIME    MALE FEMALE UNKNOWN     MALE FEMALE UNKNOWN       MALE FEMALE UNKNOWN
    --------------  RRRRRRRRRRRRRRRRRRRR  RRRRRRRRRRRRRRRRRRRR  RRRRRRRRRRRRRRRRRRRR
                        0       0       0       0       0       0       0       0       0
... --------------  RRRRRRRRRRRRRRRRRRRR  RRRRRRRRRRRRRRRRRRRR  RRRRRRRRRRRRRRRRRRRR
                                                                                            0
                                                                                            0
                                                                                            0
                                                                                            0
                                                                                            0
                                                                                            0
                                                                                            0
                                                                                            0
                                                                                            0
                                                                                            0
                                                                                            0
                                                                                            0
                                                                                            0
```

----

cumulative tallies were entered. This saved time in data entry by preventing "double entry" of data. In Window C, the sex unknown column was used mostly for counted but unpitched dead fish where data were given on the data cards with live count data but no notation was made for dead count. This column was also occasionally used for tagging data. The "Bridge/Dam" column was used for bridge and dam counts, and these were coded (under "location") as B and D, respectively. In the sockeye data entry program, these columns were labelled "Partial Counts". Glen Valley tag recoveries and repitches were recorded separately from local tag recoveries and repitches.

The major advantage of using Lotus spreadsheets for data entry was that the program was designed to be menu-driven by several macros to allow easy access to the different windows of the spreadsheet (using the macro "input"), cursor movements were restricted to labelled fields for data entry, and saving of data in standard formats was handled automatically (using the macro "save"). In addition, streams with special cases of data adjustments were handled easily. New raw data files were initialized using the macro "new". Another convenient function of the data entry system was that data from a stream that had already been saved could be loaded back into the Lotus spreadsheet (by entering year, district, stream, and substream to the spreadsheet and using the macro "read"). The data could then be edited and resaved back to the original location in the data file (using the macro "overlay") if no remarks lines were added.

Raw Data Files

Data were stored in formatted flat files. There was one such file created per year and named "in85.dat" etc. for the 18 years of data entered. Data from the spreadsheet were grouped into five different line types in the flat files (Table B.2). These lines were automatically coded with the same number (corresponding to the particular

Table B.2. Format of flat files for data storage in the pink salmon database.

FIELD	FORMAT	START LOCATION
RECORD TYPE: A1		
RECORD ID: "A1"	2	1
RECORD NUMBER	5	3
YEAR	4	8
DISTRICT	3	12
STREAM	3	15
SUBSTREAM	2	18
SPECIES	2	20
CARD #	5	22
TOTAL ESTIMATE	7	27
MALE ESTIMATE	7	34
FEMALE ESTIMATE	7	41
METHOD USED	2	48
FACTOR A:	8.2	50
FACTOR B:	8.2	58
FACTOR C:	8.2	66
TOTAL		74
RECORD TYPE: A2		
RECORD ID: "A2"	2	1
RECORD NUMBER	5	3
ADJUSTMENTS ON POPULATION ESTIMATE		
MALE 1	6	8
MALE 2	6	14
FEMALE 1	6	20
FEMALE 2	6	26
TOTAL 1	6	32
TOTAL 2	6	38
ADJUSTMENTS ON DEAD RECOVERY		
MALE 1	6	44
MALE 2	6	50
FEMALE 1	6	56
FEMALE 2	6	62
TOTAL 1	6	68
TOTAL 2	6	74
ADJUSTMENTS ON TAGS AVAILABLE		
MALE 1	6	80
MALE 2	6	86
FEMALE 1	6	92
FEMALE 2	6	98
TOTAL 1	6	104
TOTAL 2	6	110
ADJUSTMENTS ON TAGS RECOVERED		
MALE 1	6	116

MALE 2	6	122
FEMALE 1	6	128
FEMALE 2	6	134
TOTAL 1	6	140
TOTAL 2	6	146
TAG RECOVERIES		
DISTRICT - LOCAL	3	152
DISTRICT - STRAY1	3	155
DISTRICT - STRAY2	3	158
DISTRICT - STRAY3	3	161
DISTRICT - STRAY4	3	164
DISTRICT - STRAY5	3	167
STREAM - LOCAL	3	170
STREAM - STRAY1	3	173
STREAM - STRAY2	3	176
STREAM - STRAY3	3	179
STREAM - STRAY4	3	182
STREAM - STRAY5	3	185
SUBSTREAM - LOCAL	2	188
SUBSTREAM - STRAY1	2	190
SUBSTREAM - STRAY2	2	192
SUBSTREAM - STRAY3	2	194
SUBSTREAM - STRAY4	2	196
SUBSTREAM - STRAY5	2	198
# RECOVERED - LOCAL	8	200
# RECOVERED - STRAY1	8	208
# RECOVERED - STRAY2	6	216
# RECOVERED - STRAY3	6	222
# RECOVERED - STRAY4	6	228
# RECOVERED - STRAY5	5	234
TOTAL		238

RECORD TYPE: B

RECORD ID: "B "	2	1
RECORD NUMBER	5	3
SEX RATIO		
SOURCE	2	8
MALES	4.1	10
FEMALES	4.1	14
PEAK SPAWNING		
FROM MONTH	3	18
FROM DAY	5	21
TO MONTH	3	26
TO DAY	5	29
ARRIVAL DATES		
FIRST MONTH	3	34
FIRST DAY	5	37
25% MONTH	3	42
25% DAY	5	45
50% MONTH	3	50
50% DAY	5	53
75% MONTH	3	58

75% DAY	5	61
100% MONTH	3	66
100% DAY	5	69
MISCELLANEOUS		
BIOLOGIST	10	74
CARD COMPLETER	10	84
PERCENT SPAWN	5.1	94
BIOSAMPLES	1	99
TOTAL		99

RECORD TYPE: BR

RECORD ID: "BR"	2	1
RECORD NUMBER	5	3
REMARKS	220	8
TOTAL		227

RECORD TYPE: C

RECORD ID: "C "	2	1
RECORD NUMBER	5	3
MONTH	3	8
DAY	3	11
LIVE COUNT		
LIVE COUNT CODE	6	14
LIVE COUNT	7	20
TAGS APPLIED (OR LIVE COUNT, SEE CODE ABOVE)		
MALE	7	27
FEMALE	7	34
UNKNOWN	7	41
UNTAGGED DEAD PITCHED		
MALE	7	48
FEMALE	7	55
UNKNOWN	7	62
LOCAL TAGGED DEAD PITCHED		
MALE	7	69
FEMALE	7	76
UNKNOWN	7	83
G.V. TAGGED DEAD PITCHED		
MALE	7	90
FEMALE	7	97
UNKNOWN	7	104
BRIDGE/DAM COUNTS		
LOCATION	5	111
COUNT	8	116
PERCENT SPAWN DATA		
0% FRESH	6	124
0% TAINTED AND RANK	6	130
50% FRESH	6	136
50% TAINTED AND RANK	6	142
100% FRESH	6	148

100% TAINTED AND RANK	6	154
WATER TEMPERATURE DATA		
LOCATION	6	160
TEMPERATURE	5	166
TIME	5	171
UNTAGGED DEAD IN RE-PITCH		
MALE	7	176
FEMALE	7	183
UNKNOWN	7	190
LOCAL TAGGED DEAD IN RE-PITCH		
MALE	7	197
FEMALE	7	204
UNKNOWN	7	211
G.V. TAGGED DEAD IN RE-PITCH		
MALE	7	218
FEMALE	7	225
UNKNOWN	7	232
TOTAL		238

stream) when saved from the spreadsheet to the flat file. Data from the spreadsheet windows A and B were saved in line types A1, A2, and B. Remarks fields from the spreadsheet were concatenated and saved in line type BR. Data from each date of field observations were saved in separate C type lines. This system of line types maintained reasonable line lengths (less than 256 characters) and saved space in the flat files since dates with no data were ignored.

The major advantage of using flat files rather than spreadsheets for data storage was that it facilitated production of summaries of streams across years and compilation of summaries of annual data. Other advantages are that flat files have a much lower storage requirement than Lotus spreadsheets would have and are more readily accessible by other computer systems and Fortran programs. The data occupy less than 150 kilobytes per year resulting in a total storage requirement of the order of 2.5 megabytes.

<u>Reconstruction of Population Estimates (CHEKPINK)</u>

Data verification was performed by reconstructing the population estimates from the raw data entered and comparing the values to the final estimates from the data cards by sex and total. A program called "chekpink" was written in Fortran 77 that reads in the raw data from the raw data files and reconstructs population estimates for each stream according to the data, method codes, and adjustments in the file. The purpose of chekpink was, therefore, to verify the data for errors in data entry, the understanding of method of estimation and adjustments, and in the original data cards. Chekpink also provides the ultimate documentation for the methods of enumeration that have been used by the IPSFC. A flow chart of chekpink is shown in Figure B.1 and a list of the program variable names is given in Table B.3.

<u>Data Summary Files</u>

Data summary files for each year were output from chek-

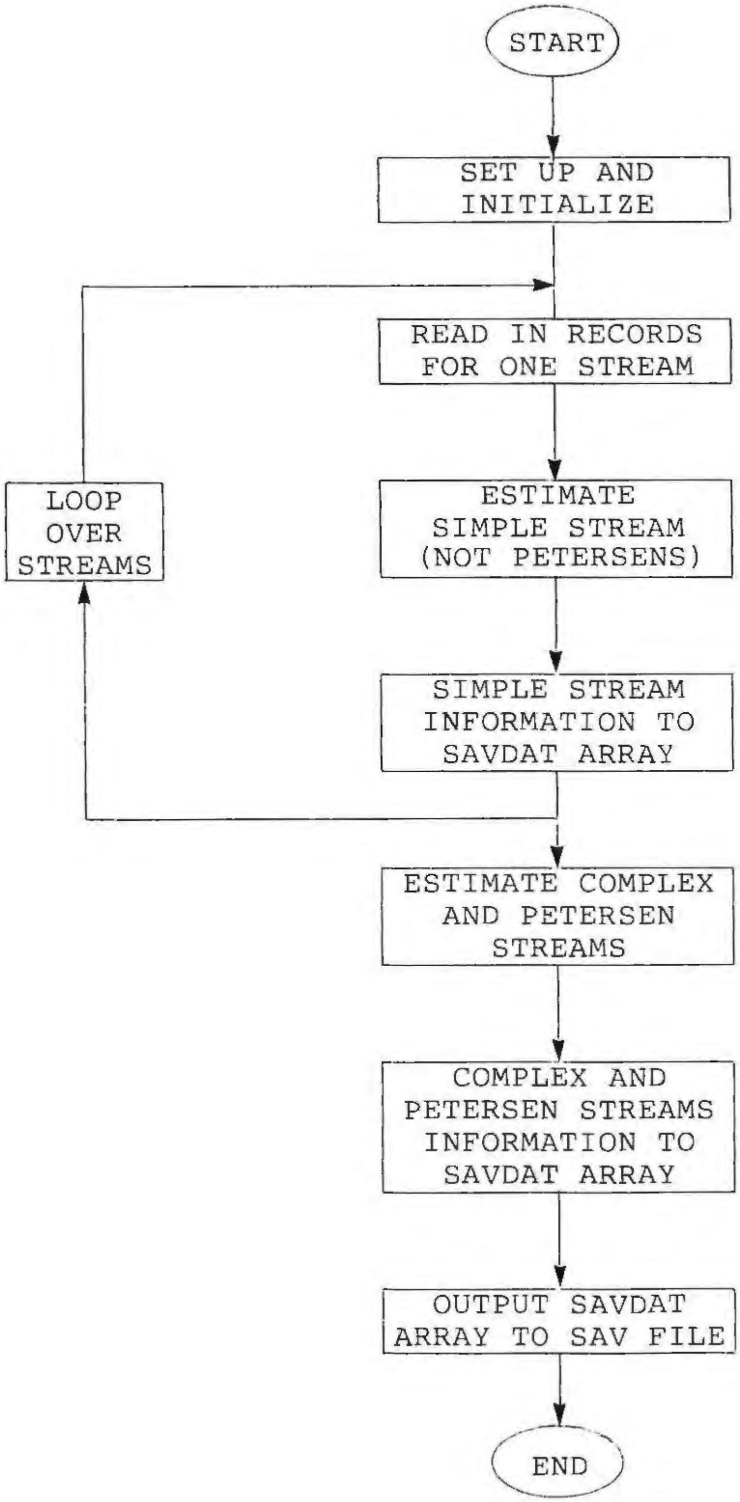

Figure B.1: Flowchart for Fortran 77 program Chekpink.

Table B.3. Names of variables, vectors, and arrays used in the Fortran 77 program CHEKPINK.

Variable, Vector or Array	Contents
iadat(10)	1 year 2 district 3 stream 4 substream 5 species 6 card number 7 population estimate total from card 8 population estimate of males from card 9 population estimate of females from card 11 method
isavyr	year (iadat(1))
factor(3)	three factors used with the method
adjust(4,6)	adjustments used with the method to population estimate, dead recovery, tags available, and tags recovered; two each for males, females, jacks, and total estimate
ilinks(6,3)	six districts, streams, and substreams from which stray tags were recovered
ntreca(6)	number of tag recoveries from six tag release sites corresponding to ilinks(6,3). Format of entry is m---f---. Abbreviated "na" in subroutine "decode".
ntrec(6,2)	number of tag recoveries from males and females from m---f--- string. Abbreviated "n" in subroutine "decode".
sexrat(2)	sex ratio; percent males and percent females
date1(7)	dates of spawning
date2(7)	dates of spawning
coment(4)	remarks lines
month(100) and day(100)	assuming a maximum of 100 dates of data collection, each element contains the month of individual sampling dates day (100); each element contains the day of individual sampling dates
lccode(100)	live count codes
itagap(100,3)	tags applied; males, females, and fish of unknown sex
iunpit(100,3)	untagged dead recovery; males, females, and fish of unknown sex
itgpit(100,3)	tagged dead recovery of local tags; males, females, and fish of unknown sex
istpit(100,3)	tagged dead recovery of Glen Valley (Fraser River system); males, females, and fish of unknown sex
pccode(100)	partial count location (used for bridge and dam counts)
parcnt(100)	partial count count

pspdat(100,6)	percent spawn; 0% F, 0% TR, 50% F, 50% TR, 100% F, and 100% TR
tmploc(100)	temperature location
temp(100)	temperature
tmptim(100)	temperature time
ireunt(100,3)	repitch untagged dead recovery; males, females, jacks, and fish of unknown sex
iretag(100,3)	repitch local tagged dead recovery; males, females, jacks, and fish of unknown sex
irstag(100,3)	repitch Glen Valley tagged dead recovery; males, females, jacks, and fish of unknown sex
livcnt(100)	live count
savdat(60,60)	summary data saved from each stream; assumes a maximum of 110 streams enumerated per year (see separate list of column contents)
istrms(50,9,2)	in the calculations for a complex, stream and substream where tags were recovered
buff	buffer
filnam	filename
biosmp	biosamples
icnum	count of C lines (max=100)
iline	count of A1, A2, B (adjustments), and BR (remarks) lines
irnum	record number (one number for all records relating to the same stream)
isex	sex ratio source
pspawn	percent spawned
psp0	total for 0% spawned (fresh + tainted and rank)
psp50	total for 50% spawned (fresh + tainted and rank)
psp100	total for 100% spawned (fresh + tainted and rank)
mthgrp	method group code (classification of method)
totdrm	total dead recovery of males (tagged plus untagged); totdrf females, and totdrj jacks
tottam	total tags available for males; tottaf females, and tottaj jacks
tottrm	total tag recovery of males; tottrf females, and tottrj jacks
myestm	population estimate for males calculated by program; myestf females, myestj jacks, and myest total
ilsum	sum of live counts
idsum	sum of dead counts
livpek	peak live count
icmax	linenumber of peak live count
numday	number of days of dead pitching
idtmp	temporary dead sum
mytmp	temporary estimate

Subroutine corr:

adjust(4,6)	as above
addfac(4,4)	addition adjustments to population estimate, dead recovery, tags available, and tag recovery for males, females, total, and sum of all these
mulfac(4,4)	multiplier adjustments to population estimate, dead recovery, tags available, and tag recovery for males, females, total, and sum of all these
lcode	adjustment code, e.g., x
nd	substitution for number of days of dead pitch
cd	substitution for cumulative dead
dr	substitution for dead recovery
plc	substitution for peak live count
igvtag(3)	number of Glen Valley tags for males, females, and unknown sex to substitute for total from raw data
loctag(3)	number of local tags for males, females, and unknown sex to substitute for total from raw data

Calculations for complexes of streams:

icomp	in do loops, savdat array element (row) number of the main stream in the complex
iscan	in do loops, savdat array element (row) number of streams in the complex other than the main stream
tdr(2)	total dead recovery of males and females
ttr(2)	total tag recovery of males and females
toto(2)	total population estimates of males and females in "other" streams that are included in the complex calculation but are also enumerated by other methods and whose populations are later subtracted out from the complex estimate
grdr(2)	total dead recovery of males and females in "group" of streams in the complex
totsty(2)	total male and female strays
iscptr(50)	row number of savdat of all streams relating to the main stream where tag release took place
comest(9)	population estimate of the complex for males and females
jsex	in do loops, vector element number which refers to males and females
isvptr	row number in savdat

---

pink using the raw data files. These files are called "sav85.dat", etc., one for each of the raw data files. They are flat files like the raw data files, but each row contains summary data from one stream. The contents of the fields are listed in Table B.4 (rows are composed of the year plus contents of the savdat array from chekpink).

Software for Analyses (CVCALC)

Descriptive analyses were conducted using the summary files (e.g., sav85) loaded into Lotus spreadsheets. Statistical analyses were conducted using the Fortran 77 program "cvcalc", which used data from summary files and calculated coefficients of variation for each stream according to the method used for enumeration, as well as annual summaries across streams. The Lotus graphics package was used to produce figures.

Table B.4. Contents of fields of SAV data summary files. (Program variable names are given in parentheses. In this list, note that "complex" refers to a group of streams for which the population estimate is calculated together.)

Field	Contents
1	year
2	district
3	stream
4	substream
5	method
6	population estimate of males calculated by the program (myestm)
7	population estimate of females calculated by the program (myestf)
8	total population estimate calculated by the program (myest)
9	total dead recovery of males (totdr(1) or totdrm)
10	total dead recovery of females (totdr(2) or totdrf)
11	total dead recovery of fish of unknown sex (totdr(4) or totdru)
12	total tags available for males (totta(1) or tottam)
13	total tags available for females (totta(2) or tottaf)
14	total tags available for fish of unknown sex (totta(4) or tottau)
15	total tag recovery of males (tottr(1) or tottrm)
16	total tag recovery of females (tottr(2) or tottrf)
17	total tag recovery of fish of unknown sex (tottr(4) or tottru)
18	factor(1) used with method
19	factor(2) used with method
20	factor(3) used with method
21	addition adjustments on the population estimate of males (addfac(1,1))
22	addition adjustments on the population estimate of females (addfac(1,2))
23	addition adjustments on the total population estimate (addfac(1,4))
24	multiplier adjustments on the population estimate of males (mulfac(1,1))
25	multiplier adjustments on the population estimate of females (mulfac(1,2))
26	multiplier adjustments on the total population estimate (mulfac(1,4))
27	estimate of total population from data card (iadat(7))
28	population estimate of males from data card (iadat(8))
29	population estimate of females from data card (iadat(9))
30	flag to indicate that this record is a main stream

	in complex (icross)
31	reference to main district
32	reference to main stream
33	reference to main substream
34	number of days of data collection (icnum)
35	total dead recovery of males for complex (tdr(1))
36	total dead recovery of females for complex (tdr(2))
37	total tag recovery of males for complex (ttr(1))
38	total tag recovery of females for complex (ttr(2))
39	percent spawn (pspawn)
40	method group code (classification of stream)
41	total of F+TR for 0% spawn (psp0)
42	total of F+TR for 50% spawn (psp50)
43	total of F+TR for 100% spawn (psp100)
44	total male strays with local (non-Glen Valley) tags from this main stream (if mainstem, then strays have Glen Valley tags)
45	total female strays with local (non-Glen Valley) tags from this main stream (if mainstem, then strays have Glen Valley tags)
46	calculated Glen Valley male tag recovery
47	calculated Glen Valley female tag recovery
48	observed Glen Valley male tag recovery
49	observed Glen Valley female tag recovery

APPENDIX C

RESULTS TABLES

Table C.1. Methods used for enumeration of pink salmon spawners from 1957 to 1985. (Use Table A.1 to interpret stream and sub-stream codes and Table A.2 to interpret method codes.)

Stream +	Substream	57	59	61	63	65	67	69	71	73	75	77	79	81	83	85
A.	Lower Fraser District															
1	0	48	61	61	53	53	53	53	53	53	53	53	53	53	53	53
2	0	0	12	12	12	12	12	0	12	12	20	0	12	12	12	12
3	0	0	0	0	0	0	0	0	0	0	0	0	0	12	12	27
4	0	12	12	12	12	12	12	0	0	0	0	0	0	0	27	0
5	0	12	0	20	20	0	0	0	0	0	0	0	0	20	0	0
6	0	12	12	12	12	12	20	0	0	0	0	0	0	0	0	27
7	0	12	12	12	12	12	12	0	0	0	0	0	0	0	0	0
8	0	12	12	12	12	12	20	0	0	0	0	0	0	0	0	0
9	0	12	0	20	20	20	20	0	0	0	0	0	0	0	0	0
10	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0
11	0	20	0	20	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0
14	0	12	0	20	20	0	0	0	0	0	0	0	0	0	0	0
15	0	12	0	20	20	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	27
17	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0
18	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27
B.	Chilliwack-Vedder District															
1	0	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4
2	0	0	20	20	0	0	0	0	0	12	20	0	20	20	20	0
3	0	12	12	12	12	12	12	12	12	16	12	12	12	12	12	12
4	0	0	0	0	12	12	12	20	20	20	0	0	12	20	20	12
5	0	0	0	0	12	12	12	20	20	20	0	0	12	12	20	20
6	0	0	0	0	12	12	12	12	12	46	20	0	27	27	12	0
7	0	0	12	12	12	12	12	12	12	12	12	12	12	12	12	0
8	0	0	20	20	12	12	12	12	12	12	20	20	20	20	20	0
9	0	0	0	0	0	0	0	0	0	0	12	12	0	19	12	12
10	0	0	0	0	0	0	0	0	0	0	20	0	0	0	20	12
11	0	0	12	12	12	12	12	12	12	12	12	12	12	12	0	12
12	0	0	0	0	0	0	0	0	0	0	20	0	12	0	0	0
13	0	0	0	0	0	0	0	0	12	0	20	0	0	0	0	0
15	0	0	0	0	0	0	12	12	0	0	0	0	0	0	0	12
16	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C.	Harrison District															
1	0	4	4	3	4	3	3	3	3	3	3	3	4	4	4	3
2	0	3	12	3	12	12	48	12	50	12	12	12	12	12	12	0

3	1	50	50	57	50	50	50	12	12	16	12	50	50	50	50	12
3	2	0	0	0	0	14	14	14	14	27	14	14	14	14	14	14
4	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0
5	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
D.	Fraser Canyon District															
1	0	12	3	12	12	12	12	12	4	3	12	12	16	12	12	12
2	1	12	0	27	27	27	0	48	27	27	27	12	16	12	12	12
2	2	7	27	7	27	0	27	48	27	27	0	27	14	14	27	14
2	3	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	12	12	12	12	12	0	0	0	0	0	0	12	12	12
4	0	12	12	12	12	12	12	12	21	12	12	12	12	12	12	12
5	0	20	12	12	12	12	12	0	12	12	12	12	12	12	12	12
6	0	12	12	12	12	12	12	0	21	0	0	0	0	12	12	12
7	0	12	12	12	12	12	12	12	12	12	0	12	0	0	12	12
8	0	12	12	12	12	12	12	0	12	0	12	12	12	12	12	12
9	0	12	12	12	12	12	12	12	12	12	12	12	12	48	12	12
10	0	20	12	12	12	12	12	0	12	20	0	20	0	0	12	12
11	0	0	12	0	20	0	0	0	0	0	0	0	0	0	20	0
12	0	12	12	12	12	12	12	12	12	12	0	0	0	12	12	12
13	0	0	12	20	20	0	0	0	0	0	0	0	0	19	0	0
14	0	0	0	0	0	0	0	0	20	20	0	12	20	0	0	0
15	0	0	12	12	12	20	12	0	12	0	0	0	0	0	0	12
16	0	0	0	0	0	27	20	0	0	0	0	0	0	0	0	0
17	0	20	12	20	20	0	0	0	0	0	0	0	0	0	0	0
18	0	0	12	20	12	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
E.	Seton-Anderson District															
1	1	4	0	3	3	3	3	3	0	0	4	4	4	22	4	3
1	2	0	0	0	0	28	14	14	14	14	14	14	14	14	14	14
1	3	0	0	0	0	0	14	14	14	14	14	14	14	14	14	14
1	4	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0
2	0	0	0	0	55	56	0	21	12	12	16	12	12	21	12	12
3	0	12	12	12	12	12	48	12	12	12	12	3	3	12	12	12
4	0	20	12	12	12	12	12	12	12	12	12	12	12	12	12	12
5	0	0	0	0	0	0	0	0	0	0	0	12	12	12	0	0
6	1	0	0	0	0	0	0	0	55	0	0	0	0	0	0	0
7	0	20	12	20	20	20	0	0	0	0	0	0	0	0	0	0
F.	Thompson District															
1	0	59	50	4	4	54	48	48	4	3	4	4	4	4	4	3
2	0	12	12	12	12	12	12	0	12	12	12	12	12	12	12	12
3	0	12	12	12	12	12	12	12	12	12	12	12	12	0	12	12
4	0	12	20	12	12	12	20	12	12	20	12	12	12	12	12	7
6	0	0	0	0	0	50	0	0	50	16	16	12	50	50	51	50
7	0	0	0	0	0	0	0	0	0	0	16	12	50	50	51	0
8	0	0	0	0	0	0	0	0	0	0	0	12	12	12	51	0
9	0	0	0	0	0	0	0	0	0	0	0	27	12	12	27	0
10	0	0	0	0	0	0	0	0	0	0	16	12	12	12	12	0
11	0	0	12	20	0	20	0	12	0	0	0	0	0	0	0	0
G.	Upper Fraser District															
1	0	12	12	12	12	12	12	0	12	0	12	12	12	12	12	12
2	0	12	0	0	12	12	12	0	12	0	0	12	27	12	12	12
3	0	0	0	0	0	27	4	19	27	20	0	27	27	12	27	20

4	0	0	0	0	0	0	20	0	12	20	0	0	12	0	0	0
5	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0
7	0	0	0	0	12	0	27	0	0	0	0	0	0	0	0	0
8	0	20	0	0	0	0	20	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0
H.	Burrard Inlet District															
1	0	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table C.2. Method group of methods used for enumeration of pink salmon spawners from 1957 to 1985. (1 = Petersen, simple stream; 2 = Petersen, complex streams; 3 = live and dead count methods; 4 = live count methods; 5 = dead count methods; 6 = miscellaneous methods; 7 = not done. Use Table A.1 to interpret stream and substream codes.)

Stream +	Substream	57	59	61	63	65	67	69	71	73	75	77	79	81	83	85
A.	Lower Fraser District															
1	0	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	0	0	3	3	3	3	3	0	3	3	7	0	3	3	3	3
3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	6
4	0	3	3	3	3	3	3	0	0	0	0	0	0	0	6	0
5	0	3	0	7	7	0	0	0	0	0	0	0	0	7	0	0
6	0	3	3	3	3	3	7	0	0	0	0	0	0	0	0	6
7	0	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0
8	0	3	3	3	3	3	7	0	0	0	0	0	0	0	0	0
9	0	3	0	7	7	7	7	0	0	0	0	0	0	0	0	0
10	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
11	0	7	0	7	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
14	0	3	0	7	7	0	0	0	0	0	0	0	0	0	0	0
15	0	3	0	7	7	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	6
17	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
18	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
B.	Chilliwack-Vedder District															
1	0	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2
2	0	0	7	7	0	0	0	0	0	3	7	0	7	7	7	0
3	0	3	3	3	3	3	3	3	3	5	3	3	3	3	3	3
4	0	0	0	0	3	3	3	7	7	7	0	0	3	7	7	3
5	0	0	0	0	3	3	3	7	7	7	0	0	3	3	7	7
6	0	0	0	0	3	3	3	3	3	6	7	0	6	6	3	0
7	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	0
8	0	0	7	7	3	3	3	3	3	3	7	7	7	7	7	0
9	0	0	0	0	0	0	0	0	0	0	3	3	0	6	3	3
10	0	0	0	0	0	0	0	0	0	0	7	0	0	0	7	3
11	0	0	3	3	3	3	3	3	3	3	3	3	3	3	0	3
12	0	0	0	0	0	0	0	0	0	0	7	0	3	0	0	0
13	0	0	0	0	0	0	0	0	3	0	7	0	0	0	0	0
15	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	3
16	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0

C. Harrison District

1	0	2	2	1	2	1	1	1	1	1	1	1	2	2	2	1
2	0	1	3	1	3	3	6	3	1	3	3	3	3	3	3	0
3	1	1	1	6	1	1	1	3	3	5	3	1	1	1	1	3
3	2	0	0	0	0	5	5	5	5	6	5	5	5	5	5	5
4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
5	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3

D. Fraser Canyon District

1	0	3	1	3	3	3	3	3	2	1	3	3	5	3	3	3
2	1	3	0	6	6	6	0	6	6	6	6	3	5	3	3	3
2	2	4	6	4	6	0	6	6	6	6	0	6	5	5	6	5
2	3	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	3	3	3	3	3	0	0	0	0	0	0	3	3	3
4	0	3	3	3	3	3	3	3	6	3	3	3	3	3	3	3
5	0	7	3	3	3	3	3	0	3	3	3	3	3	3	3	3
6	0	3	3	3	3	3	3	0	6	0	0	0	0	3	3	3
7	0	3	3	3	3	3	3	3	3	3	0	3	0	0	3	3
8	0	3	3	3	3	3	3	0	3	0	3	3	3	3	3	3
9	0	3	3	3	3	3	3	3	3	3	3	3	3	6	3	3
10	0	7	3	3	3	3	3	0	3	7	0	7	0	0	3	3
11	0	0	3	0	7	0	0	0	0	0	0	0	0	0	7	0
12	0	3	3	3	3	3	3	3	3	3	0	0	0	3	3	3
13	0	0	3	7	7	0	0	0	0	0	0	0	0	6	0	0
14	0	0	0	0	0	0	0	0	7	7	0	3	7	0	0	0
15	0	0	3	3	3	7	3	0	3	0	0	0	0	0	0	3
16	0	0	0	0	0	6	7	0	0	0	0	0	0	0	0	0
17	0	7	3	7	7	0	0	0	0	0	0	0	0	0	0	0
18	0	0	3	7	3	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3

E. Seton-Anderson District

1	1	2	0	1	1	1	1	1	0	0	2	2	2	2	2	1
1	2	0	0	0	0	4	5	5	5	5	5	5	5	5	5	5
1	3	0	0	0	0	0	5	5	5	5	5	5	5	5	5	5
1	4	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
2	0	0	0	0	6	6	0	6	3	3	5	3	3	6	3	3
3	0	3	3	3	3	3	6	3	3	3	3	1	1	3	3	3
4	0	7	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5	0	0	0	0	0	0	0	0	0	0	0	3	3	3	0	0
6	1	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
7	0	7	3	7	7	7	0	0	0	0	0	0	0	0	0	0

F. Thompson District

1	0	3	1	2	2	4	6	6	2	1	2	2	2	2	2	1
2	0	3	3	3	3	3	3	0	3	3	3	3	3	3	3	3
3	0	3	3	3	3	3	3	3	3	3	3	3	3	0	3	3
4	0	3	7	3	3	3	7	3	3	7	3	3	3	3	3	4
6	0	0	0	0	0	1	0	0	1	5	5	3	1	1	1	1
7	0	0	0	0	0	0	0	0	0	0	5	3	1	1	1	0
8	0	0	0	0	0	0	0	0	0	0	0	3	3	3	1	0
9	0	0	0	0	0	0	0	0	0	0	0	6	3	3	6	0
10	0	0	0	0	0	0	0	0	0	0	5	3	3	3	3	0
11	0	0	3	7	0	7	0	3	0	0	0	0	0	0	0	0

G.	Upper Fraser District															
1	0	3	3	3	3	3	3	0	3	0	3	3	3	3	3	3
2	0	3	0	0	3	3	3	0	3	0	0	3	6	3	3	3
3	0	0	0	0	0	6	2	6	6	7	0	6	6	3	6	7
4	0	0	0	0	0	0	7	0	3	7	0	0	3	0	0	0
5	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
7	0	0	0	0	3	0	6	0	0	0	0	0	0	0	0	0
8	0	7	0	0	0	0	7	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
H.	Burrard Inlet District															
1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table C.3. Estimates of the escapement of pink salmon to Fraser River streams from 1957 to 1985. (Numbers are in hundreds of spawners, numbers less than 100 but greater than zero are entered as 100. Where spawners were absent, there was no estimate or the escapement is included in another stream entry.)

Stream + Substream		1957	1959	1961	1963	1965	1967	1969	1971	1973	1975	1977	1979	1981	1983	1985
A.	Lower Fraser District															
1	0	10739	7339	5478	5168	5437	7857	8485	9280	7660	3150	7550	15218	22523	33078	52487
2	0		5	4	6	2	2		11	10			16	2	22	54
3	0													31	9	120
4	0	70	13	39	9	2	2								1	
5	0															
6	0		1	1	1	1										1
7	0	7	1	2	2	1	1									
8	0	1	1	1	1	1										
9	0	1														
10	0															
11	0															
12	0															
13	0															
14	0	1														
15	0	1														
16	0															10
17	0															
18	0															
19	0															
20	0															35
21	0															5
22	0															1
23	0															1
24	0															1
B.	Chilliwack-Vedder District															
1	0	2123	915	1880	3126	1888	2494	915	1605	2090	806	482	1219	686	991	955
2	0									1						
3	0	98	7	62	152	89	195	189	131	152	161	50	88	52	91	147
4	0				1	1	1						1			1
5	0				1	1	1						5	1		

6	0				2	3	1	1	1	4			11	1	2	
7	0		3	1	15	15	7	2	4	7	4	1	2	1	1	
8	0				1	1	1	1	1	1						
9	0										1	1			1	1
10	0															1
11	0		5	4	29	35	23	1	5	5	1	1	2	1		1
12	0												1			
13	0								3							
15	0						8	1								1
16	0	1														
17	0	1														
C.	Harrison District															
1	0	5857	1103	1861	6454	692	645	963	738	1961	1800	1267	2698	3145	1439	4380
2	0	93	67	119	123	76	56	71	321	143	23	26	20	1	4	
3	1	3	1	5	6	4	3	5	11	2	4	23	1	10	14	33
3	2					1	1	2	2	6	12	9	7	12	18	47
4	0													1		
5	0					1										
6	0															2
D.	Fraser Canyon District															
1	0	66	160	73	149	38	30	20	2308	1568	59	28	164	240	291	1189
2	1	9		7	7	30		4	4	7	36	14	15	26	6	6
2	2	10	21	43	28		31	13	8	18		19	34	18	3	24
2	3		4													
3	0		9	2	1	1	2							7	1	3
4	0	5	19	7	5	1	4	4		18	2	6	10	75	45	135
5	0		2	1	2	1	1		4	3	1	1	2	5	26	10
6	0	1	7	1	3	1	1							2	3	44
7	0	15	21	2	3	1	2	1	1	1		1			7	104
8	0	2	2	2	3	4	1		1		4	20	24	36	47	11
9	0	9	5	1	6	1	1	2	1	1	2	2	3	1	9	18
10	0		7	1	1	1	1		1						3	19
11	0		1													
12	0	6	12	5	1	1	2	3	12	1				18	17	57
13	0		1													
14	0											1				
15	0		5	1	1		1		1							17
16	0					1										
17	0		1													

18	0		1		1											
19	0															1
E.	Seton-Anderson District															
1	1	588		520	1074	880	1975	1988			2081	3318	4988	5193	3718	1633
1	2					70	71	39	60	67	79	111	99	104	96	44
1	3						206	148	248	236	238	371	344	338	310	338
1	4									228						
2	0				5	6			45	13	15	94	506		367	66
3	0	20	1	15	80	59	78	10	14	139	284	199	518	187	102	41
4	0		12	18	64	236	65	130	88	237	108	258	657	439	419	617
5	0											1	12	1		
6	1								316							
7	0		1													
F.	Thompson District															
1	0	2661	863	691	2822	2331	4480	2478	2573	2811	4670	9711	8822	11599	5023	1927
2	0	15	8	2	11	8	3		7	13	68	9	19	9	41	2
3	0	8	1	1	17	17	20	9	6	9	14	6	11		7	1
4	0	6		1	1	1		1	1		23	1	1	4	6	1
6	0					1			8	1	24	11	39	11	35	2
7	0										2	27	7	8	1	
8	0											13	2	15	8	
9	0											1	8	1	1	
10	0										1	1	1	1	1	
11	0		1					1								
G.	Upper Fraser District															
1	0	2	1	1	2	1	1		1		1	5	14	42	4	2
2	0	1			1	1	2		1			13	1	9	9	
3	0					30	23		4			15	3	3	4	
4	0								11				1			
5	0						1									
6	0															
7	0				4		2									
8	0															
9	0															
10	0															
H.	Burrard Inlet District															
1	0	1784														

Table C.4a. Escapements and coefficients of variation of pink salmon for the Lower Fraser District, 1957 to 1985.

Year	Escapement	Variance	Coefficient of Variation
1957	1081965	2747425000	4.8
1959	735987	2823571000	7.2
1961	552681	5658308000	13.6
1963	518764	3267503000	11.0
1965	544246	2793465000	9.7
1967	786297	7255710000	10.8
1969	848532	1583734000	4.7
1971	929185	1296639000	3.9
1973	767114	3000144000	7.1
1975	315049	732390200	8.6
1977	755016	2072750000	6.0
1979	1523458	5930301000	5.1
1981	2255753	7996520000	4.0
1983	3310999	13634680000	3.5
1985	5258311	26136240000	3.1
MEAN:	1345557		6.9

Table C.4b. Escapements and coefficients of variation of pink salmon for the Chilliwack-Vedder District, 1957 to 1985.

Year	Escapement	Variance	Coefficient of Variation
1957	222347	117432300	4.9
1959	93113	46264780	7.3
1961	194772	62489500	4.1
1963	332965	112604900	3.2
1965	203352	44340090	3.3
1967	273143	123694700	4.1
1969	111145	21028790	4.1
1971	175073	36951550	3.5
1973	225664	82999330	4.0
1975	97258	14632070	3.9
1977	53654	8746220	5.5
1979	131830	75833290	6.6
1981	74019	80541190	12.1
1983	108680	47620010	6.3
1985	110602	70248040	7.6
MEAN:	160508		5.4

Table C.4c. Escapements and coefficients of variation of pink salmon for the Harrison District, 1957 to 1985.

Year	Escapement	Variance	Coefficient of Variation
1957	595480	221736800	2.5
1959	117127	11738600	2.9
1961	198058	25391000	2.5
1963	658563	315138700	2.7
1965	77396	13103780	4.7
1967	70705	14826110	5.4
1969	104262	12436850	3.4
1971	107494	31909700	5.3
1973	210705	300333100	8.2
1975	184020	207812200	7.8
1977	132755	32862540	4.3
1979	272779	332128200	6.7
1981	316998	358512400	6.0
1983	147722	87054300	6.3
1985	446377	766486100	6.2
MEAN:	242696		5.0

Table C.4d. Escapements and coefficients of variation of pink salmon for the Fraser Canyon District, 1957 to 1985.

Year	Escapement	Variance	Coefficient of Variation
1957	12660	1121321	8.4
1959	25730	4458066	8.2
1961	14142	580197	5.4
1963	17718	8584853	16.5
1965	4551	779408	19.4
1967	4564	755890	19.0
1969	4894	683054	16.9
1971	18906	4851042	11.6
1973	14482	22170990	32.5
1975	6871	2716812	24.0
1977	7369	788101	12.0
1979	25610	14381470	14.8
1981	43234	13284670	8.4
1983	46128	35534370	12.9
1985	164437	248738500	9.6
MEAN:	27420		14.7

Table C.4e. Escapements and coefficients of variation of pink salmon for the Seton-Anderson District, 1957 to 1985.

Year	Escapement	Variance	Coefficient of Variation
1957	60820	7033366	4.4
1959	1266	109829	26.2
1961	62175	9270078	4.9
1963	136562	29584310	4.0
1965	124634	49458290	5.6
1967	239720	183584100	5.7
1969	231823	91351640	4.1
1971	344461	263561700	4.7
1973	249058	54780280	3.0
1975	280860	124164800	4.0
1977	435341	254849100	3.7
1979	712840	891409100	4.2
1981	626402	399701300	3.2
1983	501475	237980200	3.1
1985	274120	130815000	4.2
MEAN:	285437		5.7

Table C.4f. Escapements and coefficients of variation of pink salmon for the Thompson District, 1957 to 1985.

Year	Escapement	Variance	Coefficient of Variation
1957	269106	448750000	7.9
1959	87224	27659240	6.0
1961	69411	50182950	10.2
1963	285243	522733200	8.0
1965	235836	136193800	4.9
1967	450487	953594300	6.9
1969	248900	1869160000	17.4
1971	259711	168359200	5.0
1973	283504	234857000	5.4
1975	480350	928756000	6.3
1977	978175	1648538000	4.2
1979	891191	589756200	2.7
1981	1164915	1301738000	3.1
1983	512413	163217800	2.5
1985	193448	289672400	8.8
MEAN:	427328		6.6

Table C.4g. Escapements and coefficients of variation of pink salmon for the Upper Fraser District, 1957 to 1985.

Year	Escapement	Variance	Coefficient of Variation
1957	263	4680	26.0
1959	62	292	27.6
1961	83	524	27.6
1963	723	30251	24.1
1965	130	2380	37.5
1967	2715	87264	10.9
1969	0	0	0.0
1971	1346	196336	32.9
1973	0	0	0.0
1975	36	66	22.5
1977	1944	333672	29.7
1979	1446	158389	27.5
1981	5532	1516733	22.3
1983	1321	137103	28.0
1985	530	10733	19.5
MEAN:	1075		22.4

Table C.4h. Escapements and coefficients of variation of pink salmon for the Burrard Inlet District, 1957.

Year	Escapement	Variance	Coefficient of Variation
1957	178450	1614990000	22.5
MEAN:	178450		22.5

Table C.5a. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1957.

District	Escapement	Variance	Coefficient of Variation
1	1081965.	2747425000.	4.8445
2	222347.	117432300.	4.8737
3	595480.	221736800.	2.5006
4	12660.	1121321.	8.3643
5	60820.	7033366.	4.3605
6	269106.	448750000.	7.8719
7	263.	4680.	26.0106
8	178450.	1614990000.	22.5200
YEAR TOTAL:	2421091.	5158493000.	2.9665

Table C.5b. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1959.

District	Escapement	Variance	Coefficient of Variation
1	735987.	2823571000.	7.2199
2	93113.	46264780.	7.3049
3	117127.	11738600.	2.9252
4	25730.	4458066.	8.2060
5	1266.	109829.	26.1772
6	87224.	27659240.	6.0295
7	62.	292.	27.5800
YEAR TOTAL:	1060509.	2913803000.	5.0900

Table C.5c. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1961.

District	Escapement	Variance	Coefficient of Variation
1	552681.	5658308000.	13.6103
2	194772.	62489500.	4.0586
3	198058.	25391000.	2.5442
4	14142.	580197.	5.3861
5	62175.	9270078.	4.8970
6	69411.	50182950.	10.2059
7	83.	524.	27.5800
YEAR TOTAL:	1091322.	5806222000.	6.9822

Table C.5d. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1963.

District	Escapement	Variance	Coefficient of Variation
1	518764.	3267503000.	11.0189
2	332965.	112604900.	3.1870
3	658563.	315138700.	2.6956
4	17718.	8584853.	16.5368
5	136562.	29584310.	3.9829
6	285243.	522733200.	8.0154
7	723.	30251.	24.0564
YEAR TOTAL:	1950538.	4256179000.	3.3447

Table C.5e. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1965.

District	Escapement	Variance	Coefficient of Variation
1	544246.	2793465000.	9.7113
2	203352.	44340090.	3.2745
3	77396.	13103780.	4.6771
4	4551.	779408.	19.3988
5	124634.	49458290.	5.6426
6	235836.	136193800.	4.9484
7	130.	2380.	37.5300
YEAR TOTAL:	1190145.	3037342000.	4.6307

Table C.5f. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1967.

District	Escapement	Variance	Coefficient of Variation
1	786297.	7255710000.	10.8331
2	273143.	123694700.	4.0718
3	70705.	14826110.	5.4458
4	4564.	755890.	19.0495
5	239720.	183584100.	5.6521
6	450487.	953594300.	6.8549
7	2715.	87264.	10.8805
YEAR TOTAL:	1827631.	8532252000.	5.0541

Table C.5g. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1969.

District	Escapement	Variance	Coefficient of Variation
1	848532.	1583734000.	4.6900
2	111145.	21028790.	4.1259
3	104262.	12436850.	3.3824
4	4894.	683054.	16.8874
5	231823.	91351640.	4.1229
6	248900.	1869160000.	17.3699
7	0.	0.	.0000
YEAR TOTAL:	1549556.	3578395000.	3.8604

Table C.5h. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1971.

District	Escapement	Variance	Coefficient of Variation
1	929185.	1296639000.	3.8753
2	175073.	36951550.	3.4721
3	107494.	31909700.	5.2551
4	18906.	4851042.	11.6498
5	344461.	263561700.	4.7130
6	259711.	168359200.	4.9961
7	1346.	196336.	32.9196
YEAR TOTAL:	1836176.	1802469000.	2.3122

Table C.5i. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1973.

District	Escapement	Variance	Coefficient of Variation
1	767114.	3000144000.	7.1402
2	225664.	82999330.	4.0372
3	210705.	300333100.	8.2248
4	14482.	22170990.	32.5135
5	249058.	54780280.	2.9717
6	283504.	234857000.	5.4056
7	0.	0.	.0000
YEAR TOTAL:	1750527.	3695286000.	3.4726

Table C.5j. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1975.

District	Escapement	Variance	Coefficient of Variation
1	315049.	732390200.	8.5900
2	97258.	14632070.	3.9330
3	184020.	207812200.	7.8338
4	6871.	2716812.	23.9889
5	280860.	124164800.	3.9674
6	480350.	928756000.	6.3444
7	36.	66.	22.5200
YEAR TOTAL:	1364444.	2010472000.	3.2862

Table C.5k. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1977.

District	Escapement	Variance	Coefficient of Variation
1	755016.	2072750000.	6.0300
2	53654.	8746220.	5.5120
3	132755.	32862540.	4.3182
4	7369.	788101.	12.0471
5	435341.	254849100.	3.6670
6	978175.	1648538000.	4.1508
7	1944.	333672.	29.7142
YEAR TOTAL:	2364254.	4018867000.	2.6814

Table C.5l. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1979.

District	Escapement	Variance	Coefficient of Variation
1	1523458.	5930301000.	5.0548
2	131830.	75833290.	6.6057
3	272779.	332128200.	6.6810
4	25610.	14381470.	14.8079
5	712840.	891409100.	4.1884
6	891191.	589756200.	2.7250
7	1446.	158389.	27.5229
YEAR TOTAL:	3559154.	7833969000.	2.4868

Table C.5m. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1981.

District	Escapement	Variance	Coefficient of Variation
1	2255753.	7996520000.	3.9642
2	74019.	80541190.	12.1246
3	316998.	358512400.	5.9730
4	43234.	13284670.	8.4304
5	626402.	399701300.	3.1916
6	1164915.	1301738000.	3.0972
7	5532.	1516733.	22.2624
YEAR TOTAL:	4486853.	10151810000.	2.2456

Table C.5n. Escapements and coefficients of variation of pink salmon in the Fraser River system in 1983.

District	Escapement	Variance	Coefficient of Variation
1	3310999.	13634680000.	3.5267
2	108680.	47620010.	6.3496
3	147722.	87054300.	6.3161
4	46128.	35534370.	12.9229
5	501475.	237980200.	3.0762
6	512413.	163217800.	2.4932
7	1321.	137103.	28.0299
YEAR TOTAL:	4628738.	14206220000.	2.5750