# Estimating the 1998 Fraser River Sockeye Salmon (*Oncorhynchus nerka*) Escapement, with Special Reference to the Effect of Migration Stress on Estimation Accuracy

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# ESTIMATING THE 1998 FRASER RIVER SOCKEYE SALMON (*Oncorhynchus nerka*) ESCAPEMENT, WITH SPECIAL REFERENCE TO THE EFFECT OF MIGRATION STRESS ON ESTIMATION ACCURACY

by

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The Department of Fisheries and Oceans conducts annual assessments of the abundance of Fraser River sockeye salmon (*Oncorhynchus nerka*) populations on the spawning grounds. Large populations (25,000+) are assessed using enumeration fences or mark-recapture studies, while small populations (less than 25,000) are assessed using visual techniques. In 1998, study techniques included tagging and recovery (mark-recapture), enumeration fences, counts in artificial spawning channels and visual surveys. The escapement totalled 4,422,075 adults and 5,604 jacks distributed over 172 populations in ten geographic areas and four run timing groups. The proportion that was estimated by each study type was 87% by mark-recapture projects (overall precision of ±3%), 7% at enumeration fences, 2% at spawning channels and 4% by visual surveys. Estimation bias cannot be quantified, but evidence is presented in support of the conclu-sion that overall bias in the 1998 estimates is minor.

Understanding the potential biases associated with mark-recapture studies is critical because the technique is used to estimate a large proportion of the total escapement. A new three-step process evaluates: study design execution; biases in complementary two-sample data stratifications; and differences between the maximum likelihood Darroch and pooled Petersen estimates. The detection of bi-directional (positive and negative) biases in 1998 is inconsistent with the traditional bias structure in sockeye mark-recapture studies where positive biases are most common. Such positive biases result from a decreasing probability of tagging of individual sockeye with the distance upstream that they spawn, coupled with a complementary increasing probability of recovery. Improvements in study designs since 1994 have made tag incidence spatially more representative and have changed the bias structure of the estimates relative to previous years. Further refinements in the analytic process are required to quantify the size of study-specific bias

In 1998, Fraser River sockeye were exposed to record low water levels and record high water temperatures on their spawning migration, conditions that can change their behaviour and introduce bias in the population estimates. The mark-recapture technique is especially vulnerable to such bias because it requires the handling of the fish. A detailed stress assessment is used to determine whether the fish were in poor condition when they arrived on the spawning grounds, and whether handling stress represents a 'last straw' by altering their subsequent behaviour or survival, and their probability of recovery following spawning. To assess arrival condition, four factors are compared with previous years: the proportion of the sockeye that required ventilation after tagging; the proportion recaptured at the tag site; time between tagging and carcass recovery; and average female spawning success. Despite the adverse migratory route conditions, there is little evidence that fish arrived on the spawning grounds in poor condition except for the Stuart Early Run, where more fish required ventilation at release, the post-tagging life-span was reduced, and spawning success was low. To assess the 'last straw' effect, three factors are evaluated: recovery rates of tagged fish that required ventilation or were recaptured at the tag site; spawning success of tagged versus untagged fish; and the recovery distributions of tagged versus untagged fish. There is little evidence that the incremental handling stress from the mark-recapture process introduced bias in the escapement estimates.

## RÉSUMÉ

Schubert, N.D., and Houtman, R. 2007. Estimating the 1998 Fraser River sockeye salmon (*Oncorhynchus nerka*) escapement, with special reference to the effect of migration stress on estimation accuracy. Can. Tech. Rep. Fish. Aquat. Sci. 2732: ix + 121 p.

Le ministère des Pêches et des Océans évalue chaque année l'abondance des populations de saumon rouge (*Oncorhynchus nerka*) du fleuve Fraser dans les aires de fraie. Les grandes populations (25 000 saumons et plus) sont évaluées au moyen de barrières de dénombrement ou d'études de marquage-recapture, tandis que les petites populations (moins de 25 000 saumons) sont évaluées à l'aide de techniques visuelles. En 1998, les techniques d'étude comprenaient le marquage et la recapture, l'utilisation de barrières de dénombrement, le dénombrement dans des frayères artificielles et le relevé visuel. L'échappée totale s'est chiffrée à 4 422 075 adultes et 5 604 madeleineaux de 172 populations dans dix zones géographiques et quatre groupes de montaison. Chaque technique d'étude a été utilisée pour évaluer une certaine proportion de l'échappée : études de marquage-recapture - 87 % (précision générale de ±3 %), bar-rières de dénombrement - 7 %, frayères artificielles - 2 % et relevés visuels - 4 %. Le biais dans les estima-tions ne peut être quantifié, mais des données sont présentées à l'appui de la conclusion selon laquelle le biais général dans les estimations de 1998 est petit.

La compréhension des biais possibles associés aux études de marquage-recapture est essentielle puisque la technique est utilisée pour estimer une grande partie de l'échappée totale. Un nouveau processus en trois étapes évalue la réalisation du plan expérimental, les biais dans les données sur deux échantillons complémentaires et les différences entre l'estimateur de Darroch de vraisemblance maximale et l'estimateur cumulé de Petersen. La détection de biais bidirectionnels (positifs et négatifs) en 1998 ne concorde pas avec la structure de biais traditionnelle dans les études de marquage-recapture du saumon rouge, où les biais positifs sont les plus courants. De tels biais positifs sont le résultat d'une baisse de la probabilité de marquage de saumons individuels quand la distance du lieu de fraie en amont augmente, et cette baisse est combinée à une hausse complémentaire de la probabilité de recapture. Les améliorations apportées aux plans expérimentaux depuis 1994 ont fait en sorte que les cas de signalement de marques sont maintenant plus représentatifs sur le plan spatial et elles ont entraîné une modification de la structure de biais des estimations par rapport aux années précédentes. Le processus d'analyse doit faire l'objet de nouvelles amél-iorations afin de quantifier le biais propre à chaque étude.

En 1998, les saumons rouges du Fraser ont fait face à des records de faible niveau d'eau et de haute température de l'eau durant leur migration de reproduction. Ces conditions peuvent modifier le com-portement des saumons et entraîner des biais dans les estimations des populations. La technique de marquage-recapture est particulièrement vulnérable à de tels biais parce qu'elle nécessite la manipulation des poissons. Une évaluation détaillée du stress est utilisée pour déterminer si les poissons étaient en mauvaise condition au moment de leur arrivée sur les lieux de fraie et si le stress dû à la manipulation représente la « dernière goutte » en modifiant le comportement et la survie des saumons, de même que la probabilité de recapture après la fraie. Pour évaluer la condition des saumons à leur arrivée, quatre facteurs font l'objet d'une comparaison avec les données des années précédentes : la proportion de sau-mons rouges qui ont dû être oxygénés après le marquage; la proportion de saumons recapturés au site de marquage; la période entre le marquage et la récupération de carcasses; le taux de succès de repro-duction moyen des femelles. Malgré les conditions défavorables le long de la voie migratoire, très peu d'indices suggèrent que les saumons sont arrivés sur les lieux de fraie en mauvaise condition, à l'exception de la remonte précoce dans la rivière Stuart, où davantage de poissons ont eu besoin d'être oxygénés avant leur remise à l'eau, la durée de vie après le marquage était réduite et le succès de reproduction était faible. Pour évaluer l'effet de la « dernière goutte », trois facteurs sont évalués : les taux de récupération des poissons marqués qui ont eu besoin d'être oxygénés ou qui ont été recapturés au site de marquage; le succès de reproduction des poissons marqués par rapport à celui des poissons non marqués; la comparaison de la distribution des poissons marqués récupérés et des poissons non marqués récupérés. Il existe peu de preuves que le stress supplémentaire dû à la manipulation durant le processus de marquage-recapture entraîne un biais dans les estimations des échappées.

## INTRODUCTION

The Fraser River system supports the largest population of sockeye salmon *(Oncorhynchus nerka*) in the world (Northcote and Larkin 1989). Sockeye spawn in over 150 natal areas, ranging from small streams to large rivers and lakes, that are distributed throughout the accessible portion of the Fraser system. In the early decades of the twentieth century, spawner abun-dance was estimated by fisheries agencies of the Government of Canada using visual tech-niques that were often poorly suited to the popu-lations and the spawning grounds. In 1938, re-sources became available for the development of improved estimation techniques after the In-ternational Pacific Salmon Fisheries Commis-sion (IPSFC) assumed responsibility for the ma-nagement and assessment of the Fraser River sockeye salmon resource. The IPSFC's early work, described by Atkinson (1944), Howard (1948) and Schaefer (1951), led to the develop-ment of a two tiered escapement estimation sys-tem whereby the method selected for each stock was based on the number of spawners expected to return in a given year (Woodey 1984; Andrew and Webb 1987). For stocks with small expect-ed returns (less than 25,000), a variety of stock-specific visual estimation methods were used. For stocks with large expected returns (more than 25,000), enumeration fences and mark-recapture studies were used. The Department of Fisheries and Oceans (DFO), which reassumed responsibility for the estimation of sockeye salmon escapements with the signing of the Pacific Salmon Treaty in 1985, recognized the importance of maintaining consistent estimation methods by adopting the system developed by the IPSFC. These methods, adapted to address study deign deficiencies and increased escapements (Schubert 1998, 2007), remain largely in place throughout the Fraser River system.

The annual plan for the estimation of Fraser River sockeye escapements is developed from preseason forecasts of abundance provided by DFO's stock assessment sector, and stock-specific harvest rates estimated from the preseason fishing plan provided by DFO's fisheries management Sector. The 1998 plan was based on an expectation that over six million sockeye would return to spawn. Large escapements were expected for the sub-dominant cycle Summer Run and dominant cycle Late Run stocks. Con-sequently, the plan included a number of enum-eration fences (11) and mark-recapture studies (13), with the balance of the stocks (148) asses-sed using visual methods. In this report, we doc-ument the 1998 survey methods, analytic proce-dures, and results, including an evaluation of es-timation precision and bias for each of the tech-niques.

The procedures used to estimate population size from mark-recapture data and to assess sampling selectivity are described by Schubert (1998). They are further refined in this technical report to better evaluate estimation bias and the potential effects of stress on estimation accuracy. Because the fish experienced adverse con-ditions caused by low flows and high water tem-peratures along the migratory route in 1998, we compile a stress profile for each population for comparison with previous years to assess whe-ther the potential impacts are sufficient to intro-duce bias in the population estimates. We con-clude with an evaluation of the overall accuracy and direction of biases in the 1998 estimates.

## STOCK DESCRIPTION

Fraser River sockeye migrate to spawning areas located from tidal influence to as far upstream as 1,270 km (Fig. 1). Nine stocks or stock groups (Birkenhead, Weaver, Chilko, Quesnel, Stellako, Stuart (Early and Summer runs), Adams and Shuswap) account for the majority of the system's production. The predominant age at maturity for Fraser River sockeye is four years; consequently, many stocks exhibit a pronounced quadrennial escapement cycle, with a strong dominant year, an intermediate subdominant year, and two weak years. In 1998, the Weaver, Adams and Shuswap stocks were in their dominant year, the Stuart and Quesnel Summer Run stocks were in their subdominant year, and the Stuart Early Run stock was in an off-cycle year; Birkenhead, Chilko and Stellako do not exhibit a strongly cyclic pattern.

Because the size of the watershed is vast (223,000 $km^2$) and the spawning migration protracted (June to October), we aggregate the stocks into ten geographic groups based on the major sub-basins of the Fraser River, and four run timing groups based on the time of entry into the lower Fraser River. The geographic groups (and the number of constituent stocks) are: Lower Fraser (tributaries of the Fraser River from the mouth to the Thompson River, excluding the

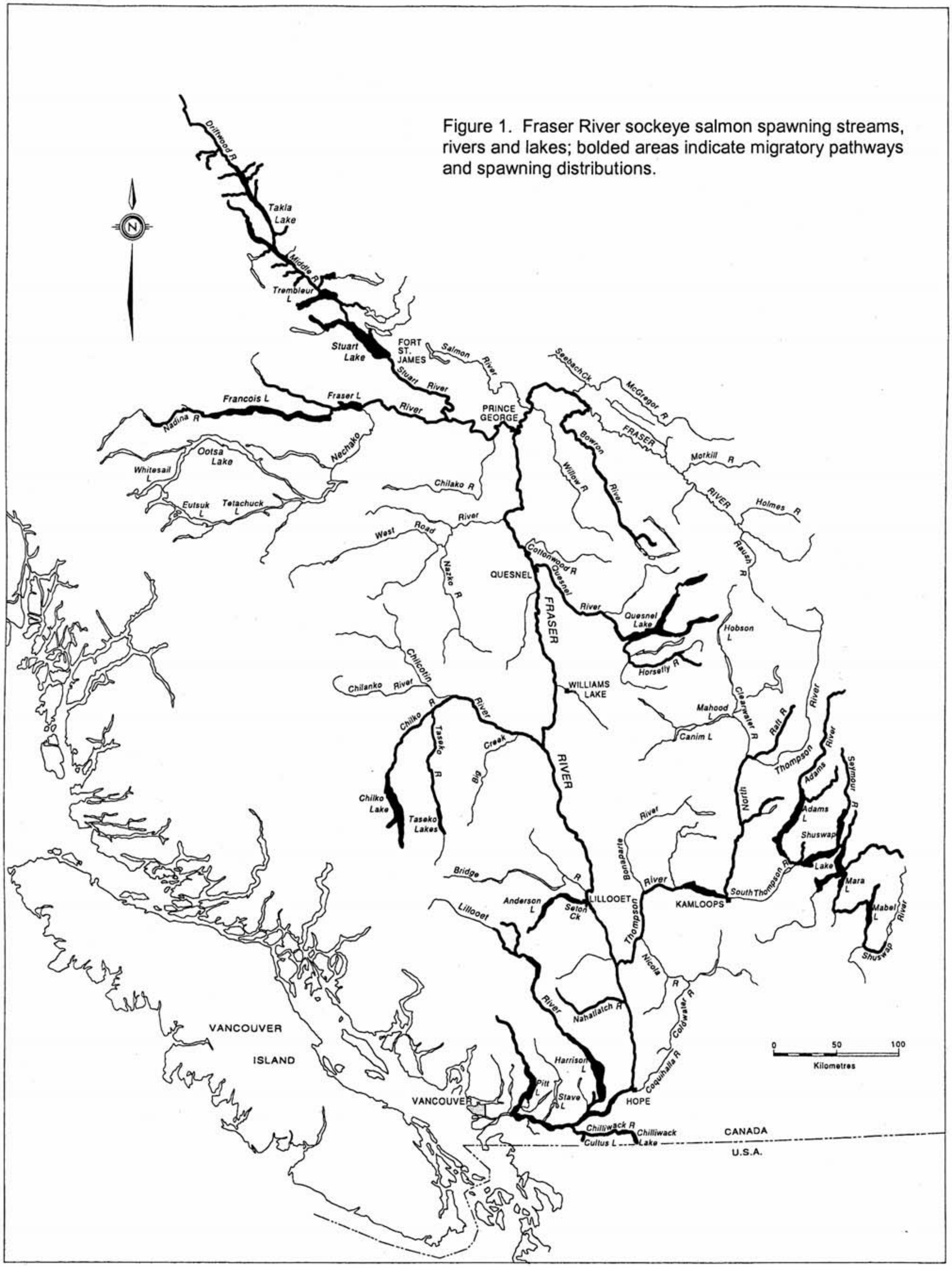


Figure 1. Fraser River sockeye salmon spawning streams, rivers and lakes; bolded areas indicate migratory pathways and spawning distributions.

Harrison-Lillooet) (5); Harrison-Lillooet (7); Seton-Anderson (2); South Thompson Early Summer (19) and Late (30) runs; North Thompson (3); Chilcotin (3); Quesnel (47); Stuart Early (38) and Summer (7) runs; Nechako (2); and Upper Fraser (tributaries of the Fraser River upstream from the Nechako River) (2). The constituent stocks are listed for each group in Table 1.

The run timing groups were established for fishery management purposes and consist of stocks with similar migratory timing during their return from the ocean to the spawning grounds. The Early Run, commonly termed the Early Stuart Run, consists of 38 stocks that spawn in the Stuart River system; the run arrives in the lower Fraser River from late June to late July. The Early Summer Run, which consists of 32 stocks that spawn throughout the Fraser system, arrives in the river from mid July to mid August. The Summer Run, which consists of 57 stocks that spawn in the Chilko, Quesnel, Stellako and Stuart systems, arrives in the river from mid July to early September. The Late Run, which con-sists of 52 stocks that spawn in the lower Fraser, Harrison-Lillooet, Thompson and Seton-Ander-son systems, arrives in the river from August to mid October. The constituent stocks are listed for each group in Table 2.

## METHODS

This section describes the arrival indices, that monitor run timing and relative abundance near the spawning grounds, and three spawner estimation techniques: mark-recapture studies that are used to estimate the escapement of the largest stocks; enumeration fences that are used in spawning channels, and in rivers with appro-priate morphology and when funds are avail-able; and stream surveys, where visual counts or estimates of live and dead spawners are ex-panded to estimate escapement.

### ARRIVAL INDICES

The 1998 arrival indices are based on obser-vations from bridges across the Chilko, Quesnel, Little, and Shuswap rivers, and from a tower at the Adams River mouth. They provide fishery managers an early indicator of the impact of management actions, and mark-recapture staff a means to establish daily tagging targets.

The arrival patterns of the major stocks are observed from a tower, or from bridges that are suitably located below the lower limit of spawning and when the height of the bridge and the colour and depth of the water permit accurate counts. Sockeye tend to migrate along the bank in a single, relatively narrow column where they can be easily counted by an observer stationed above the shoreline. Counts are made for 15 minutes each half hour and reported as a daily average. In some cases (*e.g.* Chilko), managers expand the counts by a constant to generate a rough estimate of escapement.

### MARK-RECAPTURE STUDIES

In 1998, mark-recapture studies were used to estimate the escapement of three Early Summer Run stocks, Eagle, Pitt and Seymour, five Summer Run stocks, Chilko, Horsefly, Middle, Mitchell and Tachie, and five Late Run stocks, Adams, Birkenhead, Little, Shuswap, and Weaver. An additional Summer Run stock, the Stellako, is estimated by mark-recapture as part of a study comparing fence and mark-recapture estimates.

This section describes general study object-tives, operational and analytic procedures, and specific procedures for the 13 mark-recapture studies conducted in 1998. In general, the studies designs are similar to those described in the final report of the Fraser River Sockeye Public Review Board's (FRSPRB) Spawning Escape-ment Estimation Working Group (Anon. 1995a). Exceptions are changes that address specific study design deficiencies identified in 1994 and subsequent years, including:

- Increasing the temporal and spatial coverage of the application and recovery surveys to ensure they encompass the entire period of arrival and die-off, respectively;
- Increasing the frequency and extent of the resurvey, and developing procedures to incorporate its variance into that of the popula-tion estimator;
- Applying a secondary tag to all tagged fish to permit the assessment of tag loss;
- Improving handling procedures to reduce fish stress and permit its assessment;
- Modifying fish capture procedures and the number and location of tagging sites to make more representative the spatial and

temporal distribution of tags;

- Other changes implemented to address study-specific issues.

Table 1. List of Fraser River sockeye salmon stocks by geographic group.[a]

Fraser River sockeye stocks by geographic area

***Lower Fraser***
***Early Summer and Late Run***
Chilliwack Lake
Cultus Lake
Nahatlatch Lake
Nahatlatch River
Pitt River, upper
Widgeon Slough

***Harrison-Lillooet***
***Late Run***
Big Silver Creek
Birkenhead River
Green River
Harrison River
Poole Creek
Samson Creek
Weaver Channel
Weaver Creek

***Seton-Anderson***
***Early Summer and Late Run***
Gates Channel
Gates Creek
Portage Creek

***South Thompson***
***Early Summer Run***
Adams Channel
Adams River, lower
Adams River, upper
Anstey River
Cayenne Creek
Celista Creek
Eagle River
Hiuihill Creek
Hunakwa Creek
Malakwa Creek
McNomee Creek
Momich River
Nikwikwaia Creek
Onyx Creek
Perry River
Ross Creek
Salmon River
Scotch Creek
Seymour River
Yard Creek

***South Thompson***
***Late Run***
Adams Lake
Adams River, lower
Adams River, upper
Anstey River
Bush Creek
Canoe Creek
Celista Creek
Eagle River
Hiuihill Creek
Hunakwa Creek
Little River
McNomee Creek
Momich River
Nikwikwaia Creek
Pass Creek
Perry River
Salmon River
Scotch Creek
Seymour River
South Thompson River
Tappen Creek
Yard Creek
*Shuswap Lake*
Anstey Arm
Main Arm
Salmon Arm
Seymour Arm
*Shuswap River*
Shuswap River, lower
Shuswap River, middle
Tsuius Creek
Wap Creek

***North Thompson***
***Early Summer Run***
Fennell Creek
Harper Creek
Raft River

***Chilcotin***
***Summer Run***
Chilko River and Lake
Elkin Creek
Taseko Lake

***Quesnel***
***Summer Run***
*Horsefly River*
Horsefly Channel
Horsefly River
Little Horsefly River
McKinley Creek
Moffat Creek
*Mitchell River*
Cameron Creek
Mitchell River
Penfold Creek
*Quesnel Lake, E Arm*
Big Slide Lakeshore
Bill Miner Creek
Bill Miner Lakeshore
Blue Lead Creek
Blue Lead Lakeshore
Bouldery Creek
Bouldery Lakeshore
Bouldery Lakeshore, 2 km W
Killdog Creek
Lynx Creek
Lynx Lakeshore
Niagara Creek
Slate Bay Lakeshore
Summit Creek
Taku Creek
*Quesnel Lake, N Arm*
Bear Beach Lakshore
Betty Frank's Lakeshore
Bowling Point Lakeshore
Deception Point Lakeshore
Devoe Creek
Devoe Lakeshore
Goose Point Lakeshore
Grain Creek
Grain Lakeshore
Isaiah Creek
Limestone Point Lakeshore
Long Creek
Long Lakeshore
Marten Creek
Marten Lakeshore
Roaring River
Roaring Lakeshore
Sue Creek
Trickle Creek
Wasko Creek
Watt Creek
Watt Lakeshore
*Quesnel Lake, W Arm*
Hazeltine Creek
Raft Creek
Spusks Lakeshore

***Stuart***
***Early Run***
*Driftwood River*
Blackwater River
Driftwood River
Kastberg Creek
Kotsine River
Lion Creek
Porter Creek
*Takla Lake, NE Arm*
Ankwill Creek
Bates Creek
Blanchette Creek
Forsythe Creek
French Creek
Frypan Creek
Hudson's Bay Creek
Shale Creek
Five Mile Creek
Ten Mile Creek
Fifteen Mile Creek
Twenty-five Mile Creek
*Takla Lake, NW Arm*
Crow Creek
Dust Creek
Hooker Creek
McDougall Creek
Point Creek
Sinta Creek
*Takla Lake, Main Arm*
Bivouac Creek
Gluske Creek
Leo Creek
Narrows Creek
Sakeniche River
Sandpoint Creek
*Middle River*
Forfar Creek
Kazchek Creek
Kynock Creek
Middle River
Rossette Creek
*Trembleur Lake*
Felix Creek
Fleming Creek
Paula Creek

***Stuart***
***Summer Run***
Kazchek Creek
Kuzkwa River
Middle River
Pinchi Creek
Sakeniche River
Sowchea Creek
Tachie River

***Nechako***
***Early Summer and Summer Run***
Nadina Channel
Nadina River
Stellako River

***Upper Fraser***
***Early Summer Run***
Bowron River
Indianpoint Creek

[a] Excludes streams with a record of intermittent escapements that were not surveyed in 1998.

Table 2. List of Fraser River sockeye salmon stocks by run timing group. [a]

| Early Run | Early Summer Run | ------------------------Summer Run------------------------ | | Late Run |
|---|---|---|---|---|
| ***Stuart*** | ***Lower Fraser*** | ***Quesnel*** | Grain Creek | ***Lower Fraser*** |
| *Driftwood River* | Chilliwack Lake | *Horsefly River* | Grain Lakeshore | Cultus Lake |
| Blackwater River | Nahatlatch Lake | Horsefly Channel | Isaiah Creek | Widgeon Slough |
| Driftwood River | Nahatlatch River | Horsefly River | Limestone Point Lakeshore | |
| Kastberg Creek | Pitt River, upper | Little Horsefly River | Long Creek | ***Harrison-Lillooet*** |
| Kotsine River | | McKinley Creek | Long Lakeshore | Big Silver Creek |
| Lion Creek | ***Seton-Anderson*** | Moffat Creek | Marten Creek | Birkenhead River |
| Porter Creek | Gates Channel | *Mitchell River* | Marten Lakeshore | Green River |
| *Takla Lake, NE Arm* | Gates Creek | Cameron Creek | Roaring River | Harrison River |
| Ankwill Creek | | Mitchell River | Roaring Lakeshore | Poole Creek |
| Bates Creek | ***South Thompson*** | Penfold Creek | Sue Creek | Samson Creek |
| Blanchette Creek | Adams Channel | *Quesnel Lake, E Arm* | Trickle Creek | Weaver Channel |
| Forsythe Creek | Adams River, lower | Big Slide Lakeshore | Wasko Creek | Weaver Creek |
| French Creek | Adams River, upper | Bill Miner Creek | Watt Creek | |
| Frypan Creek | Anstey River | Bill Miner Lakeshore | Watt Lakeshore | ***Seton-Anderson*** |
| Hudson's Bay Creek | Cayenne Creek | Blue Lead Creek | *Quesnel Lake, W Arm* | Portage Creek |
| Shale Creek | Celista Creek | Blue Lead Lakeshore | Hazeltine Creek | |
| Five Mile Creek | Eagle River | Bouldery Creek | Raft Creek | ***South Thompson*** |
| Ten Mile Creek | Hiuihill Creek | Bouldery Lakeshore | Spusks Lakeshore | Adams Lake |
| Fifteen Mile Creek | Hunakwa Creek | Bouldery Lakeshore, | | Adams River, lower |
| Twenty-five Mile Creek | Malakwa Creek | 2 km west | ***Chilcotin*** | Adams River, upper |
| *Takla Lake, NW Arm* | McNomee Creek | Killdog Creek | Chilko River and Lake | Anstey River |
| Crow Creek | Momich River | Lynx Creek | | Bush Creek |
| Dust Creek | Nikwikwaia Creek | Lynx Lakeshore | ***Stuart*** | Canoe Creek |
| Hooker Creek | Onyx Creek | Niagara Creek | Kazchek Creek | Celista Creek |
| McDougall Creek | Perry River | Slate Bay Lakeshore | Kuzkwa River | Eagle River |
| Point Creek | Ross Creek | Summit Creek | Middle River | Hiuihill Creek |
| Sinta Creek | Salmon River | Taku Creek | Pinchi Creek | Hunakwa Creek |
| *Takla Lake, Main Arm* | Scotch Creek | *Quesnel Lake, N Arm* | Sakeniche River | Little River |
| Bivouac Creek | Seymour River | Bear Beach Lakshore | Sowchea Creek | McNomee Creek |
| Gluske Creek | Yard Creek | Betty Frank's Lakeshore | Tachie River | Momich River |
| Leo Creek | | Bowling Point Lakeshore | | Nikwikwaia Creek |
| Narrows Creek | ***North Thompson*** | Deception Point Lakeshore | ***Nechako*** | Pass Creek |
| Sakeniche River | Fennell Creek | Devoe Creek | Stellako River | Perry River |
| Sandpoint Creek | Harper Creek | Devoe Lakeshore | | Salmon River |
| *Middle River* | Raft River | Goose Point Lakeshore | | Scotch Creek |
| Forfar Creek | | | | Seymour River |
| Kazchek Creek | ***Chilcotin*** | | | South Thompson River |
| Kynock Creek | Elkin Creek | | | Tappen Creek |
| Middle River | Taseko Lake | | | Yard Creek |
| Rossette Creek | | | | *Shuswap Lake* |
| *Trembleur Lake* | ***Nechako*** | | | Anstey Arm |
| Felix Creek | Nadina Channel | | | Main Arm |
| Fleming Creek | Nadina River | | | Salmon Arm |
| Paula Creek | | | | Seymour Arm |
| | ***Upper Fraser*** | | | *Shuswap River* |
| | Bowron River | | | Shuswap River, lower |
| | Indianpoint Creek | | | Shuswap River, middle |
| | | | | Tsuius Creek |
| | | | | Wap Creek |

[a.] Excludes streams with a record of intermittent escapements that were not surveyed in 1998.

## Field Methods

The general objective of each study is to estimate the sex-specific escapement with a precision of within ±25%. This objective is addressed by applying tags to approximately 1% of the escapement, a level known from previous studies to provide the requisite precision, and by using techniques that distribute the tags proportionally across the population. Sockeye are normally captured immediately below the spawning grounds to ensure that the entire run is vulnerable while avoiding the disproportionate capture of local spawners. In some cases, however, the fish are captured at multiple sites on the spawning grounds; this occurs when river access is limited, or previous experience shows that the use of a single downstream site causes disproportionate tag distributions. Tagging begins when sockeye are first observed and continues through the entire period of spawning ground arrival. Daily tagging targets are determined either from abundance estimates based on the previous day's visual counts on or below the spawning grounds (*e.g.,* bridge counts or boat drifts) or by standardizing the application effort at a fixed number of net sets per day. Sockeye are captur-ed using beach seine nets, marked with uniquely numbered, red Petersen disk tags, and released. They are released untagged when obviously stressed, at an advanced stage of maturation, or physically damaged. Date and location of cap-ture, tag number, sex, nose-fork length, release condition and predator marks (lamprey, hook or net) and *Flexibacter columnaris* symptoms are recorded for each tagged fish. A second, blank disk tag is applied to all tagged sockeye to per-mit the estimation of tag loss. The tags are inserted through the dorsal fin's pterygiophore bones, with the numbered primary tag placed anterior to the blank secondary tag. Fish are not sampled for scales or otoliths during tagging; however, 50 females are retained for fecundity assessment.

Since 1995, the following fish handling procedures have been used to minimize stress: activity in the net is minimized to reduce siltation; fish are removed from the water only when a tagger is ready and processed as quickly as pos-sible; when removed from the water, the fish are cradled in two hands rather than dangled by the caudal peduncle; and following tagging, the fish are immediately returned to the water. In 1998, concerns over incremental stress from migratory route conditions and the need to double tag all fish resulted in the following modifications: all fish were tagged either in a tray immersed in the water, or in an elevated tray with a built-in supply of running water; following tagging, the fish were carried in the water and released by depressing a section of the cork line; holding and processing time was limited to 90 minutes for sites with clean, well aerated water or 45 minutes for sites with low flow, sedimentation or high water temperatures; and holding time was recorded in 15 minute intervals. At no time in the process did the head of the fish leave the water for more than a few seconds.

The objective of the recovery survey is to recover carcasses in proportion to daily abundance. Crews survey the entire spawning area, beginning when the first dead sockeye are observed and continuing until the die-off is complete. Each survey is completed in a fixed period ranging from two to six days (depending on the study) to ensure that recovery effort is consistent through the run. This requires the frequent adjustment of the crew size, with more surveyors deployed at the peak of carcass abundance than at the tails of the abundance distribution. After enumeration, the tags are cut from the carcasses, and the carcasses are removed from the study area either by pitching them beyond the high water mark or by cutting them in two with a machete and returning them to the river. Periodic resurveys of previously processed carcasses are conducted to estimate the number of tags that are missed on the initial survey. Fresh carcasses are also sampled for length, otoliths and scales following a protocol provided by the Pacific Salmon Commission (PSC).

Previous analyses indicate that the precision objectives of Fraser River sockeye mark-recapture studies are generally exceeded by a considerable margin. Consequently, the 1998 recovery areas for the largest stocks were subsampled as a cost saving measure. Before the arrival of sockeye, each river was marked in 250 m (dense spawning areas) or 500 m (light spawn-ing areas) subsections. Alternate subsections were surveyed and, within a subsection, only one, randomly selected bank was covered. This reduced the survey coverage by up to 75% with-out compromising its representativeness. Study-specific procedures are outlined below.

**Adams Complex:** The Adams complex is

part of the South Thompson system in the south-east Fraser River watershed (Fig. 1). The study population includes sockeye that spawn in the lower Adams River, Adams Lake and tributaries, Little River, Scotch Creek, and along the fore-shores of Shuswap (west of the Scotch Creek mouth) and Little Shuswap lakes. Late Run sockeye first arrive on the spawning grounds in mid September. Peak spawning normally occurs in mid October, and the die-off is complete by late November.

Until 1994, tags were applied at a site on the Shuswap Lake foreshore adjacent to the Adams mouth. In 1994, the tagging site was moved into the Adams River to reduce the: a) capture probability of sockeye destined for other parts of the Shuswap Lake system; and b) catch per set, thereby making application more representative by increasing the daily number of sets, and reducing handling stress and immediate mortality by reducing holding time (Schubert and Fanos 1997a). In 1995, additional tagging sites were added in the middle and upper river to increase the tag rates in those areas (Houtman and Fanos 2000). Previously, the use of a single tagging site on the lake or in the lower river resulted in decreasing tag rates with distance upstream.

The 1998 study was conducted from September 21 to November 17. The study design was similar to that used in 1995 (Schubert 2007), except for changes described in the previous section and the following modifications: the tagging sites were shifted in response to channel changes; an additional site was established in Little River to increase the tag rate in the lower part of the study area; counting towers were erected at the mouth to provide the daily immigration estimates used to set tagging targets; and a radio-telemetry study, implemented on the recommendation of the FRSPRB (Anon. 1995b), documented intra-system movements to determine whether tagged sockeye reached the lower part of the study area through active migration or as a result of the flushing of carcasses. Tags were applied at six sites, one in the upper river, two each in the lower and middle rivers, and one in Little River. The daily tagging goals were set at 1% of the previous day's mi-gration as estimated from the tower counts, and by standardized application effort in Little River. Recovery surveys were conducted on a two-day cycle, with subsampling of the Adams River and full coverage in other areas. Radio tags were applied in both the Adams and Little rivers and were monitored in the study area by fixed and mobile receivers.

**Birkenhead River:** The Birkenhead River, a tributary of Lillooet Lake, is part of the Harrison-Lillooet system in the southwest Fraser River watershed (Fig. 1). Late Run sockeye spawn primarily in the mainstem up to the canyon at km 28, and in a tributary, Poole Creek. They first ar-rive on the spawning grounds in mid August. Peak spawning normally occurs in late Septem-ber, and the die-off is complete by early Novem-ber.

The 1998 study was conducted from August 29 to October 19. The study design was similar to that used in 1994 (Schubert and Tadey 1997) and 1995 (Houtman *et al.* 2000), except for changes described in the previous section and the addition of two tagging sites. Tags were applied to migrating sockeye at three sites, one below the lower limit of spawning and two in the lower/middle river. Daily tag releases were established from standardized application effort, *i.e.* all fish from an equal number of sets were tagged each day. Complete recovery surveys were conducted on a 4-5 day cycle, *i.e.,* the entire spawning area was surveyed every 4-5 days.

**Chilko System:** The Chilko River is part of the Chilcotin River system in the west-central Fraser River watershed (Fig. 1). Summer Run sockeye spawn in the Chilko River downstream from the lake, in a spawning channel on the upper Chilko River, and along the foreshore of Chil-ko Lake. They first arrive on the spawning grounds in August. Peak spawning normally occurs in late September, and the die-off is complete by late October.

Until 1987, the Chilko study was designed to estimate the escapement of the river population only; the lake populations were estimated using a variety of subjective techniques. In 1987, the study was changed to the current design that provides a system-wide (river, spawning channel and north and south lake) estimate of escape-ment. In 1987-1989, migrating fish were tagged near the confluence of the Chilko and Taseko rivers (Fig. 1); in 1990, the tagging site was moved upstream to the current site at Lingfield Creek near the lower limit of spawning.

The 1998 study was conducted from August 14 to October 19 in the upper Chilko River and Chilko Lake. The study design was similar to that used in 1994 (Schubert and Fanos 1997b) ex-cept for the changes described in the previous section and the following modifications: the ex-tent and frequency of the south lake surveys were increased, and the surveys started earlier; the river between Lava Canyon and Lingfield Creek was surveyed to improve the assessment of immediate mortality; and the spawning chan-nel was included in the study area, and was opened to permit spawners destined for the up-per part of the study area to migrate back into the river. Tags were applied to migrating sock-eye at Lingfield Creek, with daily tagging goals set at 1% of the previous day's migration as esti-mated from visual counts at Henry's Bridge (4 km below the tagging site). Recovery surveys were conducted on a cycle of 3-4 days in the river, 4-5 days in the north lake, and weekly in the south lake. Complete recovery surveys were conducted in the river and north lake; in the south lake, foot surveys were restricted to known spawning areas and the remainder of the area was surveyed by boat.

**Eagle River:** The Eagle River, a tributary of the Salmon Arm of Shuswap Lake, is part of the South Thompson system in the southeast Fraser River watershed (Fig. 1). Early Summer Run sockeye spawn in the mainstem and in two trib-utaries, Perry River and Yard Creek. They first arrive on the spawning grounds in August. Peak spawning normally occurs in early September, and the die-off is complete by late November.

Previously, visual surveys were used to as-sess the Eagle River sockeye escapement. Such surveys are effective in the clear water above the Perry River confluence, which traditionally sup-ported the bulk of the escapement, but inef-fective in the silty water discharged into the lower river by Perry River. In 1994, the escapement was unusually large (45,000) and spawned pri-marily in the turbid lower river. Because visual surveys are poorly suited to such large abun-dances and limited visibilities, the escapement was likely underestimated. Consequently, on the recommendation of the FRSPRB (Anon. 1995b), a mark-recapture study was implemented for the first time in 1998. The 1998 study was conduct-ed from August 20 to September 20. Tags were applied to migrating sockeye near the lower limit of spawning, with daily tag releases established from standardized application effort; however, the tagging site proved relatively ineffective, and the beach seining operation was later moved to the spawning grounds. Complete recovery sur-veys were conducted on a four-day cycle.

**Horsefly River:** The Horsefly River, a tribu-tary of the main section of Quesnel Lake, is part of the Quesnel River system in the east-central Fraser River watershed (Fig. 1). The Horsefly is a group of Summer Run stocks that spawn in the lower and upper Horsefly and Little Horsefly riv-ers, in McKinley and Moffat creeks, and in a spawning channel on the Horsefly River 25 km above Quesnel Lake. Sockeye first arrive on the spawning grounds in August. Peak spawning normally occurs in early to mid September, and the die-off is complete by mid October.

The 1998 study was conducted from August 17 to October 7. The study design was similar to that used in 1994 (Cone 1999) and 1995 (Hout-man and Cone 2000) except for the changes de-scribed in the previous section and the exclusion from the study area of the low gradient area be-tween the lower and upper spawning grounds. The study had four components. First, tags were applied to migrating sockeye in the lower river approximately 2 km above the lake; daily tag releases were established from standardized ap-plication effort. Recovery surveys were conduct-ed in the lower and upper river on a four-day cycle, with subsampling on the Horsefly River and full coverage in other areas. Second, the spawning channel was enumerated by a com-plete carcass count. Third, McKinley Creek was enumerated at a fence located near the con-fluence with the Horsefly River. This permitted a full enumeration (and removal from the mark-re-capture data set) of tagged sockeye that emi-grated from the Horsefly study area. Fourth, the populations in the Little Horsefly River, Moffat Creek and tributaries to Quesnel Lake were sur-veyed on foot using the procedures described later.

**Little River:** The Little River is a short inter-lake system that flows between Shuswap and Little Shuswap lakes in the South Thompson system in the south-central Fraser River water-shed (Fig. 1). Late Run sockeye spawn through-out the river. They arrive on the spawning grounds in late September. Peak spawning nor-mally occurs by late October, and die-off is com-plete by late November.

Previous dominant cycle escapements in Lit-tle River have been assessed as part of the Ad-ams complex; the Little River population's contri-bution to the complex was estimated from visual surveys. Concerns expressed by the FRSPRB (Anon. 1995b) led to a redesign of the study in 1998. An independent mark-recapture study was designed to generate a discrete population esti-mate for Little River sockeye while, at the same time, a radio-telemetry study was implemented to establish whether an independent estimate was actually required. A new tagging site was established in Little River; daily beach seining ef-fort was standardized, and spawning rather than migrating sockeye were selected for tagging. When it became apparent from the tagging and radio-telemetry studies that Little River sockeye were a component of the larger Adams complex, the new tagging site was incorporated into the Adams study. The Little River data were also analysed separately to produce a discrete estimate for that population.

**Middle River:** The Stuart River system is lo-cated in north-central British Columbia and con-stitutes the most northern portion of the Fraser River watershed (Fig. 1). Summer Run sockeye, commonly termed the late Stuart stock, spawn in the Tachie and Middle rivers and in streams trib-utary to Stuart Lake (Pinchi and Sowchea creeks), Tachie River (Kuzkwa River), Middle Ri-ver (Kazchek Creek) and Takla Lake (Sakenich-ie River). They first arrive on the spawning grounds in late August, with peak spawning nor-mally occurring in late September; the die-off is complete by mid-October.

The Middle River flows between Takla and Trembleur lakes in the northern part of the Stuart River watershed. Previously, the subdominant cycle escapement was estimated from visual surveys conducted by air and foot during the peak of die-off. The first mark-recapture study on this cycle was conducted in 1994 after es-capements exceeded the threshold for intensive assessment. The 1998 study was conducted from September 9 to October 15. The study de-sign was similar to that used in 1994 (Schubert and Fanos 1997c) except for the changes de-scribed in the previous section and the relocation of tagging to two sites in the lower river near Kazchek Bar. Daily tag releases were establish-ed from standardized application effort. Recov-ery surveys were conducted on a 3-4 day cycle in the main riverine spawning areas; the lake-like portions of the river were excluded because spawning density was light.

**Mitchell River:** The Mitchell River is a tribu-tary of the North Arm of Quesnel Lake in the east-central Fraser River watershed (Fig. 1). Summer Run sockeye spawn in the mainstem and in two tributaries, Cameron and Penfold creeks. They arrive on the spawning grounds in August. Peak spawning normally occurs in mid September, and die-off is complete by mid Oct-ober.

The 1998 study was conducted from August 27 to October 8. The study design was similar to that used in 1994 (Schubert 1997a). Design changes are described in the previous section. Concerted efforts were made to improve on the poor execution of the study design that occurred in 1994. Tags were applied to migrating fish at one site near the lower limit of spawning, with the daily release based on standardized applica-tion effort. Complete recovery surveys were con-ducted on a 4-5 day cycle in the main spawning area, and weekly in the upper river where the abundant grizzly bear population prevented fre-quent access.

**Pitt River, upper:** The Pitt River is a tribu-tary of the Fraser River in the southwest portion of the Fraser River watershed (Fig. 1). Early Summer Run sockeye spawn primarily in the lower 17 km of the mainstem of the upper Pitt River (*i.e.,* above Pitt Lake) and in three tribu-taries, Boise, Corbold and Fish Hatchery creeks. They arrive on the spawning grounds in early August. Peak spawning normally occurs in mid September, and die-off is complete by late

September.

Previously, escapements were estimated from tags applied during hatchery brood stock acquisition and later recovered during often *ad hoc* surveys of the spawning grounds. Because the primary focus of field activities was not population estimation, the results did not provide defensible population estimates. The 1998 study, conducted from July 29 to October 1, was the first upper Pitt River study explicitly designed to provide defensible escapement estimates. Tags were applied to migrating sockeye at a site near the lower limit of spawning, with daily tag releases established from standardized application effort, and from test sets in Corbold Creek to moni-tor tag rates. Complete recovery surveys were conducted on a four-day cycle.

**Seymour River:** The Seymour River, a tributary of the Seymour Arm of Shuswap Lake, is part of the South Thompson River system which drains a large portion of the southeast Fraser River watershed (Fig. 1). Early Summer Run sockeye spawn in the river and its main tributary, McNomee Creek. They arrive on the spawning grounds in August. Peak spawning normally oc-curs in early September, and die-off is complete by late September.

The 1998 study was conducted from August 22 to September 21. The study design was simi-lar to that used in 1994 (Schubert 1997b) and 1995 (R. Houtman, pers. comm..) except for the changes described in the previous section. Tags were applied to migrating sockeye at a site near the lower limit of spawning, with daily tag releases established from standardized application effort. Complete recovery surveys were conducted on a four day cycle. McNomee Creek was surveyed on foot using the visual survey procedures described later.

**Shuswap System:** The Shuswap River, a tributary of Shuswap Lake, is part of the South Thompson system in the south-east Fraser River watershed (Fig. 1). The system consists of the upper, middle, and lower Shuswap Rivers, delin-eated by Sugar, Mabel, and Mara lakes, respect-tively, and a number of small tributaries. Late Run sockeye spawn in the lower and middle rivers, and in three Mabel Lake tributaries, Nois-ey, Tsuius, and Wap creeks. They first arrive on the spawning grounds in late September. Peak spawning normally occurs in mid October, and the die-off is complete by mid November.

The 1998 study was conducted from September 28 to November 2. The study design was similar to that used in 1994 (Schubert and Vivian 1997) except for the changes described in the previous section and the following study-specific modifications: both application and recovery sur-veys were made spatially and temporally repre-sentative (a serious 1994 design deficiency), with the middle and lower rivers surveyed at the same frequency; and a second tagging site was added in the lower river near Mabel Lake. The latter was intended to increase the tag rate in the middle river; however, the site was dropped from the analysis when it became apparent that most of the fish tagged at this site spawned in the low-er river. Tags were applied to migrating sockeye at the main tagging site near the lower limit of spawning. Complete recovery surveys were con-ducted on a four-day cycle. The Mabel Lake trib-utaries were surveyed on foot using the visual survey procedures described later.

**Tachie River:** The Tachie River, part of the Stuart River system, flows between Trembleur and Stuart lakes (Fig. 1). Summer Run sockeye spawn in the upper portions of the Tachie River and in the main tributary, Kuzkwa River. They first arrive on the spawning grounds in late Au-gust, with peak spawning normally occurring by late September; the die-off is complete by mid-October.

The 1998 study was conducted from September 4 to October 16. The study design was similar to that of the first mark-recapture study conducted on this cycle in 1994 (Schubert and Fanos 1997c). Design changes include those described in the previous section, as well as the following study-specific actions: additional tagging sites were established in the upper river to improve tag distributions; and the Kuzkwa River stock was enumerated at a fence located near the confluence with Tachie River. The latter per-mitted a full enumeration (and removal from the mark-recapture data set) of tagged sockeye that emigrated from the Tachie study area. Tags were applied at four sites in the upper river, two near Kuzkwa Bar and two lower in the spawning area. Complete recovery surveys were conduct-ed on a three-day cycle.

**Weaver Creek:** Weaver Creek, a tributary of the Harrison River, is part of the Harrison-Lillooet system in the southwest Fraser River watershed (Fig. 1). The Weaver is a short creek with a total accessible length of only 4.8 km. A spawning channel enters the creek at km 0.8, where a barrier weir divides the creek into upper and lower sections. Late Run sockeye spawn in the lower creek; passage into the channel and upper creek is controlled by channel staff. Sockeye arrive in the creek in late September. Peak spawning normally occurs in late October, and the die-off is complete by mid November.

Assessment of Weaver sockeye is complicated by the return of large numbers of channel-produced fish that are surplus to spawning requirements. The 1998 terminal return had five components: sockeye harvested by the Chehalis Indian Band in the Harrison River near Weaver Creek; lower creek spawners; channel spawn-ers; sockeye that returned to the channel but were surplus to channel requirements; and spawners passed over the weir into the upper creek. The surplus and channel returns were censused, and the upper creek fish were enumerated over the weir. The study was designed, therefore, to estimate the lower creek spawners.

The 1998 study was conducted from October 10 to November 2. Tags were applied to local spawners at a number of sites in the lower creek, with daily tagging targets based on observed spawner abundance. Complete recovery surveys were conducted on a two-day cycle in both the lower and upper creeks. Because channel staff passed carcasses that accumulated on the weir into the lower creek rather than remove them from the system, it was necessary to expand the study area to include the upper creek.

### Analytic Procedures

The analytic process involves four steps. First, data are entered into a computer database and their veracity verified. Second, the data are evaluated and corrected for (in order) sex identification error, emigration from the study area, missed tags, tag loss and acute stress effects. Third, population estimates are calculated for adult males, females and precocious males (if five or more tags are recovered). Fourth, a bias and stress profile is developed by evaluating four pot-ential biases (temporal, spatial, fish size and sex) and six potential indicators of stress (inci-dence of *F. columnaris* infections, condition at release, recovery effects of additional stresses such as long holding time or multiple recapture, elapsed time to recovery, recovery distribution and spawning success). This profile is used to subjectively evaluate overall bias for each popul-ation. The first step is self-explanatory; the latter three steps are described in more detail below.

**Data Corrections:** Before calculating population estimates, we evaluate (and correct when appropriate) the data in four ways. First, sex identification errors at tagging can result from the limited development of sexually dimorphic traits among newly arriving spawners (live fish cannot be examined internally) or simply from recording errors during the sometimes hectic tagging oper-ation. We correct such errors by comparing the sex of tagged fish recorded at release and re-covery, and applying the procedures described by Staley (1990). It is unnecessary to correct the carcass recovery data because the carcasses are examined carefully and can be incised for in-ternal examination. Second, tagged sockeye sometimes spawn outside the study area. Their number is estimated from area-specific estimates of tag incidence and population size provided from assessments independent of the mark-recapture study; the sex-specific estimate is subtracted from the application sample. Third, the failure to correctly identify tagged carcasses can occur as a result of surveyor inexperience, fatigue, or carelessness. Resurvey data are us-ed to estimate the incidence of missed tags and to correct the recovery data. Fourth, fish can lose tags between application and recovery for a number of reasons. We use the double tags to estimate the tag loss rate for primary and secon-dary tags; the product of the rates is an estimate of the simultaneous rate of loss of both tags. These data are used to correct the recovery sample for tag loss.

**Population Estimation:** In this section, we briefly describe estimation procedures for adults, precocious males (hereafter, *jacks*), and females that spawned effectively (hereafter, *effective fe-males*). For adults, we use the Stratified Popula-tion Analysis System (SPAS) software developed by Arnason *et al.* (1996) to calculate sex-specific population estimates (the use of sex-specific data avoids potential biases resulting from differences in arrival timing and behaviour on the spawning grounds). SPAS calculates estimates and stan-dard errors using the pooled Petersen estimator (PPE) (Seber 1982) and the stratified Darroch maximum likelihood estimator (MLE) (Plante 1990). The latter is generated from application-recovery matrices using temporal:temporal (TxT), temporal:spatial (TxS) and spatial:spatial (SxS; where appropriate) stratifications. Temporally, we stratify the data into 4-6 application and recovery periods in which the number of tags applied or re-covered are approximately equal. Spatially, we use 2-5 application (multiple tag site studies) and recovery strata. Pooling is often required to satis-fy the assumptions of model fit, *i.e.*, to minimize the number of low recovery cells and reduce lin-ear dependence in the recovery matrix.

Formerly, Fraser mark-recapture studies evaluated sampling selectivity to determine whe-ther to use the PPE or MLE. The PPE was used when selectivity tests showed no evidence of bias. When bias was detected, the MLE was used only if the 95% confidence limits of the PPE and MLE did not overlap (the bias was judged to be minor if the 95% confidence limits overlapped). In 1998, we abandon the MLE in favour of the PPE for two reasons. First, the MLE appears reliable only when there is a strong temporal correlation between application and re-covery strata. Such correlations are typically ob-served only when tagging and recovery occur on an active migratory route where there is a largely contagious migration between the sites (*e.g.,* Schwarz and Taylor 1998); they are not charac-teristic of most sockeye studies, where mixing across strata is common. Second, there are no clear rules for choosing among the MLE esti-mates calculated under different stratifications. The experimenter can be faced with a large number of valid estimates, but no way to identify those that improve on the accuracy of the PPE (*e.g.,* Schubert 2000). Consequently, we reject the MLE for population estimation but retain it for bias evaluation (described later). Even in bias evaluation, however, we advise caution in inter-preting MLE results.

The jack escapement is similarly calculated when five or more tags are recovered. This did not occur in 1998; consequently, an alternate population estimator is used. The jack escape-ment is estimated as the product of the number of carcasses recovered, an expansion factor (1.26) developed by the IPSFC, and the inverse of the 1998 study-specific mark recovery rate for adult males. The expansion factor is based on comparisons of jack and adult male recovery rates from previous mark-recapture studies (An-drew and Webb 1987). The source data for these comparisons, however, are not document-ed in published reports and have not been pro-vided to DFO in unpublished form. A review of this estimation procedure recommended by Schubert (1998) has not been completed.

The effective female population is the pro-duct of the female escapement estimate and the average spawning success. The latter is calcu-lated from the female carcass recovery sample; daily results are weighted to the number of fe-male carcasses recovered that day because egg retention is not recorded for all carcasses.

**Sampling Selectivity Assessment:** The assumptions of equal probability of capture, sim-ple random recovery sampling and complete mix-ing (Seber 1982, p 434-9) are assessed by testing the application and recovery samples for tempor-al, spatial and sex biases using chi-square tests, and size bias using the Kolmogorov-Smirnov two-sample test (Sokal and Rohlf 1981). We assess application bias (unequal probability of capture or incomplete mixing) by stratifying the recovery sample and comparing the proportion tagged among strata. Recovery bias (non-random recov-ery sampling or incomplete mixing) is assessed by stratifying the application sample and comparing the proportions recovered. These assessments are presented for each study, and are compared to similar tests from the 1995-1997 studies.

Temporally, we stratify the application and re-covery samples into 5-6 periods of approximately equal duration, sampling effort, and sample size (*i.e.,* three stratifications each). We interpret three significant results to be a true bias, while a single significant result may be a stratification artifact. Spatially, we stratify the application sample based on the number of tagging sites, and aggregate the recovery sample into 3-6 geographically contigu-ous sections. Sex bias at application is assessed by comparing the sex ratios of marked and un-marked recoveries. Recovery bias is assessed by comparing the sex ratios of tagged fish that are recovered and those that are not. We examine size bias at recovery (application bias cannot be assessed because unmarked carcasses are not measured) by comparing the cumulative NF length-frequency distributions of recovered and non-recovered portions of the application sample.

**Stress Assessment:** A critical assumption of mark-recapture studies is that marked and unmarked animals have the same probability of recapture (*i.e.,* recovery); if this assumption is not met, the population estimate will be biased. If the stress of marking (capture and holding in the net, handling during tagging and release) causes tagged sockeye to behave differently than untagged fish (*e.g.,* spawning distribution, timing of die-off), this can result in differential probabilities of recapture. In 1998, sockeye were handled in a low-stress manner. If, however, their fitness upon return to the spawning grounds was poorer than normal due to *en route* condi-tions, tagging stress could represent the 'last straw' and lead to altered behaviours for a larger than normal proportion of the tagged fish.

To determine whether returning sockeye were in poor condition, we evaluate four vari-ables that are likely correlated with condition (*i.e,* condition indicators) and compare the results with those for 1994-1997. First, some sockeye require ventilation after tagging. If the fish are already stressed before capture, the proportion requiring ventilation will likely be higher (although small difference can be ignored because the ev-aluation is subjective). Second, some marked sockeye are recaptured in the seine net used at the tagging site. This fraction may be larger if sockeye are in poor condition because healthy fish are more likely to resume their migration and clear the tagging site quickly (this comparison is valid only when similar tagging sites are used each year). Third, sockeye in poor condition may die sooner, reducing the time between tagging and recovery. Fourth, the mean spawning suc-cess of females (the fraction of eggs deposited) is likely to be correlated with fish condition be-cause females in poor condition are likely to die before spawning completely. A fifth condition in-dicator, the incidence of *Flexibacter columnaris* lesions, was considered and rejected because such observations were not recorded in all stud-ies across all years.

To determine whether capture and handling stress may have represented the last straw by altering the behaviour and recovery probability of tagged sockeye, we evaluate four indicators across 1994-1998. First, we compare recovery rates of fish that required ventilation at release (assumed to be a symptom of arrival stress) and those that did not. Second, we similarly compare recovery rates of fish recaptured at the tagging site. Third, we compare the fractions among tag-ged and untagged females that had completely spawned. Fourth, we examine the influence of tag status on the recovery distribution of car-casses. The latter two comparisons are stronger indicators of the effect of tagging stress on recovery rates because they compare aspects of the behaviour of tagged and untagged sockeye. We additionally compare recovery rates among releases stratified in 15-minute increments of holding time. Similar data are unavailable in pre-vious years; therefore, multi-year comparisons are not made.

**Bias Assessment:** We cannot definitively evaluate the accuracy of the mark-recapture es-timates because the true population size is un-known. Instead, we rely on three somewhat lim-ited assessments to provide a largely subjective evaluation of the potential magnitude and direc-tion of the bias.

First, on a relatively gross and subjective le-vel, we evaluate how well the study design was executed. Did tagging begin when sockeye first arrived and continue until the migration was complete? Did recovery begin shortly after the start of tagging, cover the entire study area, and continue until the die-off was complete? Were the tagging and recovery efforts applied repre-sentatively over time and space? Were lost and missed tags reliably assessed? If the answer to these questions is yes, then the study design was adequately executed and the estimates can reasonably approximate the true population size.

Second, on a more refined but still subject-tive level, we evaluate complementary stratifica-tions of the two-sample data (*e.g.,* recovery rate by application period versus tag incidence by recovery area) to determine if the observed bias-es also bias the population estimate. This level of evaluation can likely provide a reasonable approximation of the probable direction and rela-tive magnitude (on a gross scale) of estimation bias. This analysis focuses on an evaluation of the probabilities of tagging ($P_{cap}$) and recovery ($P_{rec}$); if correlated, the PPE estimate will be bias-ed. Such correlations exist if $P_{cap}$ and $P_{rec}$ are both dependent on correlated variables. While several mechanisms can lead to this relation-ship, three are especially likely in sockeye mark-recapture studies: for multiple tagging site stu-dies, spatial (hereafter, *SxS*) dependencies can result when the physical characteristics of a giv-en section of river make $P_{cap}$ and $P_{rec}$ anomalous, and fish tagged in the area also spawn locally; temporal (*TxT*) dependencies can occur be-cause time of arrival and time of death are us-ually correlated; and temporal:spatial (*TxS*) de-pendencies can result when $P_{cap}$ varies temporal-ly and $P_{rec}$ varies spatially because arrival time can be correlated with spawning (and recovery) area (*e.g.,* early arriving sockeye migrate faster and spawn in the upper river, while the reverse true of late migrants). To evaluate the influence of each of these mechanisms, we graph tag inci-dence versus recovery time and area to illustrate temporal and spatial patterns in $P_{cap.}$. Similarly, we graph recovery rate versus application time and tagging site to illustrate temporal and spatial patterns in $P_{rec}$. To evaluate the influence of the *TxT* mechanism, the two temporal trends are compared. Similarly, to evaluate the influence of the *SxS* mechanism, the two spatial trends are compared. Finally, in cases where there appears to be a correlation between tagging date and re-covery area, the temporal trend in tag incidence and the spatial trend in recovery probability are compared to evaluate the influence of the *TxS* mechanism.

Third, on a more quantitative level, Schwarz and Taylor (1998) suggest that comparing the MLE and PPE estimates provides an estimate of PPE bias. We reject this as a reliable quantita-tive approach for the reasons noted previously (see *Population Estimation*). Instead, we com-pare the MLE and PPE to roughly estimate the maximum probable PPE bias. We generate at least three valid MLE estimates (those with ac-ceptable Plante's $G^2$ and $\chi^2$ test results) from three matrices, TxT, TxS, and SxS. Because there are no criteria to select among the altern-ate estimates, we report the largest MLE-PPE discrepancy, and the fraction of the valid MLE estimates that are larger than the PPE estimate.

## ENUMERATION FENCE STUDIES

This section describes: a) enumeration fen-ces, *i.e.,* structures to intercept and permit the enumeration of sockeye as they migrate into a spawning area; and b) spawning channels, that have control structures to permit complete live counts and the enumeration of carcasses. In both cases, it is possible to obtain an almost complete census of the spawner population.

In 1998, enumeration fences were used for 11 stocks: Forfar, Gluske and Kynock creeks on the Early Run; Gates and Scotch creeks on the Early Summer Run; Kuzkwa and Stellako rivers and McKinley Creek on the Summer Run; and Salmon River, and Sweltzer and Weaver creeks on the Late Run. Fences were installed on two additional streams supporting Late Run stocks, Nikwikwaia Creek and Momich River. They were primarily intended to assess coho salmon es-capements and, either spatially or temporally, did not assess the entire sockeye return; conse-quently, they are not used to estimate escape-ment. Project objectives vary among the enum-raion fence studies. The fences on Early Run Stuart stocks provide inseason calibrations for the visual surveys conducted in the area. The Kuzkwa and MacKinley fences both enumerate large stocks, and permit the removal of tagged sockeye from the mark-recapture data sets for the Tachie and Horsefly populations, respectively. The Stel-lako fence provides a harvest platform for native fishers and permits the evaluation of bias in a major mark-recapture study. The remaining fenc-es are operated by other agencies within or exter-nal to DFO.

Six spawning channels operated in 1998: Gates and Nadina on the Early Summer Run; Chilko and Horsefly on the Summer Run; and Weaver and Adams on the Late Run. Channel counts are used to estimate escapement in all but the Adams and Chilko channels, where es-capement is estimated as part of the respective mark-recapture study.

### Field Methods

The fences operate continuously through vir-tually the entire migration. After a fence is instal-led, visual surveys are conducted to estimate the number of sockeye already in the river. The fence then funnels the remainder of the run into a counting area where the fish are either inter-

cepted for sampling or tagging, or counted as they swim over a white board installed in an opening in the fence. Data collected at the fence
include species-specific daily counts of adults, jacks and disk tagged fish (if part of a mark-recapture study). Sex is not recorded because it cannot be reliably determined in moving sockeye; however, sex ratios and female spawning success are estimated from regular surveys above the fence. If spawning occurs below the fence, regular foot surveys are conducted using the visual survey techniques described later.

Live sockeye are counted as they enter the spawning channels, and all carcasses are count-ed and removed from the channels after the die-off begins. Escapement is estimated from the carcass count, when complete, or from the count of live sockeye entering the channel.

### Analytic Procedures

For the Gates, Kuzkwa, MacKinley, Sweltzer and Weaver populations, the channel or fence counts provide a census of the escapement. If the fence is installed after some spawners arrive (Stellako River), or if spawning occurs below the fence (Forfar, Gluske and Kynoch creeks), the estimated escapement is the sum of the upriver live count on the date of fence installation, the fence count, and the below-fence estimate. The latter is calculated using techniques described later (see *Visual Surveys*). The sex composition and female spawning success are estimated from the associated carcass survey data. Fecundity is sampled at most fences and carcasses are sampled according to the protocols provided by the PSC.

**Bias Assessment:** Estimation accuracy de-pends on the proportion of the stock that is actu-ally enumerated. This is determined by how well the study design is implemented: Was the fence installed after the arrival of sockeye? Were oper-ations interrupted during the migration? Was the fence removed before the migration was com-plete? Did it inhibit immigration, causing sock-eye to hold or die downstream? Did large daily abundances confound the counts? If the answer to these questions is yes, then a higher propor-tion of the escapement is estimated rather than counted and accuracy is reduced.

## VISUAL SURVEYS

Visual surveys are used for stocks with expected escapements of less than 25,000 spawners; this includes both the typically small stocks and the major stocks on an off-cycle year. The majority of the stocks were surveyed visually in 1998; specifically: all 38 from the Early Run; 26 from the Early Summer Run; 49 from the Summer Run; and 35 from the Late Run.

### Field Methods

Spawning streams and lakes are inspected visually by an experienced observer. Survey periods are based on historic averages or, if one stream in an aggregate is surveyed more intensively, a peak in that stream triggers the survey of nearby streams. Each survey covers the entire accessible spawning area using one or more techniques that include foot or boat surveys and aerial overflights. The actual technique used for a given stock is determined largely by the physical features of each lake, river, or stream. Surveys are scheduled during the daily period of op-timal light conditions, when possible, to minimize surface glare. Each stock is surveyed at least once, with some stocks visited a dozen or more times based on the expected escapement and the observations on the initial surveys. The fol-lowing information is recorded on each trip: counts of live and dead sockeye; viewing condit-ions; water level and temperature; and condit-ions that might influence spawning success (*e.g.,* beaver dams, habitat encroachments). For the foot and boat surveys, all carcasses are recorded by date, location, sex and female spawning success; sex and spawning success can not be recorded during aerial surveys. After enumeration, the carcasses are removed from the study area by pitching them beyond the river's mean high water mark or by cutting them in two and returning them to the water.

### Analytic Procedures

Escapement is estimated using the IPSFC procedures (Andrew and Webb 1987). For lake spawning populations where water depth or turbidity preclude the direct observation of live fish, estimated escapement is the product of the total number of carcasses recovered and an effort ex-pansion that assumes each person-day of sur-vey effort recovers 5% of the population. For riv-er and lake spawning stocks where conditions permit the observation of live spawners, the total escapement is the product of the maximum daily count of live spawners, the cumulative recovery of all carcasses (males, females, jacks) through the date of the peak live count, and an index expansion factor. Two index expansion factors are used: a) the escapement of most stocks is calculated using a factor of 1.8. Both this index expansion factor and the effort expansion factor identified above are based on historic compare-sons of visual survey and mark-recapture or fence data (Woodey 1984). The source data for these comparisons, however, are not document-ed in published reports and are available to DFO only in unpublished form; a review suggested by Schubert (1998) has not been completed; and b) the escapement of the Early Run in the Stuart system is calculated using the index expansion factor measured annually at three enumeration fences in the Middle River area.

The total escapement is partitioned into adult males, females and jacks in three steps. First, the total carcass recovery (rather than the cumu-lative recovery to the date of the peak live count) is adjusted in two ways: a) unsexed carcasses are excluded; and b) an expansion factor of 1.26 is applied to the total jack recovery. The ratio of adult males, females and jacks from these ad-justed data is then used to calculate the escape-ment of adult males, females and jacks. Se-cond, if the adult carcass recovery (excluding unsexed carcasses and jacks) is greater than or equal to 10% of the estimated escapement, then the estimate is stratified by adult males, females and jacks on the basis of the proportions calcu-lated above. Third, if the total adult carcass re-covery is less than 10% of the escapement estimate, then the sex and jack composition and female spawning success is estimated from a nearby stock or stock aggregate with a similar run timing (jacks are excluded from this calcula-tion if none were recovered by the survey of the stream in question). If a similar nearby stock is unavailable, then the total escapement is allo-cated equally between sexes and spawning suc-cess is assumed to be 100%.

Carcass samples are obtained for stocks specified by the PSC protocol; fecundity samples are not obtained from these smaller stocks.

**Bias Assessment:** Estimation accuracy de-pends on the study design, how appropriate it is to the population size, and how well it is executed. We evaluate it in a largely subjective manner by considering the following criteria: a) estimated

Table 3. Dates of start and completion of tagging and recovery, first sighting of sockeye, and of peak live and dead counts, and proportions of carcasses recovered on the peak and final recovery cycles, in the 1998 Fraser River sockeye salmon mark-recapture studies.

| Study | Tag application Start | Tag application End | Carcass recovery Start | Carcass recovery End | First sockeye seen Date | First sockeye seen N | Peak of spawning | Dates of peak recovery cycle | % of recoveries Peak cycle | % of recoveries Final cycle |
|---|---|---|---|---|---|---|---|---|---|---|
| Adams | 21-Sep | 3-Nov | 23-Sep | 17-Nov | 14-Sep | 28 | Oct 18-25 | Oct 24-25 | 10.8% | 0.7% |
| Birkenhead | 29-Aug | 27-Sep | 11-Sep | 19-Oct | 29-Aug | 50 [a] | Sep 22-27 | Sep 30 - Oct 4 | 31.6% | 3.3% |
| Chilko | 14-Aug | 30-Sep | 21-Aug | 19-Oct | 1-Aug | 4 | Sep 25 - Oct 5 | Sep 30 - Oct 2 | 15.2% | 8.5% |
| Eagle | 20-Aug | 10-Sep | 25-Aug | 20-Sep | 17-Aug | 1 | Sep 5-10 | Sep 10-12 | 27.8% | 6.7% |
| Horsefly | 17-Aug | 20-Sep | 21-Aug | 7-Oct | 15-Aug | 6 | Sep 7-17 | Sep 14-17 | 24.8% | 2.3% |
| Middle | 9-Sep | 27-Sep | 22-Sep | 15-Oct | 9-Sep | 26 [a] | Sep 26 - Oct 5 | Oct 1-3 | 32.6% | 4.6% |
| Mitchell | 27-Aug | 18-Sep | 3-Sep | 8-Oct | 26-Aug | 4,050 | Sep 18-25 | Sep 22-26 | 34.9% | 1.3% |
| Pitt | 29-Jul | 11-Sep | 2-Aug | 1-Oct | 29-Jul | 13 [a] | Sep 15-20 | Sep 22-26 | 32.6% | 17.6% |
| Seymour | 22-Aug | 12-Sep | 16-Aug | 21-Sep | 19-Aug | 9 | Sep 6-8 | Sep 13-15 | 25.6% | 8.7% |
| Shuswap | 28-Sep | 19-Oct | 2-Oct | 2-Nov | 26-Sep | 235 | Oct 12-16 | Oct 18-21 | 32.2% | 5.5% |
| Tachie | 4-Sep | 27-Sep | 23-Sep | 16-Oct | 4-Sep | 3 [a] | Sep 26 - Oct 2 | Oct 2-4 | 25.0% | 3.9% |
| Weaver | 10-Oct | 29-Oct | 8-Oct | 2-Nov | 10-Oct | 25 [a] | Oct 11-16 | Oct 24 | 15.9% | 5.8% |

[a] Number of sockeye tagged on the first day of tag application.

population size (<25,000); b) calibration technique (inseason or historic average); c) survey frequency; d) survey coverage (partial or complete); and e) survey conditions (visibility of fish).

## RESULTS AND DISCUSSION

### MARK-RECAPTURE

The 13 stocks assessed using mark-recapture studies are identified in Appendix 11. These stocks account for 87% of the 1998 Fraser River sockeye escapement estimate, 1,779,200 males, 2,075,900 females and 3,700 jacks. The attributes of these estimates are described below.

#### Implementation Of Study Design

In this section, we address the following ques-tions. Did tagging begin when sockeye first arriv-ed and continue until the migration was complete? Did recovery begin shortly after the start of tag-ging, cover the entire study area, and continue until the die-off was complete? Was the tagging and recovery effort applied representatively over time and space? Were lost and missed tags reli-ably assessed? Were study precision objectives achieved?

**Tagging:** Tagging generally began within three days of the arrival of the first sockeye (Table 3). In the Chilko study, tagging began when more than ten sockeye per index period were observed from Henry's Bridge (5 km downstream of the tagging site) (Appendix 6). The few fish seen two weeks before the start of tagging (Table 3) represent a small number of immigrants that arrived very early relative to the bulk of the stock. The Adams study began seven days after sockeye were first seen, a result of the extremely early migration of Late Run South Thompson sockeye. The Mitchell study also began late, as indicated by the live count of 4,050 on the first day after crews arrived (Table 3). The tag incidence among early recoveries (discussed below) was higher than average in both the Adams and Mitchell studies, however, indicating that the delays did not affect the temporal distribution of the tags. Tagging al-ways continued until it was difficult to capture fresh sockeye, indicating the near completion of the immigration.

**Carcass Surveys:** Surveys near the tagging area and spot checks in other areas began the day after the start of tagging. Regular recovery surveys began after carcasses were first observ-ed. This occurred within one week of the start of tagging in all studies except the Birkenhead (13 days), Middle (13 days) and Tachie (19 days) (Ta-ble 3). In all studies,

Table 4. Percent of the escapement tagged and recovered, of the carcasses resurveyed, and of tags missed on the initital survey in the 1998 Fraser River sockeye salmon mark-recapture studies.

| Study | % of population tagged | | | % of population recovered | | | Percent of population resurveyed | Percent of tags missed |
|---|---|---|---|---|---|---|---|---|
| | Males | Females | Total | Males | Females | Total | | |
| Adams | 1.1% | 0.9% | 1.0% | 15.8% | 14.6% | 15.2% | 70.7% | 2.7% |
| Birkenhead | 1.1% | 0.9% | 1.0% | 33.4% | 25.8% | 28.7% | 32.5% | 3.6% |
| Chilko | 0.8% | 0.8% | 0.8% | 24.4% | 22.0% | 23.0% | 44.2% | 1.3% |
| Eagle | 0.6% | 0.4% | 0.5% | 14.9% | 14.6% | 14.7% | 29.8% | 0.0% |
| Horsefly | 1.3% | 1.2% | 1.2% | 12.1% | 11.5% | 11.8% | 53.4% | 2.7% |
| Middle | 1.5% | 1.5% | 1.5% | 23.2% | 25.4% | 24.3% | 39.4% | 0.0% |
| Mitchell | 1.2% | 1.0% | 1.1% | 13.2% | 11.9% | 12.5% | 37.4% | 3.2% |
| Pitt | 1.3% | 1.1% | 1.2% | 10.1% | 9.0% | 9.4% | 80.7% | 0.0% |
| Seymour | 2.4% | 2.9% | 2.6% | 11.2% | 15.9% | 13.3% | 15.2% | 0.0% |
| Shuswap | 1.1% | 0.9% | 1.0% | 21.7% | 20.4% | 21.1% | 77.5% | 1.4% |
| Tachie | 0.7% | 0.9% | 0.8% | 13.2% | 15.7% | 14.4% | 10.4% | 0.0% |
| Weaver | 2.8% | 2.9% | 2.8% | 54.6% | 42.3% | 48.2% | 46.4% | 0.0% |
| Mean: | 1.3% | 1.3% | 1.3% | 20.7% | 19.1% | 19.7% | 44.8% | 1.2% |

recovery surveys continued at least ten days after the end of the spawning peak, and until no new spawners were observed. In all studies except the Pitt, the carcasses recov-ered on the final cycle represent less than 10% of the total recovery. In all studies, less than 35% of the carcasses were recovered on the peak recov-ery cycle (Table 3). The recovery rates of tagged sockeye decreased near the end of the project in the Chilko and especially the Pitt studies; the potential impact on the population estimates is discussed below. Previously documented distri-butions of spawning and carcasses were used to establish the recovery survey area. In 1998, sock-eye expanded the upper limit of their distribution in the Birkenhead and upper Pitt rivers. The Birken-head recovery survey was adjusted to encompass the new area; the Pitt was not. In all other pro-jects, the 1998 recovery surveys encompassed the entire known spawning area.

**Temporal and Spatial Allocation of Survey Effort:** There were no significant departures from the objective of standard daily capture effort or quotas based on live counts. Similarly, there were regular recovery surveys through-out the die-off, with crew sizes increased during periods of high carcass abundance to allow the maintenance of the recovery cycle.

**Carcass Resurveys:** The percentage of the recovered carcasses misidentified as untagged is estimated by resurveying a sub-sample of the die-off. The resurveys were frequent and extensive, recovering an average 45% of the previously sur-veyed carcasses (considerably higher than in re-cent years) (Table 4). In only two studies, Tachie (10%) and Seymour (15%), were less than 30% of the carcasses resurveyed (thus, the estimate is relatively imprecise for these studies). The num-ber of tagged carcasses misidentified as untag-ged was low in all studies, with an average of 1.2% and a high of 3.6% in Birkenhead (Table 4). This was a substantial improvement over recent years, *e.g.,* in 1994 the missed tag rate averaged 7.6% with a high of 20% (Schubert 1998).

**Tag Loss:** The loss of primary and second-ary tags averages 0.6% and 0.8% in males and 0.1% and 1.1% in females, respectively (Table 5). Because primary and secondary tags had very low loss rates, the probability that a fish lost both tags (the product of the two loss rates) is also very low. The new procedures introduced in 1998 are a substantial improvement over previous years when high secondary tag loss (spaghetti tags) or observer recognition error (opercular punches) hindered the interpretation of results.

**Tagging and Recovery Rates:** The studies are designed to tag 1% and recover either 10% (Chilko, Horsefly) or 20% of the population. The average tagging rates approximated 1%, at 1.3%

Table 5. Primary and secondary disk tag loss, by sex, in the 1998 Fraser River sockeye salmon mark-recapture studies.

| | Males | | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Missing tags | | | Tag loss rate | | | Missing tags | | | Tag loss rate | |
| Study | Total tagged [a] | 1° | 2° | Both | 1° tag | 2° tag | Total tagged [a] | 1° | 2° | Both | 1° tag | 2° tag |
| Adams | 845 | 11 | 1 | 0.01 | 1.3% | 0.1% | 691 | 0 | 5 | 0.00 | 0.0% | 0.7% |
| Birkenhead | 403 | 3 | 2 | 0.01 | 0.7% | 0.5% | 421 | 1 | 2 | 0.00 | 0.2% | 0.5% |
| Chilko | 733 | 0 | 16 | 0.00 | 0.0% | 2.2% | 850 | 1 | 14 | 0.02 | 0.1% | 1.6% |
| Eagle | 10 | 1 | 0 | 0.00 | 10.0% | 0.0% | 10 | 0 | 0 | 0.00 | 0.0% | 0.0% |
| Horsefly | 591 | 4 | 4 | 0.03 | 0.7% | 0.7% | 495 | 1 | 2 | 0.00 | 0.2% | 0.4% |
| Middle | 65 | 0 | 3 | 0.00 | 0.0% | 4.6% | 74 | 0 | 5 | 0.00 | 0.0% | 6.8% |
| Mitchell | 219 | 0 | 1 | 0.00 | 0.0% | 0.5% | 208 | 0 | 1 | 0.00 | 0.0% | 0.5% |
| Pitt | 36 | 0 | 1 | 0.00 | 0.0% | 2.8% | 46 | 0 | 1 | 0.00 | 0.0% | 2.2% |
| Seymour | 51 | 0 | 1 | 0.00 | 0.0% | 2.0% | 68 | 0 | 3 | 0.00 | 0.0% | 4.4% |
| Shuswap | 351 | 2 | 0 | 0.00 | 0.6% | 0.0% | 287 | 1 | 2 | 0.01 | 0.3% | 0.7% |
| Tachie | 40 | 0 | 0 | 0.00 | 0.0% | 0.0% | 65 | 0 | 0 | 0.00 | 0.0% | 0.0% |
| Weaver | 98 | 0 | 0 | 0.00 | 0.0% | 0.0% | 83 | 0 | 0 | 0.00 | 0.0% | 0.0% |
| Total | 3,441 | 21 | 29 | 0.05 | 0.6% | 0.8% | 3,298 | 4 | 35 | 0.03 | 0.1% | 1.1% |

[a.] Total tagged includes a trivial number of recoveries estimated to have lost both tags.

(of the estimated population) for both sexes (Table 4). All studies had tag rates of 0.8% or greater, except the Eagle where only 0.5% of the population was tagged. Similarly, the average recovery rates approximated 20%, at 21% and 19% for males and females, respectively (Table 4). Five studies recovered less than 15% of the popu-lation: Pitt (9%), Horsefly (12%; expected due to subsampling of recovery areas), Mitchell (13%), Seymour (13%), Tachie (14%) and Eagle (15%) (Table 4). Regardless, the precision goal of ±25% of the population estimate was achieved in all studies except the Eagle (52% for males and females) and Pitt (30% for males and 27% for females) (Table 6). This reflects the fact that, because precision is determined by the number of tags recovered, it results from an interaction of both tagging and recovery rates. Low tag rates in the Eagle reflect the difficulty in identifying appropriate tagging sites and capture methods in the first year of this mark-recapture study. Low recov-ery rates in the Eagle reflect the small crew size and poor visibility in the turbid, glacial run-off. The extremely low recovery rates in the Pitt study result from the extensive spawning area and the difficult viewing conditions that result from glacial run-off and spawning in the river's mainstem.

**Summary:** All of the 1998 mark-recapture studies were well designed and executed in most aspects. The distribution of application, recovery and resurvey effort improved slightly over recent years for most studies, while the improvement since 1994 (Schubert 1998) and 1995 (Schubert 2007), the most recent years that the studies are fully documented, is dramatic. This results from an increased emphasis on training the field crews regarding the importance of study design execution. When tagging began late, the temporal pattern of tag incidence does not indicate an impact on proportional tagging. Application and recovery was also sufficient, in most cases, to achieve the precision target; only the Eagle and Pitt studies were relatively imprecise. Two concerns persist in the distribution of carcass recovery effort. First, recovery appeared to end early in the Chilko and Pitt studies, as indicated by the temporal patterns in the recovery rate of tagged sockeye. Second, the Pitt recovery area did not encompass the entire spawning distribution.

### Stress

**Arrival Condition:** To evaluate the potential impact of the condition of sockeye arriving on the spawning grounds on estimation accuracy, we

Table 6. Tag application and recovery samples, escapement estimates and 95% confidence limits for the 1998 Fraser River sockeye stocks estimated using mark-recapture studies.

| | Adult males [a] | | | | | Adult females [a] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tag appli- | Carcass recovery | | Escapement [b] | | Tag appli- | Carcass recovery | | Escapement [b] | |
| Study | cation | Tagged | Total | Estimate | +/- | cation | Tagged | Total | Estimate | +/- |
| Adams | 5,360 | 845 | 80,655 | 507,322 | *6%* | 4,724 | 691 | 79,492 | 539,802 | *7%* |
| Birkenhead | 1,207 | 403 | 38,213 | 114,299 | *8%* | 1,634 | 421 | 46,767 | 181,370 | *8%* |
| Chilko | 3,011 | 733 | 89,568 | 367,336 | *6%* | 3,860 | 850 | 112,748 | 511,674 | *6%* |
| Eagle | 73 | 10 | 1,946 | 12,321 | *52%* | 74 | 10 | 2,513 | 16,157 | *52%* |
| Horsefly | 4,911 | 591 | 45,296 | 373,601 | *7%* | 4,295 | 495 | 42,954 | 369,521 | *8%* |
| Middle | 283 | 65 | 4,501 | 19,400 | *21%* | 295 | 74 | 4,948 | 19,506 | *19%* |
| Mitchell | 1,663 | 219 | 18,634 | 136,240 | *12%* | 1,755 | 208 | 20,058 | 163,680 | *13%* |
| Pitt | 365 | 36 | 2,807 | 27,753 | *30%* | 522 | 46 | 4,366 | 49,135 | *27%* |
| Seymour | 463 | 51 | 2,123 | 18,604 | *25%* | 433 | 68 | 2,392 | 14,774 | *21%* |
| Shuswap | 1,619 | 351 | 32,446 | 142,094 | *9%* | 1,410 | 287 | 32,516 | 149,537 | *10%* |
| Tachie | 309 | 40 | 6,224 | 47,066 | *28%* | 420 | 65 | 7,187 | 45,897 | *22%* |
| Weaver [c] | 180 | 98 | 3,539 | 13,188 | *13%* | 198 | 83 | 2,916 | 14,832 | *16%* |
| Total | 19,444 | 3,442 | 325,952 | 1,779,224 | *3%* | 19,620 | 3,298 | 358,857 | 2,075,885 | *2%* |

[a.] Tagging and recovery totals are not adjusted (see *Analytic Procedures* ).
[c.] Includes upper creek.
[b.] PPE estimate with 95% confidence intervals.

examine the proportion that required ventilation after release, the proportion recaptured at the tag site, time out between tagging and carcass recovery, and average female spawning success (Table 7). An average 2.4% of the fish required ventilation after tagging, with unusually high rates in Middle (6.5%), Weaver (6.6%) and early Stuart (10.8%) (Fig. 2) (1994-1997 average 1.5%; range 0%-9.2%). The values for Weaver and Stuart are extreme both in 1998 and relative to previous years in the same studies (Weaver: 0.4% in 1996; Stuart: 0.4% in 1996, 5.4% in 1997), but similar to extreme values reported in 1994 for Middle and Stellako sockeye.

In studies where the number and location of tagging sites has not changed from previous years, the proportion of previously tagged fish that were recaptured at the tagging site is not unusual-ly high relative to 1994-1997 (Table 7; Fig. 2).

The mean time between application and recovery (*i.e.,* days out) is quite constant between 1994 and 1998 for most studies except Pitt, Weaver and early Stuart (Table 7; Fig. 2). The change in the former two stocks reflects study design modifications. In the Pitt, the tagging site was moved from the spawning grounds to the migratory route and tagging started earlier. In Weaver, the shorter time out (by almost three days) is an artifact of more frequent recovery surveys in 1998, reducing the time between death and recovery. The time out in the Stuart study in 1998 (8.7 days) is longer than in 1997 (5.8 days); however, 1997 was abnormally low due to the exhausted state of returning sockeye. Time out in 1998 is approxi-mately three days shorter than in

Table 7. Indicators of the condition of sockeye salmon spawning in mark-recapture study areas from 1994 to 1998. Values are for combined sex data (see Appendix 2 for values specific to sex and tag application method).

| Study | 1994 | 1995 | 1996 | 1997 | 1998 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Proportion requiring ventilation at release (%)* | | | | | *Proportion recaptured liveone or more times (%)* | | | | |
| Adams | 0.1% | 0.1% | - | - | 0.3% | 10.4% | 6.8% | - | - | 4.7% |
| Birkenhead | 1.7% | 0.0% | 0.2% | 1.2% | 0.2% | 9.5% | - | 18.4% | 19.1% | 3.5% |
| Chilko [a] | 0.4% | 0.1% | 0.1% | 0.5% | 1.0% | 0.1% | 0.0% | 0.6% | 0.4% | 0.3% |
| Eagle | - | - | - | - | 3.4% | - | - | - | - | 4.1% |
| Horsefly [a] | 2.0% | 1.1% | - | 0.2% | 1.1% | 3.6% | 4.7% | - | 7.1% | 8.5% |
| Middle | 9.2% | - | - | 0.5% | 6.5% | 34.5% | - | - | 1.9% | 10.3% |
| Mitchell [a] | 0.1% | - | - | 1.0% | 0.1% | 0.7% | - | - | 8.5% | 2.5% |
| Pitt | - | - | 0.7% | 2.9% | 0.1% | - | - | 0.9% | 5.1% | 7.6% |
| Seymour | 0.7% | 0.1% | - | - | 0.9% | 5.1% | 7.1% | - | - | 19.9% |
| Shuswap [a] | 0.6% | - | - | - | 0.2% | 0.3% | - | - | - | 2.8% |
| Stellako | 8.1% | 3.8% | 1.7% | - | 0.4% | - | - | - | - | - |
| Stuart early | - | - | 0.4% | 5.4% | 10.8% | - | - | - | - | - |
| Tachie | 2.8% | - | - | 0.5% | 1.2% | 11.2% | - | - | 4.8% | 7.8% |
| Weaver [a] | - | - | 0.4% | - | 6.6% | - | - | 1.7% | - | 1.5% |
| | *Mean time between application and recovery (days)* | | | | | *Mean spawning success (%)* | | | | |
| Adams | 13.8 | 13.7 | - | - | 12.8 | 99.5% | 93.7% | 91.5% | 94.7% | 97.7% |
| Birkenhead | 17.5 | 15.9 | 19.2 | 21.7 | 21.5 | 99.8% | 92.0% | 91.9% | 94.8% | 95.4% |
| Chilko | 28.6 | 31.6 | 32.1 | 27.3 | 31.6 | 97.1% | 93.5% | 94.8% | 91.5% | 92.2% |
| Eagle | - | - | - | - | 11.4 | 87.5% | 100.0% | 96.3% | 90.1% | 97.3% |
| Horsefly | 17.5 | 15.9 | - | 15.7 | 16.0 | 99.0% | 97.3% | 94.7% | 93.3% | 89.1% |
| Middle | 14.4 | - | - | 18.6 | 17.6 | 99.5% | 100.0% | 86.4% | 95.5% | 98.6% |
| Mitchell | 14.7 | - | - | 13.5 | 14.7 | 99.7% | 97.4% | 100.0% | 92.7% | 94.6% |
| Pitt | - | - | 14.0 | 18.7 | 37.5 | 98.3% | 90.0% | 95.7% | 91.2% | 96.9% |
| Seymour | 11.7 | 12.9 | - | - | 12.5 | 98.9% | 98.3% | 95.0% | 84.6% | 96.7% |
| Shuswap | 15.7 | - | - | - | 15.8 | 99.1% | 100.0% | 89.3% | 66.7% | 96.3% |
| Stellako | 21.6 | 18.1 | 26.1 | - | 22.2 | 89.1% | 74.9% | 93.4% | - | 98.4% |
| Stuart early | - | - | 11.4 | 5.8 | 8.7 | 91.6% | 88.7% | 96.5% | 76.0% | 52.0% |
| Tachie | 17.0 | - | - | 16.4 | 15.4 | 97.0% | 100.0% | 84.7% | 87.5% | 98.4% |
| Weaver | 9.1 | - | 8.4 | - | 6.0 | 97.9% | 56.0% | 48.7% | 50.7% | 90.4% |

[a] Studies in which tagging locations have been essentially constant over the years examined; important to interpretation of recaptures.

1996, when the sockeye appeared in better condition. Further, the mean days between the median arrival date (the date when 50% of the return was counted through the fence) and the median carcass recovery date is five days shorter than the average between 1988 and 1997 (MacDonald *et al.* 2000). Thus, the Stuart early run stocks appear to have died earlier than normal.

Finally, mean spawning success averages 92% (96% if Stuart is excluded) and is above 90% in all but the Horsefly (89%) and early Stuart (52%) (Table 7; Fig. 2). In fact, the 1998 level exceeds the 1994-1997 average in all stocks but Chilko, Horsefly, Mitchell and Stuart. Spawning success of the Stuart stocks is extremely low, both relative to the other stocks examined and to the same stocks in previous years (Fig. 2).

**Handling Stress:** To examine whether cap-ture and handling stress may have represented the 'last straw' by altering the behaviour and re-

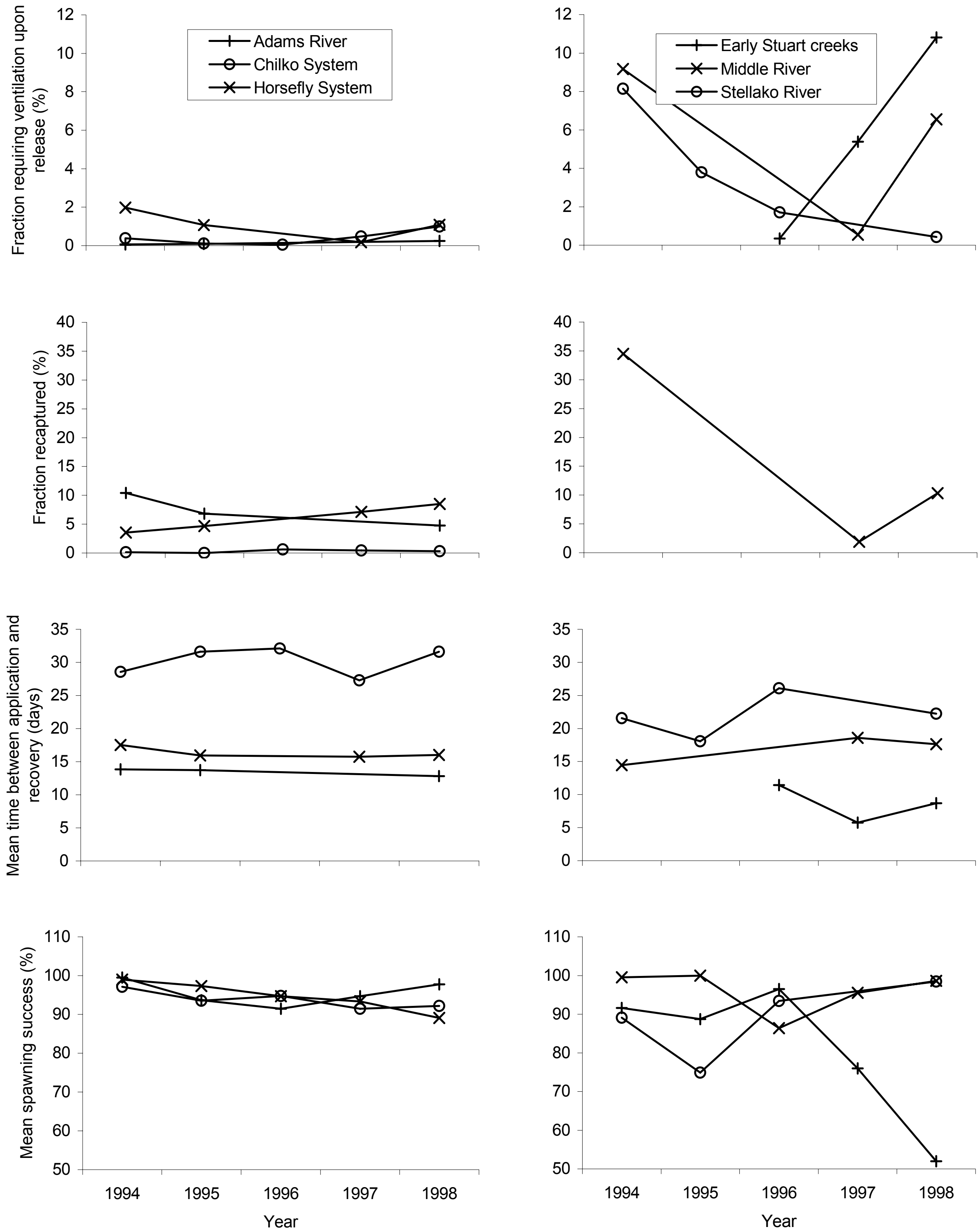


Figure 2. Condition indicators versus year for the period 1994-1998 for six projects: Adams, Chilko, Horsefly, Stuart Early Run (Forfar, Gluske and Kynoch creeks combined), Middle and Stellako.

Table 8. Recovery rates of sockeye salmon in high and low stress categories, and the fraction of the tagged and untagged sockeye salmon that spawned successfully, in the 1998 Fraser River mark-recapture studies.

| | | Recovery rate | | | | | | Percent spawned | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Required ventilation at release? | | | Recaptured? | | | Tagged? | | |
| Sex | Study | No | Yes | Δ | No | Yes | Δ | No | Yes | Δ |
| Females | Adams | 14.8% | 30.0% | 15.2% [a] | 14.8% | 15.8% | 1.0% [a] | 95.4% | 94.0% | 1.4% [a] |
| | Birkenhead | 25.5% | 25.0% | -0.5% | 25.5% | 28.6% | 3.1% [a] | 95.3% | 91.9% | 3.4% [a, b] |
| | Chilko | 22.5% | 11.1% | -11.4% [a, b] | 22.4% | 0.0% | -22.4% | 85.7% | 94.9% | -9.2% [a, b] |
| | Eagle | 12.3% | 100.0% | 87.7% | 13.5% | - | - | 96.9% | 90.0% | 6.9% |
| | Horsefly | 10.2% | 8.7% | -1.5% [a] | 10.2% | 10.9% | 0.7% [a, b] | 83.6% | 80.1% | 3.5% [a, b] |
| | Middle | 33.1% | 2.4% | -30.7% [a] | 29.0% | 37.9% | 8.9% [a] | 98.4% | 97.1% | 1.3% |
| | Mitchell | 11.5% | 0.0% | -11.5% | 11.7% | 7.7% | -4.0% [a] | 92.1% | 94.6% | -2.5% [a] |
| | Pitt | 8.2% | - | - | 8.4% | 6.7% | -1.7% [a] | 96.3% | 87.5% | 8.8% [a] |
| | Seymour | 16.7% | 25.0% | 8.3% | 16.6% | 17.3% | 0.7% [a] | 96.3% | 94.4% | 1.9% [a] |
| | Shuswap | 20.0% | 0.0% | -20.0% [b] | 19.8% | 27.5% | 7.7% [a] | 92.6% | 96.7% | -4.1% [a, b] |
| | Stellako | 35.5% | 0.0% | -35.5% | 0.0% | - | - | 98.4% | 95.4% | 3.0% [a] |
| | Stuart early | 64.3% | - | - | - | - | - | 50.0% | 22.2% | 27.8% |
| | Tachie | 15.4% | 40.0% | 24.6% | 16.4% | 11.4% | -5.0% [a] | 98.3% | 98.2% | 0.1% [a] |
| | Weaver | 43.4% | 50.0% | 6.6% [a] | 43.7% | 100.0% | 56.3% | 89.4% | 79.1% | 10.3% |
| Males | Adams | 15.9% | 23.1% | 7.2% [a] | 16.1% | 12.0% | -4.1% [a] | - | - | - |
| | Birkenhead | 30.7% | 33.3% | 2.6% | 31.5% | 21.6% | -9.9% [a] | - | - | - |
| | Chilko | 23.3% | 26.1% | 2.8% [a] | 23.3% | 8.3% | -15.0% [a] | - | - | - |
| | Eagle | 13.0% | 25.0% | 12.0% | 13.4% | 16.7% | 3.3% | - | - | - |
| | Horsefly | 10.9% | 12.5% | 1.6% [a] | 11.0% | 10.2% | -0.8% [a] | - | - | - |
| | Middle | 27.6% | 33.3% | 5.7% | 25.6% | 42.2% | 16.6% [a] | - | - | - |
| | Mitchell | 12.6% | 25.0% | 12.4% [b] | 12.7% | 10.2% | -2.5% [a] | - | - | - |
| | Pitt | 9.8% | 0.0% | -9.8% | 9.9% | 8.0% | -1.9% [a] | - | - | - |
| | Seymour | 11.7% | 0.0% | -11.7% | 11.0% | 13.6% | 2.6% [a] | - | - | - |
| | Shuswap | 21.8% | 33.3% | 11.5% | 21.8% | 20.0% | -1.8% [a] | - | - | - |
| | Stellako | 52.4% | 0.0% | -52.4% | 0.0% | - | - | - | - | - |
| | Stuart early | 42.1% | 50.0% | 7.9% | - | - | - | - | - | - |
| | Tachie | 12.7% | 0.0% | -12.7% | 11.8% | 18.2% | 6.4% [a] | - | - | - |
| | Weaver | 55.3% | 66.7% | 11.4% [a] | 56.1% | 100.0% | 43.9% | - | - | - |

[a.] N > 10 in the high stress category.

[b.] Difference is statistically significant (p<0.05, chi-square test).

covery probability of tagged sockeye, we evaluate recovery rates of fish that required ventilation at release or were recaptured at the tagging site, spawning success between tagged and untag-ged females, and the influence of tag status on the recovery distribution of carcasses.

**Ventilation:** Little insight is provided by com-parisons of recovery rates of ventilated sockeye across years because, in most projects and years, less than ten releases required ventilation. Only in the Chilko, Horsefly and Middle studies are sam-ple sizes greater than ten in both 1998 and any previous year (Table 8; Appendix 3). In the Chilko, the difference in recovery rate for females is much greater in 1998 than 1997. In the Horsefly, the difference in recovery rates is small for both sexes. Finally, the difference in recovery rates of females in the Middle study is greater (and op-posite in sign) in 1998 than 1994 and 1997. Even in this case, though, the difference in recovery rates between ventilated and non-ventilated fe-males in 1998 is not significant.

**Recapture:** The number of sockeye recaptured is generally much larger than the number ventilated; therefore the recovery rate of recaptured fish is limited to a sample of ten or more releases. The difference in recovery rates of recaptured and non-recaptured sockeye is unusual in the Birkenhead (males), Chilko (males) and Middle (both sexes) studies (Appendix 3). In all of these cases, however, the test for an effect of the number of times recaptured on recovery rate is not significant.

**Spawning Success:** In most projects, the difference in the fraction of tagged and untagged recovered females that had completely spawned is not unusual. The Chilko and Pitt study results are an exception (among those in which ten or more tagged females were recovered). The Chilko, however, is in the direction opposite to that generally expected if tagging is stressful and thus does not support the interpretation that females were unusually stressed. In the Pitt, fewer tagged than untagged females were completely spawned (Appendix 3). This result is weak evidence that Pitt females were somewhat stressed by tagging.

**Tag Distribution:** Finally, we compare spatial patterns of tag incidence across 1994-1998 to ex-amine the influence of tag status on the recovery distribution (presumably indicative of the spawning distribution). In 1998, if tagging was the last straw for a larger fraction of tagged fish than normal, the tag distribution should be more skewed toward the lower river than in previous years. Such a change occurred only in the Horsefly and Pitt projects (Ap-pendix 4).

**Summary:** Overall, the 1998 condition indicators are similar to recent years. The most atypical is the Stuart early run, where the fraction requiring ventilation, the days out and the spawning success are all low compared to typical years. As well, the fraction requiring ventilation is twice as high as in 1997 and the spawning success is approximately two thirds of the low 1997 level. These results suggest that sockeye returning to the Stuart were in poor condition, while those returning to other rivers arrived in normal condition. The comparisons of recovery rates, spawning success and spatial patterns of tag incidence between sockeye that had not experienced additional stress generally does not support the view that tagging was the last straw for a larger fraction of returning sockeye than normal. The strongest evidence of a stress effect is for the Horsefly and Pitt studies. We note, however, that while Horsefly sockeye were subject to adverse environmental conditions over their protracted migration through the Fraser River, Pitt sockeye were not.

**Bias Assessment**

The sampling biases detected (significant test result) in the 1998 data are described in Table 9. Appendix 1 provides the bias test results for all studies from 1994 to 1998; sex bias is not reported because the mark-recapture estimates are calculated separately for the two sexes.

**Size Bias:** The test for size bias at recovery is only significant for females in the Adams; larger females had a higher recovery rate. Untagged carcasses were not measured during recovery, and thus no test for size bias at application can be performed; however, sockeye were captured for tagging using beach seine nets, a capture gear that is unlikely to be selective by size. Furthermore, unless the source of selectivity in the application sample is correlated with a source of selectivity in the recovery sample, bias will not be introduced in the estimate (Junge 1963). In the studies examined here, there is no indication that fish size influences recovery distribution, either temporally or spatially; therefore, the population estimates are unlikely to be biased due to size-bias in sampling.

**Temporal and Spatial Bias:** Sampling profiles for the 1998 studies are presented in Appendix 5. The evaluations of the influence of temporal and spatial sampling biases on the population estimates are based on the following logic. When the probability of tagging ($P_{cap}$) and recovery ($P_{rec}$) are correlated, the Petersen mark-recapture estimate will be biased. We consider three mechanisms that can lead to such correlations in sockeye. First, the time of tagging and recovery are usually correlated, since early arrivals tend to die earlier. Second, spawning location can influence both tag-ging probability and recovery rates. Finally, the time of application and the area of recovery are often correlated, with earlier fish spawning further upstream. We refer to these three mechanisms as *TxT*, *SxS* and *TxS*, respectively. A similar shape in the relevant patterns of tag incidence and recovery rate (*e.g.*, temporal patterns in the Seymour study; Appendix 5) can establish a posi-tive correlation between the probabilities of tag-

Table 9. Results of statistical tests for sampling bias in the mark-recapture studies of Fraser River sockeye salmon in 1998. For significant tests, the bias is described (non-significant tests are indicated by *No bias*); when bias is detected in only one stratification, the stratification type is indicated as equal periods (EP), effort (EE) or recoveries (ER). [a]

| | | Male | | Female | |
|---|---|---|---|---|---|
| Study | Test type | Application | Recovery | Application | Recovery |
| Adams | Temporal | ↑ t.i. early, ↓ t.i. late | No bias | ↑ t.i. early, ↓ t.i. middle | No bias |
| | Spatial | ↓ t.i. Shuswap L., Little R. | ↓ r.r. from 'OO' to mouth | ↓ t.i. in Shus. L, Little R. | ↓ r.r. at mouth |
| | Fish sex | ↑ than expected t.i. | No bias | No bias | No bias |
| | Fish size | Not applicable | No bias | Not applicable | No bias |
| Birken-head | Temporal | ↑ t.i. early | No bias | ↑ t.i. early | No bias |
| | Spatial | No bias | Primary ↓ r.r., 2° ↑ r.r. | ↓ t.i. in upper reaches | No bias |
| | Fish sex | No bias | ↑ than expected r.r. | No bias | ↓ than expected r.r. |
| | Fish size | Not applicable | No bias | Not applicable | No bias |
| Chilko | Temporal | No bias | ↓ r.r. early | Declining t.i. | ↓ r.r. early |
| | Spatial | No bias | Not applicable | No bias | Not applicable |
| | Fish sex | No bias | ↑ than expected r.r. | No bias | No bias |
| | Fish size | Not applicable | No bias | Not applicable | No bias |
| Eagle | Temporal | No bias | No bias | ↓ t.i. early (EP) | No bias |
| | Spatial | No bias | No bias | No bias | No bias |
| | Fish sex | No bias | No bias | No bias | No bias |
| | Fish size | Not applicable | No bias | Not applicable | No bias |
| Horsefly | Temporal | No bias | Complex pattern in r.r. | ↓ t.i. late | ↓ r.r. 2nd period (EE) |
| | Spatial | ↑ t.i. in lower reaches | Not applicable | ↑ t.i. in lower reaches | Not applicable |
| | Fish sex | ↓ than expected t.i. | No bias | ↑ than expected t.i. | No bias |
| | Fish size | Not applicable | No bias | Not applicable | No bias |
| Middle | Temporal | Complex pattern (EP) | No bias | ↑ t.i. early | No bias |
| | Spatial | ↑ t.i. in lower reaches | No bias | ↑ t.i. in lower river | No bias |
| | Fish sex | No bias | No bias | No bias | No bias |
| | Fish size | Not applicable | No bias | Not applicable | No bias |
| Mitchell | Temporal | Complex pattern in t.i. | No bias | ↓ t.i. late | ↓ r.r. 2nd period (EP) |
| | Spatial | ↓ t.i. in lower reaches | Not applicable | ↓ t.i. in lower reaches | Not applicable |
| | Fish sex | No bias | No bias | No bias | No bias |
| | Fish size | Not applicable | No bias | Not applicable | No bias |
| Pitt | Temporal | No bias | No bias | ↓ t.i. late (ER) | ↓ r.r. late |
| | Spatial | No bias | Not applicable | Complex t.i. pattern | Not applicable |
| | Fish sex | No bias | No bias | No bias | No bias |
| | Fish size | Not applicable | No bias | Not applicable | ↑ r.r. in larger females |
| Sey-mour | Temporal | ↓ t.i. late (EP) | ↓ r.r. late | No bias | No bias |
| | Spatial | No bias | Not applicable | No bias | Not applicable |
| | Fish sex | No bias | No bias | No bias | No bias |
| | Fish size | Not applicable | No bias | Not applicable | No bias |
| Shuswap | Temporal | No bias | ↓ r.r. early and late (ER) | ↓ t.i. late | No bias |
| | Spatial | No bias | Not applicable | ↓ t.i. in upper reaches | Not applicable |
| | Fish sex | ↑ than expected t.i. | No bias | No bias | No bias |
| | Fish size | Not applicable | No bias | Not applicable | No bias |
| Tachie | Temporal | No bias | No bias | No bias | No bias |
| | Spatial | No bias | No bias | No bias | No bias |
| | Fish sex | No bias | No bias | No bias | No bias |
| | Fish size | Not applicable | No bias | Not applicable | No bias |
| Weaver | Temporal | ↓ t.i. in first period | ↓ r.r. in later period | ↓ t.i. in first period | ↓ r.r. late |
| | Spatial | No bias | Not applicable | No bias | Not applicable |
| | Fish sex | No bias | ↑ than expected r.r. | No bias | ↓ than expected r.r. |
| | Fish size | Not applicable | No bias | Not applicable | No bias |

[a.] t.i. indicates tag incidence; r.r. indicates recovery rate.

Table 10. Effect of application and recovery sampling biases on mark-recapture estimates of 1998 Fraser River sockeye salmon escapements, by sex and mechanism (see text). Effects are indicated on a qualitative scale, with <<, <, -, >, >> indicating large negative, small negative, no effect, small positive and large positive biases, respectively. *Max.* is the is the largest discrepancy between the Darroch and Petersen estimates, and *Prop'n>* is the proportion of acceptable Darroch estimates that are larger than the Petersen estimate.

| | Males | | | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mechanism | | | Darroch discrepancy | | Mechanism | | | Darroch discrepancy | |
| Study | TxT | SxS | TxS | Max. [a] | Prop'n > | TxT | SxS | TxS | Max. [a] | Prop'n > |
| Adams | - | < | - | 2.5% | 3/3 | >> | >> | - | -5.0% | 0/2 |
| Birkenhead | > | > | - | 2.9% | 1/3 | > | > | - | -3.6% | 2/3 |
| Chilko | - | > | - | 4.0% | 1/2 | >> | > | - | -6.9% | 1/2 |
| Eagle | - | > | - | 9.0% | 2/2 | - | - | - | 23.5% | 3/3 |
| Horsefly | < | - | - | 4.3% | 1/2 | - | - | - | 7.3% | 2/2 |
| Middle | < | > | - | 56.5% | 3/3 | - | > | - | 10.0% | 1/3 |
| Mitchell | > | - | - | 14.8% | 2/2 | - | - | - | -14.9% | 1/2 |
| Pitt | - | - | - | -3.9% | 1/2 | << | - | - | n/a | n/a |
| Seymour | << | > | - | -38.1% | 1/2 | < | - | - | -17.9% | 2/3 |
| Shuswap | - | - | - | 1.3% | 2/2 | - | - | - | -0.4% | 1/2 |
| Tachie | - | - | - | 30.7% | 2/2 | - | - | - | 10.7% | 2/2 |
| Weaver | > | - | - | 0.4% | 1/1 | < | - | - | -5.4% | 0/1 |

[a.] Discrepancies are positive when the Darroch is larger than the Petersen.

Ing and recovery (and thus a negative bias). Opposite shapes (*e.g.,* temporal patterns in the Birkenhead study; Appendix 5) can create a negative correlation (and a positive bias). Flat profiles, for either sample, will not cause a correlation (no bias). Finally, differently shaped profiles (*e.g.,* temporal patterns in the Eagle study; Appendix 5) will lead to, at most, a weak correlation.

Conclusions from these evaluations (Table 10) are qualitative for two reasons. First, the shapes of the sampling profiles are usually complicated (*e.g.,* in the Birkenhead, tag incidence generally decreases through time, but increases somewhat near the end; Appendix 5). Second, the trends indicated by the data are only estimates of the true patterns in tag incidence or recovery rate. Based on the evaluation of each mechanism, we estimate whether the sampling biases would likely have caused a large negative bias, a small nega-tive bias, no bias, a weak positive bias or a large positive bias. We consider the influence of a par-ticular mechanism on the population estimate to be large when the relevant trend in tag incidence strongly parallels (negative bias) or opposes (pos-itive bias) that in recovery rate and if both trends are significant. Otherwise, we consider the effect to be small. We further note that we have no way of quantifying large and small biases.

**Estimation Bias:** The results of the qualitative evaluation of the effects of sampling biases on the population estimates are presented in Table 10. A large biases may be present in the Adams female (+), Chilko female (+), Pitt female (-) and Seymour male (-) estimates. Small biases may be present in the Adams male (-), Birkenhead male (+) and female (+), Chilko male (+), Eagle male (+), Horsefly male (-), Middle female (+), Mitchell male (+), Seymour female (-) and Weaver male (+) and female (-) estimates. The *TxT* and *SxS* mechanisms appear to result in counteracting biases in the Seymour and Middle study; we assume that the resulting bias is likely to be small. We note that the identified biases are bi-directional, and that the positive biases (7) may offset the negative biases (5) in the total estimate.

Table 10 also presents information on the size and direction of MLE-PPE discrepancies for valid MLE estimates (those that pass Plante's $G^2$). Maximum discrepancies exceed 5% in the Eagle, Seymour, Mitchell, Middle and Tachie (both sexes) and in the Weaver, Adams, Chilko and Horsefly (females; Table 10). We present these comparisons as maximum possible biases that, based on work in the Stellako River (Houtman and Schu-bert 2007), are likely to exceed the level by a con-siderable margin.

Table 11. Dates of fence installation, sockeye arrival, fence removal, and the completion of migration, and an evaluation of operational effectiveness for the 1998 Fraser River sockeye salmon enumeration fence studies.

| | | Date of | | | | | Downstream | | |
|---|---|---|---|---|---|---|---|---|---|
| Stock Group | Stock | First arrival of sockeye | Fence instal-lation | Comple-tion of migration | Fence removal | Fish tight | Holding | Mortality | Peak daily count |
| Lower Fraser | Cultus Lake | 14-Sep | 14-Sep | 21-Nov | 23-Nov | Yes | No | No | 279 |
| Seton-Anderson | Gates Creek | 08-Aug | 06-Aug | 07-Sep | 17-Sep | Yes | No | No | 500 |
| South Thompson | Salmon River | 05-Oct | 30-Jun | 05-Nov | Dec | Yes | No | No | 17 |
| | Scotch Creek | 15-Aug | 31-Jul | 14-Sep | 16-Sep | Yes | No | Yes | 3,782 |
| Quesnel | McKinley Creek | 24-Aug | 15-Aug | 26-Sep | Nov | Yes | No | No | 8,355 |
| Stuart | Forfar Creek | 24-Jul | 17-Jul | 18-Aug | 19-Aug | Yes | No | No | 105 |
| | Gluske Creek | 23-Jul | 16-Jul | 17-Aug | 19-Aug | No | No | No | 184 |
| | Kynoch Creek | 21-Jul | 18-Jul | 18-Aug | 19-Aug | Yes | No | No | 399 |
| | Kuzkwa River | 06-Sep | 04-Sep | 01-Oct | 19-Oct | Yes | No | No | 1,297 |
| Nechako | Stellako River | 18-Aug | 17-Aug | 17-Oct | 19-Oct | Yes | No | No | 21,166 |

**Summary:** We cannot provide quantitative estimates of estimation biases; however, simulations examining the influence of major sampling biases on the Petersen estimates (Schubert and Fanos, 1997; Schubert and Vivian, 1997) indicate that deviations as large 10% are rare. The bi-directional biases (positive and negative) noted here represent a departure from the traditional bias structure in sockeye mark-recapture where overestimates are common (*e.g.,* Cousens *et al.* 1982). This reflects recent improvements to field procedures that have permitted a more represent-ative distribution of tags through the populations. We suggest that the traditional bias pattern results from two common sampling biases. First, in stu-dies where the majority of tags are applied at a single site near the bottom of the spawning distri-bution, tag incidence generally decreases moving upstream. This reflects the lower vulnerability to tagging of rapidly moving early migrants destined for spawning sites in the upper river (Schubert and Scarborough 1996), and the higher vulner-ability of slow moving (or milling) late migrants that spawn near the tagging site in the lower river. Second, the probability that a carcass will be flushed out of the study area is lower for fish that spawn further upstream. Thus, individuals tagged at a higher rate in the lower river are less likely to be recovered than those tagged at a lower rate in the upper river, introducing a positive bias in the population estimate. Because the 1998 biases are bi-directional and off-setting, the overall bias in the mark-recapture studies is probably low.

## ENUMERATION FENCE

The 17 stocks assessed by essentially complete censuses at either spawning channels (6 stocks) or fences (11 stocks) are identified in Appendix 11. These stocks account for 9% (2% and 7%, respectively) of the 1998 Fraser River sockeye escapement estimate, 181,900 males, 201,600 females and 1,700 jacks. By far the largest escapements were counted at fences in the Stellako River (185,700), and McKinley (75,800), and Scotch (36,000) creeks. The attributes of these estimates are described below.

### Implementation of Study Design

In this section, we address the questions raised under *Bias Assessment* (spawning channels are not addressed because detailed operational data are unavailable): Was the fence installed after the arrival of sockeye? Were operations inter-rupted during the migration? Was the fence re-moved before the migration was complete? Did it cause fish to hold or die downstream? Did large daily abundances confound the counts?

**Installation Timing:** The fences were install-ed at least three days (and usually over a week) before the arrival of the first sockeye (Table 11), except in Cultus, Gates, Kuzkwa and Stellako, where fence installation preceded sockeye arrival by 0, 2, 2 and 1 day, respectively. Cultus returned unusually early and is likely estimated with a small negative bias, while Gates, Kuzkwa and Stellako are likely unbiased because no sockeye were observed in the river following fence installation. In all cases, the fences operated until at least two days of zero counts were recorded and down-stream surveys reported no new sockeye. The fences were maintained without incident and likely intercepted all immigrants, except in Gluske where a breech in the live box for two days early in the study permitted fish to enter the box and jump its wall. The counts were corrected from in-tensive creek surveys that, because the creek is small and abundance was low, approximate a complete census.

**Obstruction of Migration:** There was one significant observation of fish holding or dying below the enumeration fences: Scotch Creek. Because flows were low near the creek mouth, project staff sandbagged the creek to create a deeper channel; some mortality occurred when vandals removed the sand bags causing the channel to de-water.

**Peak Migration:** Daily migrations generally were less than 1,500 sockeye, except in Scotch (3,782) and McKinley (8,355) creeks and Stellako River (21,166) (Table 11). These large daily mi-grations are unlikely to introduce error in the counts because the migrations were pulsed over the entire 24-hour period, the number of sockeye in each pulse was strictly controlled, and multiple crews were used to avoid observer fatigue.

**Summary:** The enumeration fence studies were well executed in 1998. With only minor exceptions, the fences were fish-tight and operated over the entire immigration periods. The fences did not obstruct upstream passage and, while daily abundances were sometimes large, they were anticipated and operational procedures were in place to accommodate them.

### Bias Assessment

Total counts of live or dead fish are considered to be accurate measures of spawning escapement. Errors can occur, however, for a number of reasons: a) sex and species misidentification when live fish are counted while swimming past a fixed point; b) inaccurate counts at night due to poor lighting, surface glare or viewer fatigue, or at any time when there is a rapid migration of large numbers of fish; and c) inaccurate channel counts due to the loss of carcasses to predators or washouts. For these reasons, Andrew and Webb (1987) recommend that a coefficient of variation of 5% be assigned to all complete counts. This roughly translates into 95% confidence limits of ±10%. We believe that this over-states the probable error in 1998 because the study designs addressed the first three issues: sex was not recorded from live fish; spawning colouration makes sockeye highly recognizable; night observations were avoided when possible and supported by adequate lighting when necessary; and high daily abundances were anticipated and accommodateed. While a 10% error may be reasonable during the peak migration when 20,000 or more fish may be counted, it over-states the error in the balance of the run and does not apply to the smaller populations. It also ignores the likelihood of asymmetric confidence intervals, *i.e.,* underestimates would be more probable than overestimates. We conclude, therefore, that the fence and channel estimates are likely estimated with a negative bias of less than 5%.

## VISUAL SURVEYS

The 144 stocks assessed using visual techniques are identified in Appendix 11. These stocks account for 4% of the 1998 Fraser River sockeye escapement estimate, 85,000 males, 98,500 fe-males and 300 jacks.

### Implementation of Study Design

In this section, we address the questions raised under *Bias Assessment*: Were visual surveys limited to small (<25,000) populations? Was the extent and frequency of the surveys adequate? Did local conditions permit the effective observation of fish?

**Population Size:** Of the stocks surveyed, 44% had fewer than 100 spawners, while only one (Portage Creek) had slightly more than the maxi-mum 25,000 spawners intended for assessment by this technique (Table 12; Appendix 11). The relatively large size of the Portage population and the small size of the creek resulted in high spawn-er densities that made counting difficult.

Table 12. The number of stocks with estimated escapements of greater than 25,000 sockeye, with peak live counts on the first or last survey, and with total survey effort of 1, 2-3, 4-6, and 7+ surveys, among the Fraser sockeye populations where the 1998 escapement is estimated using visual techniques.

| | | | | Number of stocks by survey frequency and average estimated escapement for those stocks [d] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 survey | | 2-3 surveys | | 4-6 surveys | | 7+ surveys | |
| Geographic area [a] | Number of stocks surveyed [b] | 25,000+ Escape-ment | Peak on first or last survey [c] | No. stocks | Escape-ment | No. stocks | Escape-ment | No. stocks | Escape-ment | No. stocks | Escape-ment |
| Lower Fraser | 4 | 0 | 0 | 0 | - | 1 | 1,600 | 3 | 2,500 | 0 | - |
| Harrison-Lillooet | 5 | 0 | 1 | 1 | 0 | 2 | 400 | 1 | 6,000 | 1 | 4,500 |
| Seton-Anderson | 2 | 1 | 1 | 0 | - | 0 | - | 1 | 25,200 | 1 | 1,100 |
| South Thompson (ES) | 18 | 0 | 1 | 3 | 0 | 4 | 60 | 7 | 6,100 | 4 | 1,000 |
| South Thompson (L) | 27 | 0 | 6 | 0 | - | 7 | 100 | 15 | 800 | 4 | 6,800 |
| North Thompson | 3 | 0 | 0 | 0 | - | 1 | 9 | 2 | 8,000 | 0 | - |
| Chilcotin | 2 | 0 | 0 | 2 | 200 | 0 | - | 0 | - | 0 | - |
| Quesnel | 44 | 0 | 0 | 16 | 34 | 11 | 46 | 17 | 2,000 | 0 | - |
| Stuart, Early Run | 41 | 0 | 1 | 6 | 1,600 | 5 | 400 | 1 | 0 | 29 | 600 |
| Stuart, Summer Run | 4 | 0 | 1 | 0 | - | 2 | 50 | 1 | 1,300 | 1 | 2,200 |
| Nechako | 1 | 0 | 0 | 0 | - | 1 | 800 | 0 | - | 0 | - |
| Upper Fraser | 2 | 0 | 0 | 1 | 0 | 1 | 4,800 | 0 | - | 0 | - |
| Total/mean | 152 | 1 | 11 | 29 | 360 | 35 | 340 | 48 | 3,020 | 40 | 1,500 |

[a.] ES - Early Summer Run; L - Late Run.

[b.] Excludes stocks or components of stocks where other techniques (fence or mark-recapture) were used to estimate the escapement, or where other agencies conducted visual surveys but did not provide the daily counts.

[c.] Excludes stocks that were surveyed only once or twice, and below-fence surveys that intentionally started late to permit upriver spawners to clear the area.

[d.] Average escapements greater than 100 are rounded to the nearest 100.

**Survey Extent:** The entire spawning area was surveyed for each stock, except when ex-tremely low water levels prevented the access of fish into the stream. When that occurred (largely in tributaries to Quesnel and Shuswap lakes), the survey was limited to observations off the creek mouth. Because such blockages induce straying to other spawning areas, efforts were made to in-spect non-traditional spawning areas when tran-siting between streams.

**Survey Frequency:** Each stream was sur-veyed 1-12 times (Appendices 9-10), with survey frequency determined by population size, or the size of the dominant population when a number of stocks were surveyed as a group. Of the streams surveyed 1-3 times, 78% had estimated popula-tions of <100 spawners, while 86% of those surveyed 4+ times had >100 spawners (40% had 1,000+ spawners). Exceptions are largely limited to remote areas that preclude frequent access: Driftwood River (1 survey; 9,227 spawners); and Taseko Lake (1 survey; 400 spawners). When survey effort is limited, the level of carcass recov-ery is often insufficient to estimate sex composi-tion; this occurred in 26 cases in 1998 (Appendix 10).

**Sighting Conditions:** Conditions were gen-erally good, reflecting low water levels through most of the season. The few cases of poor visibil-ity resulted from glacial run-off (upper

Adams) or spawning in deep water (Harrison, South Thomp-son).

**Bias Assessment**

Bias in visual surveys can take several forms: the inappropriate use of visual surveys for large stocks; survey frequency that is inadequate to identify the peak of abundance; the use of a fixed expansion factor under variable survey conditions; the failure to survey the complete distribution of a stock; or the failure to survey a stock at all.

**Population Size:** The use of visual surveys on large stocks is limited to one case (Portage Creek) in 1998. It is generally accepted that such surveys result in escapement estimates with a substantial negative bias. For example, in a comparison of visual and mark-recapture estimates in Middle, Mitchell and Tachie rivers in 1994, Schubert (1998) reported that the latter averaged 4.9 times larger than the former. It is unlikely that the magnitude of the bias is this high in the Portage estimate because the creek is small and the spawning area much less extensive. Regardless, the bias is likely substantial because of high densities of spawners are difficult to count and the stream surveys began after spawners had arrived (the peak observation was on the first survey) (Appendix 9).

**Fixed Expansion Factor:** The application of a fixed expansion factor to stream survey data clearly results in estimation error. The reliability of this technique is dependent on stream characteristics (morphology, clarity, *etc*.), climatic conditions, survey intensity and observer efficiency being similar in the index stream and the stream or streams where the expansion factor is calculated. Error occurs when there is variability between streams within a year if, for example, discharge patterns differ between geographic parts of the watershed, or even within streams among years. Cousens *et al.* (1982) note that the method could be as accurate as ±30% when observations were made by experienced observers in small, clear, stable streams. Because a large number of streams are surveyed using this technique, how-ever, central tendency may balance over and un-der-estimates, resulting in less biased estimates for the aggregate. Regardless, these stocks com-prise a very small proportion of the total escape-ment in 1998. Even gross errors, therefore, would introduce a relatively small bias in the overall escapement estimate.

**Inseason Calibration:** The early Stuart assessment is a refinement of this technique because the expansion factor is recalibrated each year. Data from three streams are used in 1998 to calibrate the year-specific expansion factor; therefore, the factors should accurately index the streams that are surveyed at the same level of frequency as the calibration streams. This is the case for most streams in the stock group (Appendix 10), with the exception of the Driftwood River system (1-3 surveys). The Driftwood River was surveyed by helicopter, with the date of the flight selected to coincide with the peak of abundance in streams in the northeast arm of Takla Lake. The probability of an underestimate is greater in the Driftwood because the single flight may not have coincided with the actual peak of abundance. The estimate for the Driftwood system, therefore, may have a negative bias of perhaps as high as 20% (it cannot be quantified from the available data). Given the spawner distributions observed in 1998, this would introduce a negative bias in the early Stuart estimate of about 8%.

**Unsurveyed Areas:** Another potential bias stems from spawning areas that are not surveyed, a possibility that was identified in 1994 (Anon. 1995a). In 1998, low water prevented spawner en-try into several natal areas; these fish may have spawned in nontraditional areas. All of the known spawning areas were surveyed frequently in 1998, and the surveys include (in transit) observations of nontraditional areas. We do not eliminate the pos-sibility of spawning in nontraditional areas that was not assessed by our surveys; however, if pre-sent, its magnitude is likely small and probably no different than in past years.

**Summary:** It is not possible to quantify the bias in visual estimates from the available data. It is likely, however, that the escapement of these stocks is under-estimated in 1998. In the early Stuart group, the bulk of the stocks are likely estimated accurately; however, the use of a single survey in the Driftwood River may introduce a negative bias of up to 8%. For the balance of the stocks that were not calibrated inseason, there are likely random errors of up to ±30%; however, over and under-estimates may compensate to produce a less biased aggregate estimate. The exceptions are the large escapement to Portage Creek, and the stocks spawning in glacial (upper Adams) or deep (Harrison, South Thompson) water where the negative bias may be substantial.

## TOTAL ESCAPEMENT

upper Pitt and Nahatlatch systems. Most of the Lower Fraser stocks were surveyed visually, with three to five surveys per stock (Appendix 10). Cultus Lake sockeye were enumerated at a fence in Sweltzer Creek (Appendix 7) that has operated most years since 1926. The upper Pitt escapement is estimated from a mark-recapture study, the first structured study with the primary objective to estimate the escapement of this stock. Previous studies, conducted since 1968, focused on hatchery brood stock acquisition rather than population estimation

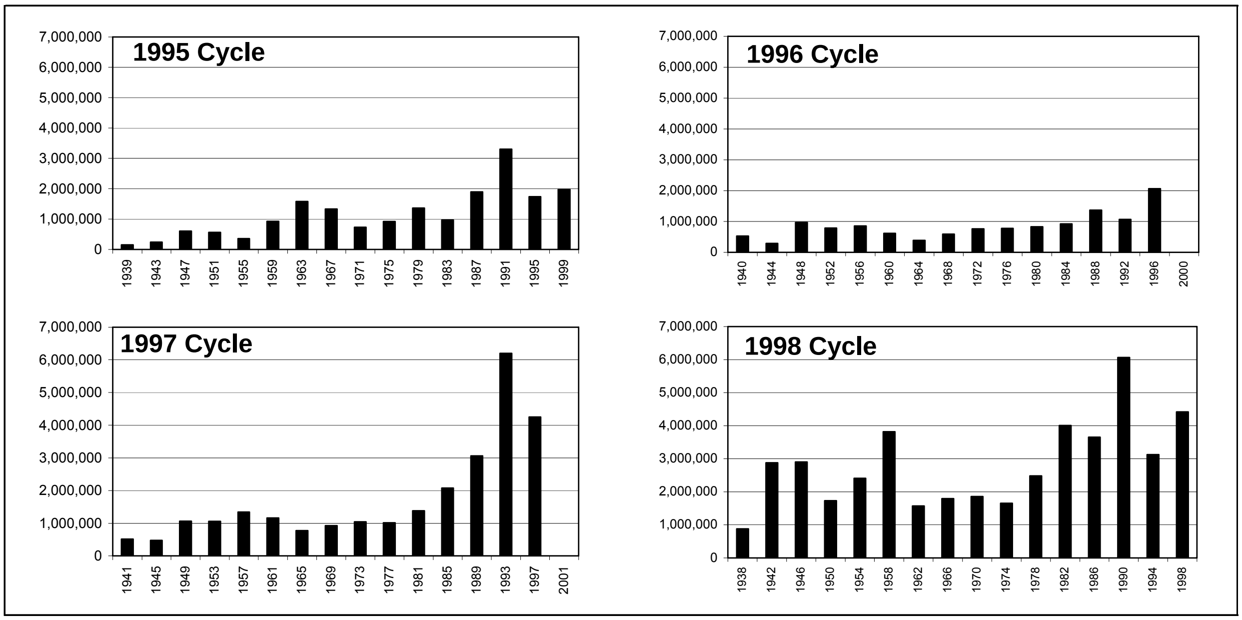


Fig. 3. Fraser River adult sockeye escapement by cycle.

The 1998 Fraser River sockeye escapement totals 4,422,075 adults and 5,604 jacks (Table 13). The sockeye adult escapement increased by 41% from the 1994 brood year escapement of 3,128,543, but declined by 27% from the record 1990 escapement of 6,064,285. The 1998 es-capement is the second largest reported on this cycle and the third largest regardless of cycle since 1938 (Fig. 3).

## GEOGRAPHIC GROUP

### Lower Fraser

The Lower Fraser group consists of five Early Summer Run and five Late Run stocks from relatively small streams that enter the Fraser River between the Pitt and Thompson rivers (Fig. 4). The largest stocks on this cycle spawn in the

The 1998 Lower Fraser group escapement of 87,978 adults and 211 jacks comprises 2% and 4%, respectively, of the Fraser River total (Table 13). The adult escapement is triple that of the brood year (Fig. 4), with virtually all of the increase resulting from the record escapement in the upper Pitt River. Average spawning success (94%; range 41%-97%) declined from the brood year (98%; range 94%-100%), with poor success in Chilliwack, Cultus and Nahatlatch lakes (Ap-pendix 11).

The accuracy of the 1998 Lower Fraser estimates depends largely on the upper Pitt, which comprises 87% of the total. The restructuring of the Pitt study resulted in significant study design improvements over previous years. Study execu-tion deficiencies, however, resulted in low recov-ery rates and relatively poor estimation precision, and may bias the estimate. The most serious concern is among females, where temporal bias-es may introduce negative estimation bias (Ta-ble 10) with an extreme probable bound equiv-alent to the upper confidence limit. Assuming random error in the visual estimates, the maxi-mum probable bias for this group is a negative bias that is unlikely to exceed 5%.

### Harrison-Lillooet

The Harrison-Lillooet group consists of sev-en Late Run stocks that spawn in Harrison River and its tributaries, and in streams tributary to Harrison Lake, Lillooet River and Lillooet Lake (Fig. 5). The largest stocks on this cycle spawn in the Birkenhead River, which was assessed by

Table 13. Estimated escapement of Fraser River sockeye salmon adults and jacks, by stock group and selected major stocks, for cycle years 1986, 1990, 1994 and 1998.

| Stock group | Stock | 1998 Period of peak spawning | Estimated sockeye adult escapement 1986 | 1990 | 1994 | 1998 | Jack escape-ment 1998 |
|---|---|---|---|---|---|---|---|
| **Lower Fraser** | Chilliwack Lake | Early Sep | 1,164 | 2,230 | 7,910 | 1,068 | 4 |
| | Cultus Lake | Early Dec | 3,256 | 1,860 | 4,399 | 1,959 | 207 |
| | Nahatlatch System | 07-Sep to 12-Sep | 8,996 | 7,044 | 6,042 | 7,993 | 0 |
| | Pitt River, upper | 15-Sep to-20-Sep | 29,177 | 12,202 | 9,500 | 76,888 | 0 |
| | **Total [a]** | - | **45,193** | **23,347** | **28,064** | **87,978** | **211** |
| **Harrison-Lillooet** | Birkenhead River | 22-Sep to 27-Sep | 335,630 | 166,773 | 39,234 | 295,669 | 369 |
| | Harrison River | 10-Nov to 15-Nov | 7,265 | 4,515 | 9,515 | 4,496 | 0 |
| | Weaver Channel | 11-Oct to 16-Oct | 44,892 | 10,396 | 44,939 | 29,071 | 46 |
| | Weaver Creek | 11-Oct to 16-Oct | 65,846 | 5,969 | 20,017 | 28,020 | 22 |
| | **Total [a]** | - | **456,671** | **189,505** | **114,432** | **364,064** | **443** |
| **Seton-Anderson** | Gates System | 29-Aug to 02-Sep | 3,572 | 5,374 | 3,360 | 7,248 | 1,477 |
| | Portage Creek | 25-Oct to 30-Oct | 14,291 | 18,336 | 9,270 | 25,179 | 26 |
| | **Total [a]** | - | **18,403** | **25,322** | **12,666** | **32,427** | **1,503** |
| **South Thompson** | Adams River, upper | 02-Sep to 07-Sep | 567 | 625 | 581 | 344 | 0 |
| ***Early Summer Run*** | Eagle River | 05-Sep to 10-Sep | 7,138 | 4,147 | 45,452 | 28,478 | 0 |
| | Scotch Creek | 30-Aug to 03-Sep | 26,624 | 83,388 | 73,180 | 35,981 | 12 |
| | Seymour River | 06-Sep to 08-Sep | 126,166 | 272,041 | 56,192 | 33,379 | 11 |
| | **Total [a]** | - | **167,631** | **387,623** | **206,899** | **108,576** | **25** |
| **South Thompson** | Adams River, lower | 18-Oct to 25-Oct | 1,325,089 | 2,068,378 | 680,269 | 870,919 | 265 |
| ***Late Run*** | Eagle River | Early Oct | 25,697 | 56,200 | 28,350 | 11,398 | 0 |
| | Little River | 18-Oct to 25-Oct | 226,778 | 359,172 | 198,112 | 176,205 | 47 |
| | Shuswap R., lower | 12-Oct to 16-Oct | 600,370 | 983,481 | 367,661 | 291,631 | 0 |
| | Shuswap R., middle | 09-Oct to 15-Oct | 80,529 | 96,441 | 31,806 | 15,262 | 0 |
| | **Total [a]** | - | **2,345,230** | **3,717,673** | **1,370,678** | **1,389,271** | **312** |
| **North Thompson** | Fennell Creek | 25-Aug to 01-Sep | 6,024 | 11,862 | 5,919 | 8,741 | 0 |
| | Raft River | 30-Aug to 09-Sep | 2,095 | 630 | 1,712 | 7,198 | 31 |
| | **Total [a]** | - | **8,190** | **12,592** | **7,671** | **15,948** | **31** |
| **Chilcotin** | Chilko Channel | 25-Sep to 05-Oct | 0 | 9,934 | 1,930 | [c] | [c] |
| | Chilko River and Lake | 25-Sep to 05-Oct | 293,804 | 815,903 | 448,815 | 879,010 | 1,934 |
| | Taseko Lake [b] | Early Sep | n/r | n/r | 270 | 400 | 0 |
| | **Total** | - | **293,804** | **825,837** | **451,015** | **879,495** | **1,934** |
| **Quesnel** | Horsefly System | 07-Sep to 17-Sep | 150,386 | 439,485 | 550,481 | 848,997 | 0 |
| | Mitchell System | 18-Sep to 25-Sep | 30,827 | 43,755 | 129,235 | 310,329 | 0 |
| | Quesnel Lake | 07-Sep to 30-Sep | 254 | 4,404 | 6,695 | 19,926 | 0 |
| | **Total [a]** | - | **181,467** | **488,259** | **686,411** | **1,179,252** | **0** |
| **Stuart** | Takla System | 30-Jul to 19-Aug | 8,269 | 37,273 | 10,675 | 23,802 | 1 |
| ***Early Run*** | Middle System | 28-Jul to 15-Aug | 16,433 | 43,039 | 13,266 | 5,841 | 19 |
| | Trembleur System | 29-Jul to 11-Aug | 3,882 | 16,723 | 5,890 | 2,947 | 0 |
| | **Total** | - | **28,584** | **97,035** | **29,831** | **32,570** | **20** |
| **Stuart** | Middle River | 18-Sep to 24-Sep | 9,940 | 76,500 | 29,573 | 38,906 | 11 |
| ***Summer Run*** | Tachie River | 26-Sep to 02-Oct | 13,617 | 94,570 | 42,571 | 92,963 | 1,010 |
| | **Total [a]** | - | **28,715** | **189,079** | **76,462** | **138,397** | **1,024** |
| **Nechako** | Nadina System | 20-Sep to 25-Sep | 3,549 | 6,033 | 2,008 | 3,705 | 19 |
| | Stellako River | 26-Sep to 05-Oct | 77,177 | 93,920 | 137,995 | 185,641 | 56 |
| | **Total [a]** | - | **80,726** | **100,153** | **140,034** | **189,346** | **75** |
| **Upper Fraser** | **Bowron System** | Early Sep | **3,124** | **7,860** | **4,380** | **4,751** | **26** |
| **Total [a]** | **Total** | **Adults** | **3,657,738** | **6,064,285** | **3,128,543** | **4,422,075** | |
| | | **Jacks** | **59,706** | **20,546** | **4,083** | **5,604** | |
| | | **Total** | **3,717,444** | **6,084,831** | **3,132,626** | **4,427,679** | |

[a] Includes smaller, miscellaneous stocks; see Appendix 6.

[b] Taseko Lake was not surveyed in 1982, 1986 and 1990.

[c] Included in Chilko River and Lake.

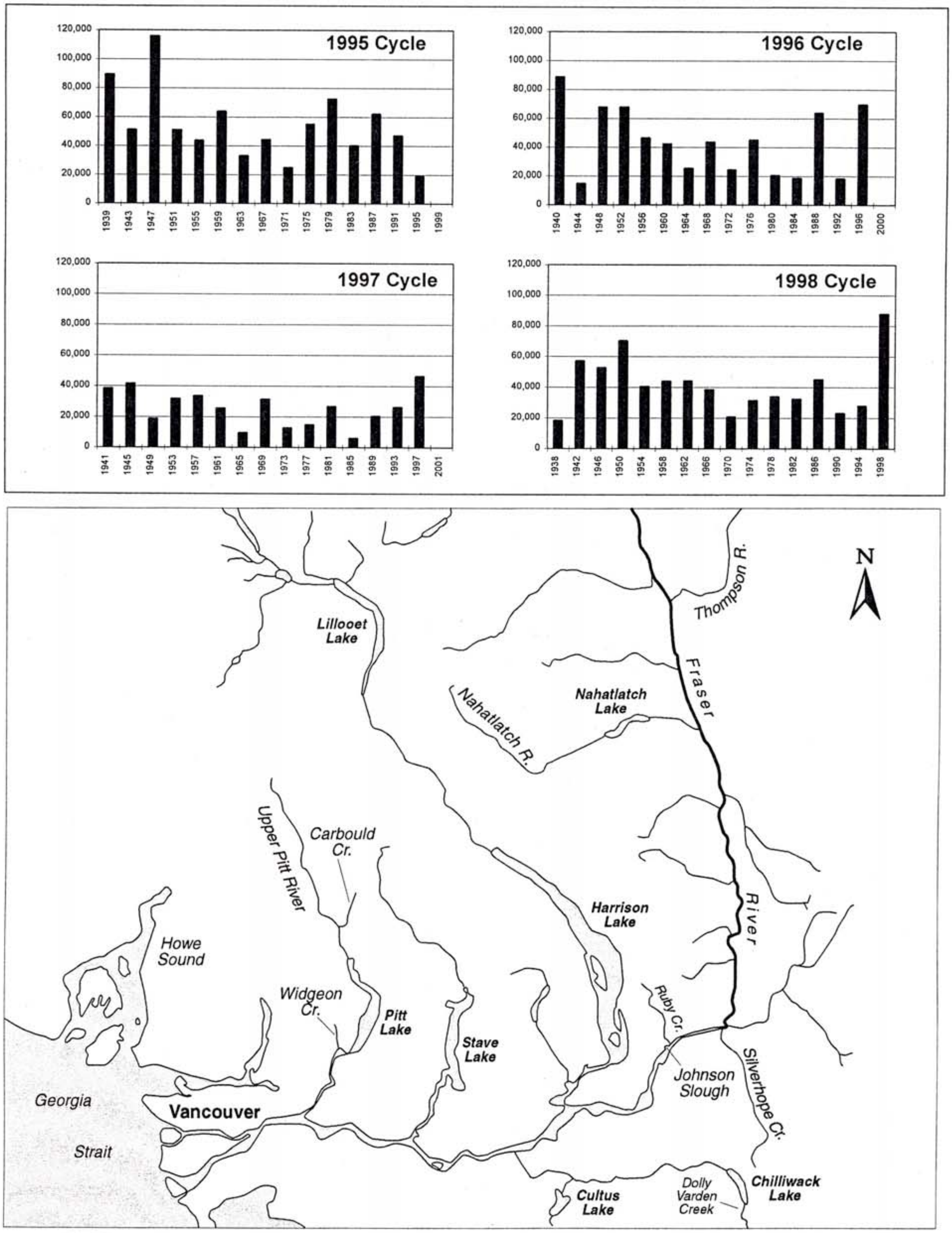


Fig. 4. Adult escapement by cycle and spawning distribution map for Lower Fraser sockeye salmon.

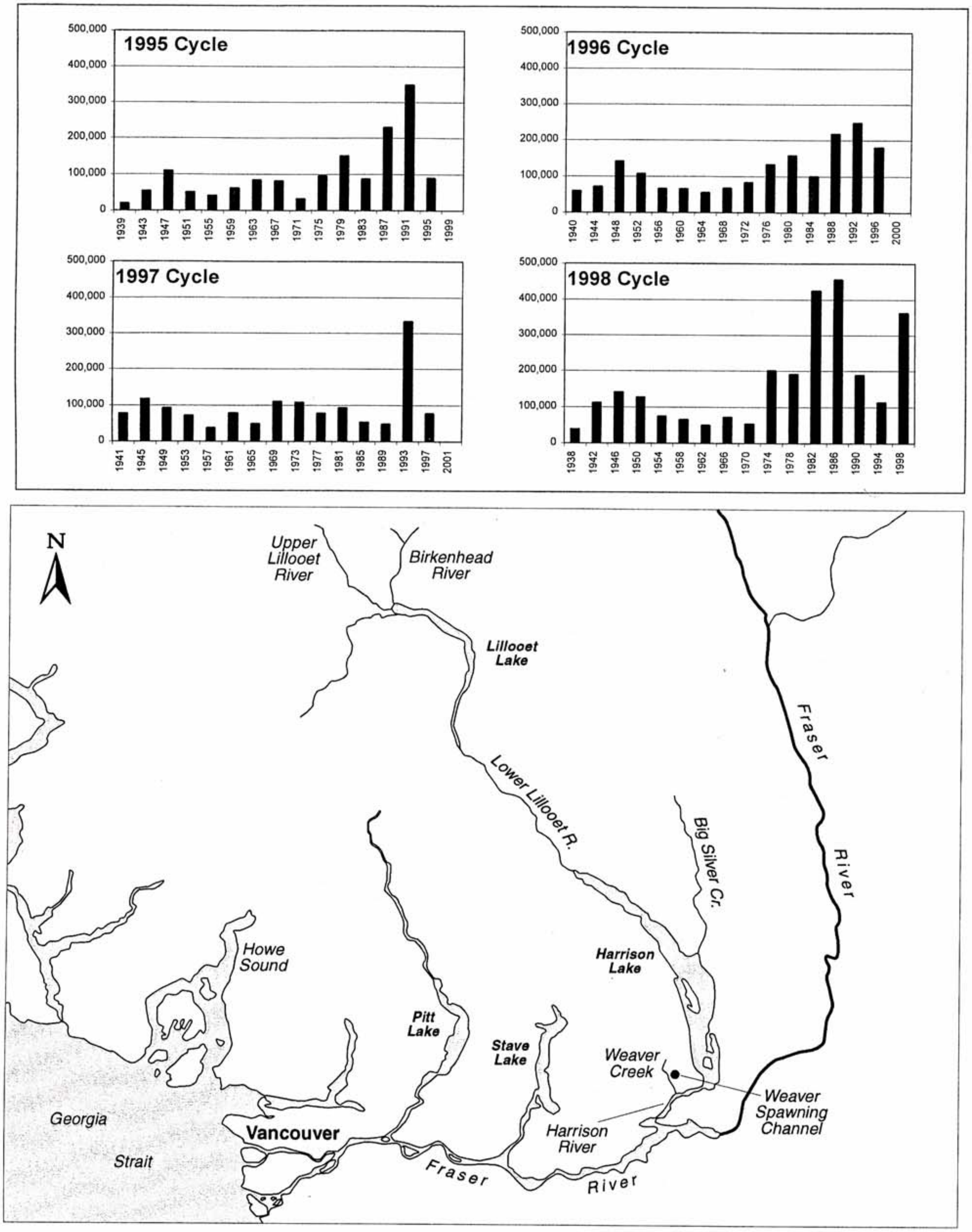


Fig. 5. Adult escapement by cycle and spawning distribution map for Harrison-Lillooet sockeye salmon.

mark-recapture, and Weaver Creek, which was assessed by mark-recapture in the creek and a fence in the channel (Appendix 8). The other stocks were surveyed visually. Survey frequency varied from one in Green River (low water prevented access) to eight in Harrison River (Ap-pendix 10). The latter likely results in an under-estimate because observations were confound-ed by the size and depth of the river and the large co-incident spawning populations of chi-nook and chum salmon.

The 1998 Harrison-Lillooet group escape-ment of 364,064 adults and 443 jacks comprises 8% of the Fraser River totals (Table 13). The adult escapement is triple that of the brood year and is the third largest on this cycle since 1938 (Fig. 5). The increase results from the strong escapement of 295,700 to the Birkenhead River, an increase from 39,200 in 1994. In contrast, es-capement to Harrison River is half that of 1994. The Weaver System escapement also decreas-ed from the brood year; however, it was inten-tionally limited using terminal fisheries and does not reflect reduced returns. Spawning success (95%; range 90%-99%) declined from the brood year (99%; range 98%-100%), but exceeded 90% in all stocks (Appendix 11).

The accuracy of the 1998 Harrison-Lillooet escapement estimates depends largely on the Birkenhead and Weaver estimates that comprise 89% of the estimated total escapement. We identify small probable biases in both studies (positive in Birkenhead males, females and Weaver males; negative in Weaver females) (Table 10). We also note that the use of visual surveys in the Harrison River likely introduces a negative bias in that estimate. Assuming ran-dom error in the remaining visual estimates, these biases are off-setting to some extent and likely result in a small positive estimation bias for the group.

## Seton-Anderson

The Seton-Anderson group consists of one Early Summer Run and one Late Run stock that spawn in Gates and Portage creeks, respectively (Fig. 6). The Gates escapement was estimated at fences in the creek and channel (Appendix 8), while the Portage Creek escapement was esti-mated from four visual surveys (Appendix 10).

The 1998 Seton-Anderson group escape-ment of 32,427 adults and 1,503 jacks compris-es 1% and 27%, respectively, of the Fraser River total (Table 13). The adult escapement is almost triple the brood year level (Fig. 6). Average spawning success (84%; range 54%-91%) de-clined from the brood year (average 90%; range 78% to 100%), with particularly poor success in the Gates system (Appendix 11).

The Gates stock was enumerated at a fence and in the spawning channel; consequently, its escapement is likely estimated with only a small negative bias. The use of visual techniques to assess the Portage stock, however, likely intro-duces a large negative bias (as much as 50%) because abundance was high and the surveys started late. Escapement for this group, there-fore, may have a large negative bias.

## South Thompson

**Early Summer Run:** The early South Thompson group consists of 19 stocks that spawn primarily in streams tributary to Shuswap Lake (Fig. 7). The largest stocks on the 1998 dominant cycle spawn in Scotch Creek and Sey-mour and Eagle rivers. The Scotch escapement (Appendix 7) was estimated at an enumeration fence, while the escapements to Seymour and Eagle rivers were estimated by mark-recapture studies. The latter is the first such study for this stock. The remaining stocks were surveyed vis-ually, with 2-10 surveys per stock (Appendix 10).

The 1998 early South Thompson group es-capement of 108,576 adults and 25 jacks com-prises 3% and <1%, respectively, of the Fraser River total (Table 13). The adult escapement de-clined by 48% from the brood year, the second consecutive cycle of significant escapement de-clines (Fig. 7). Declines are consistent among all of the major stocks in this group. Average spawning success (96%; range 75%-100%) im-proved from the brood year (94%; range 67%-100%), with particularly high success in the large populations in Eagle and Seymour rivers and Scotch Creek (Appendix 11).

The accuracy of the 1998 South Thompson Early Summer Run escapement estimates de-pends largely on the Eagle, Scotch and Seymour estimates that comprise 90% of the estimated total escapement. Scotch Creek, counted at a fence, is likely estimated with a small negative bias. For Seymour, our evaluation of sampling biases indicates that the population may be esti-mated with a small negative bias (Table 10) that is

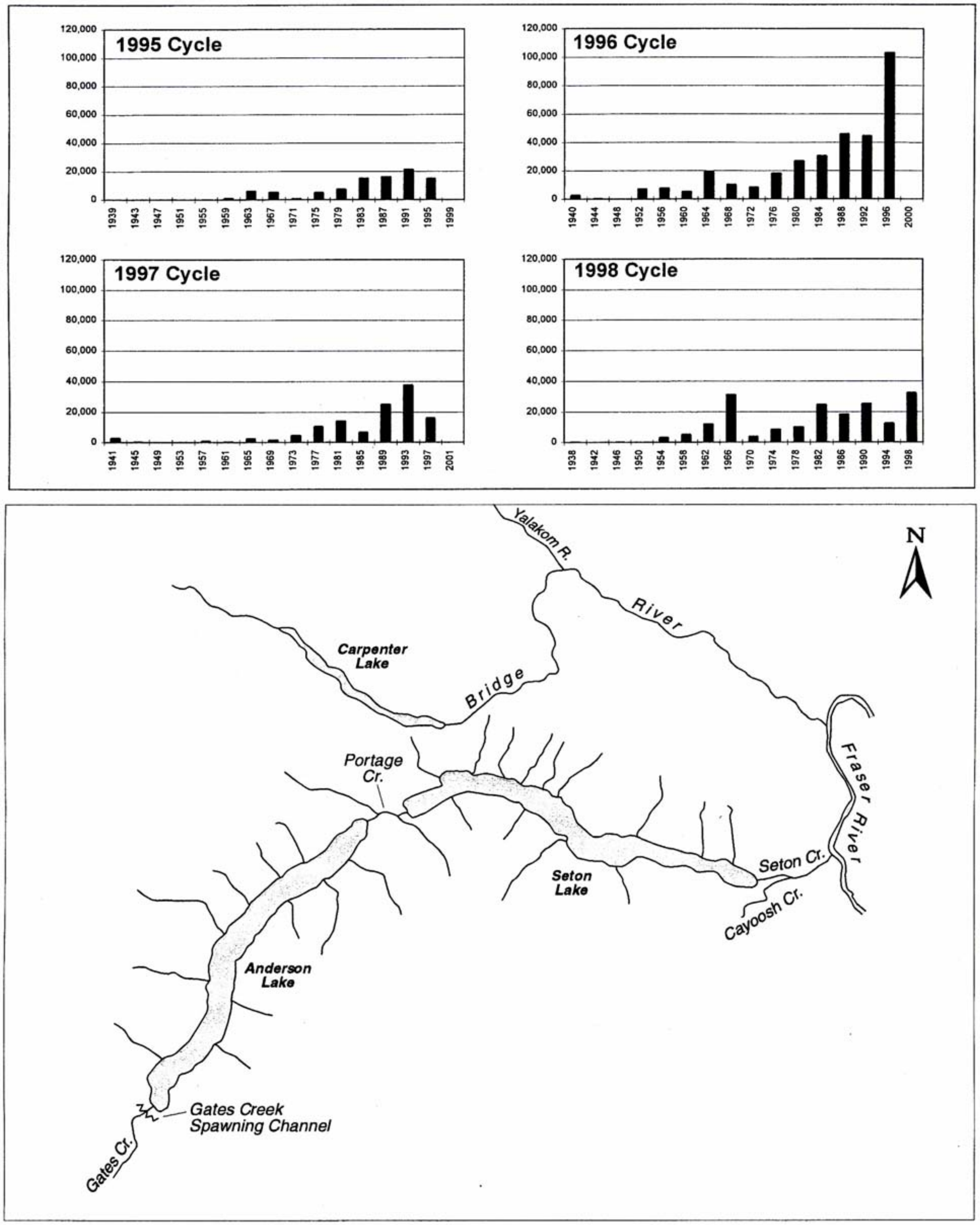


Fig. 6. Adult escapement by cycle and spawning distribution map for Seton-Anderson sockeye salmon.

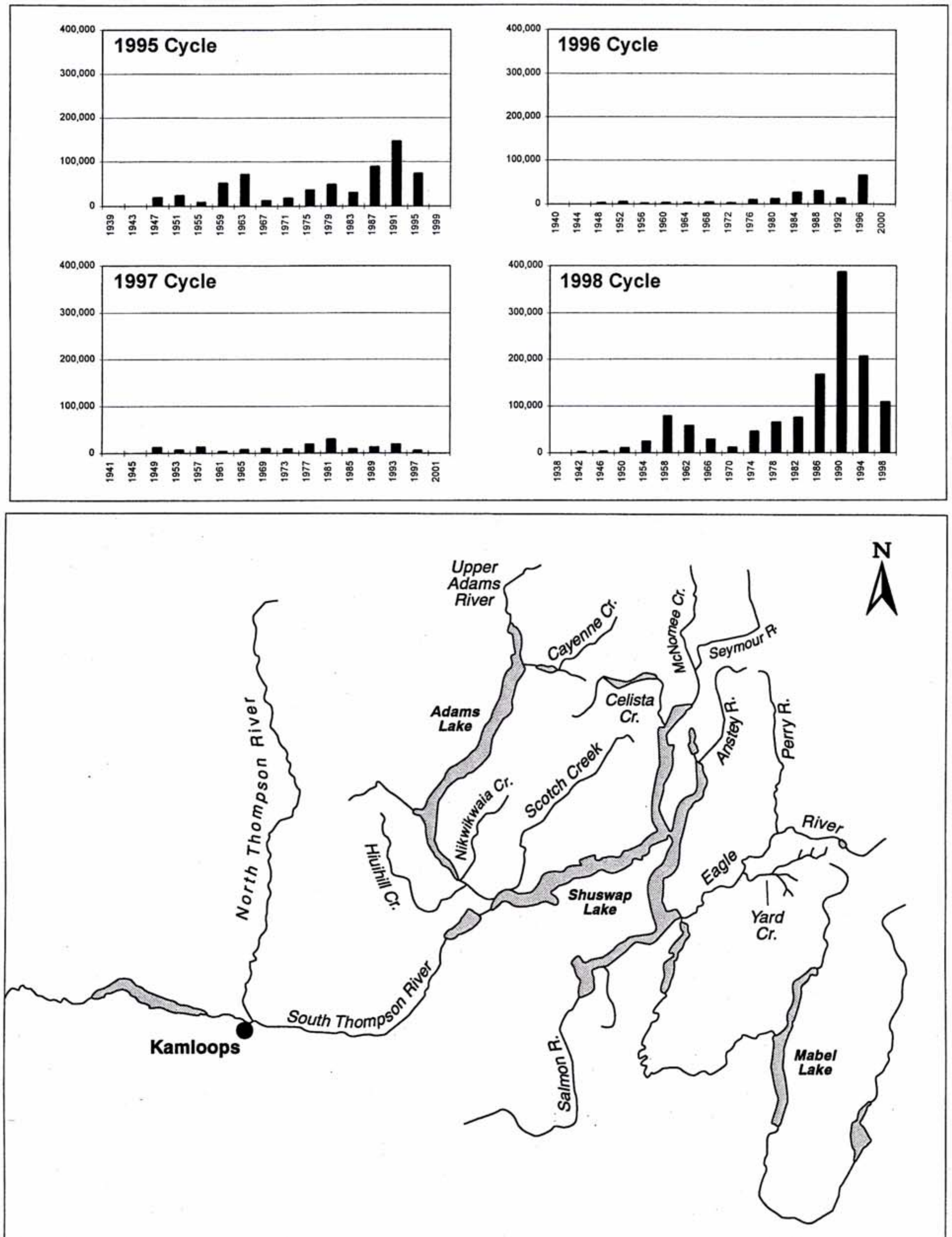


Fig. 7. Adult escapement by cycle and spawning distribution map for South Thompson Early Summer Run sockeye salmon.

unlikely to have exceeded 10%. We are most concerned with the Eagle estimate, where low tag and recovery rates resulted in poor estimation precision and hinder our bias evaluation. We note the possibility of a small positive bias among males. Assuming random error in the remaining visual estimates, the identified biases are off-setting to some extent and likely result in a small negative bias for the group.

**Late Run:** The late South Thompson consists of 30 stocks that spawn primarily in the low-er Adams River area (Adams, Little and South Thompson rivers and Scotch Creek), Adams and Shuswap lake foreshores and tributaries, and the Shuswap River system (Fig. 8). The largest stocks on the 1998 dominant cycle spawn in the lower Adams River area and the Shuswap River; both were assessed by mark-recapture studies. The Eagle River escapement was assessed at a fence (Appendix 7); the remaining stocks were assessed visually, with 2-12 surveys per stock (Appendix 10).

The 1998 late South Thompson escapement of 1,389,271 adults and 312 jacks comprises 31% and 6%, respectively, of the Fraser River total (Table 13). The adult escapement is 1% larger than the brood year, but is one of the smallest on this cycle since 1938 (Fig. 8). The lower Adams River increased from 680,300 in 1994 to 870,900 in 1998, while the Shuswap declined from 399,500 in 1994 to 306,900 in 1998. The latter is the second consecutive cycle of significant escapement declines for this stock. Spawning success (95%; range 83%-100%) declined from the brood year (99%; range 87%-100%), but exceeds 95% among the large populations in the Adams and Shuswap rivers (Appendix 11).

The accuracy of the 1998 South Thompson Late Run escapement estimates depends entire-ly on the Adams, Little, and Shuswap estimates that comprise 97% of the estimated total es-capement. Our evaluation of the Shuswap com-plex does not identify sampling biases that might bias the population estimate (Table 10). For the Adams complex, however, sampling biases may introduce a positive bias in the female estimate.

### North Thompson

The North Thompson group consists of three Early Summer Run stocks that spawn in Fennell and Harper creeks and Raft river (Fig. 9); sockeye were not observed in the North Thompson and Barrier rivers in 1998. The largest stock on the 1998 off-cycle is Fennell Creek. Escapements were estimated visually from six surveys in Fennell Creek and Raft River and two surveys in Harper Creek (Appendix 10).

The 1998 North Thompson group escapement of 15,948 adults and 31 jacks comprises <1% and 1% of the Fraser River total (Table 13). The adult escapement doubled from the 1994 brood year (Fig. 9), largely a result of the increase in Raft River from 1,700 to 7,200. Average spawning success (93%; range 93%-100%) declined from the brood year (98%; range 96%-99%) (Appendix 11).

The North Thompson group was assessed using visual techniques. There are likely random errors of up to ±30% among the individual estimates; however, over and under estimates may off-set to produce a less biased total estimate.

### Chilcotin

The Chilcotin group consists of a Summer Run stock that spawns in the Chilko River, Chilko channel, and the north end of Chilko Lake, and three Early Summer Run stocks that spawn in Elkin Creek, Taseko Lake, and the south end of Chilko Lake (Fig. 10). Escapements of the Chilko River and Lake populations were assessed in aggregate by a mark-recapture study; consequently, it is not possible to provide separate estimates for the south lake and north lake and river populations. Elkin Creek and Taseko Lake were assessed visually; the remoteness of the areas, the difficult viewing conditions in Taseko Lake (glacial runoff), and the small expected escapements limited the assessment of these stocks to a single survey (Appendix 10).

The 1998 Chilcotin group escapement of 879,495 adults and 1,934 jacks comprises 20% and 35%, respectively, of the Fraser River total (Table 13). The adult escapement is the largest on this cycle, almost double the 1994 brood year (Fig. 10). Average spawning success (91%; range 91%-92%) declined from the brood year (97%; range 37%-100%) (Appendix 11).

Over 99% of the Chilcotin group escapement was estimated from the Chilko mark-recap-ture study. Our evaluation of sampling biases in-dicates that the population may be estimated with a small positive bias (Table 10).

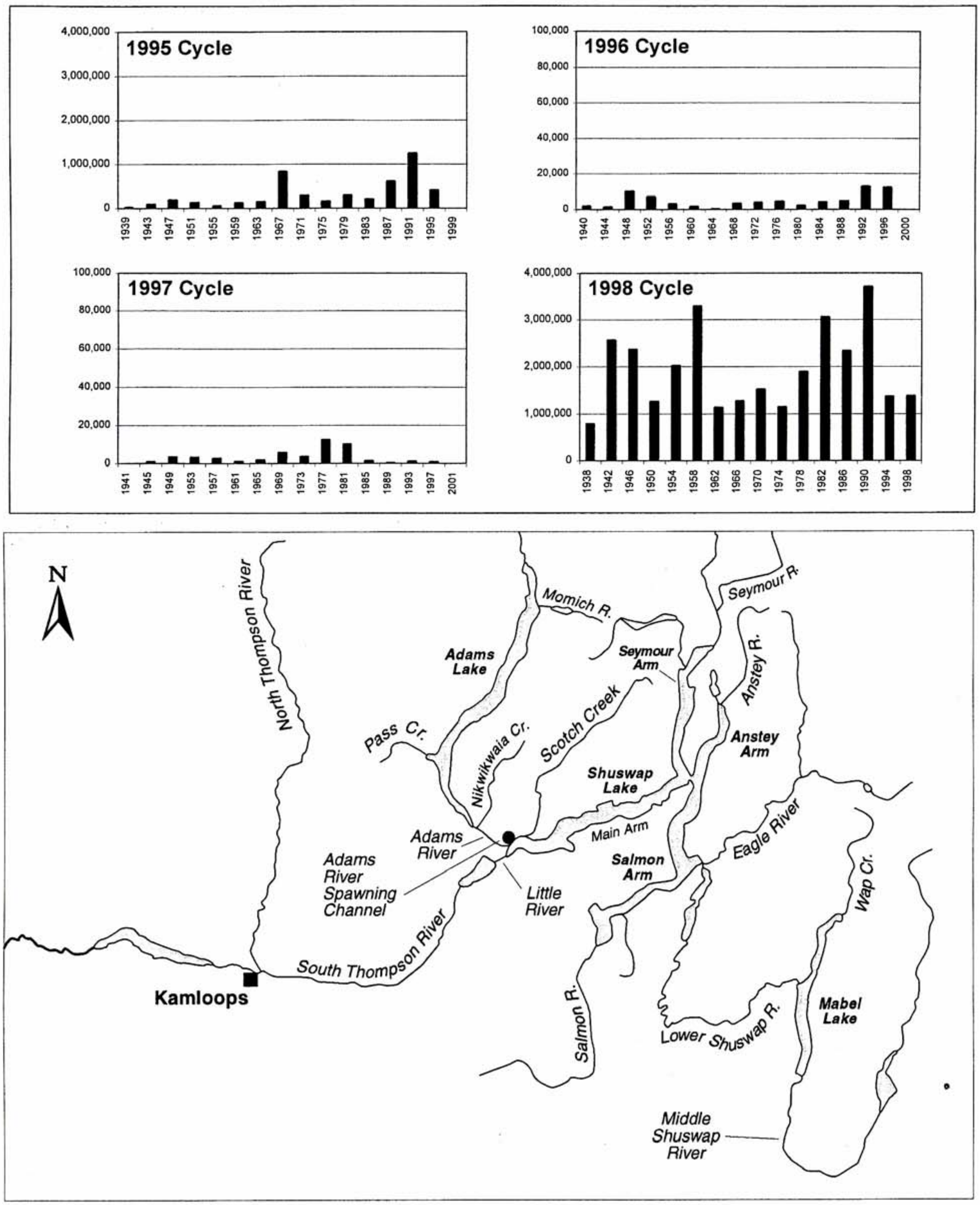


Fig. 8. Adult escapement by cycle and spawning distribution map for South Thompson Late Run sockeye salmon.

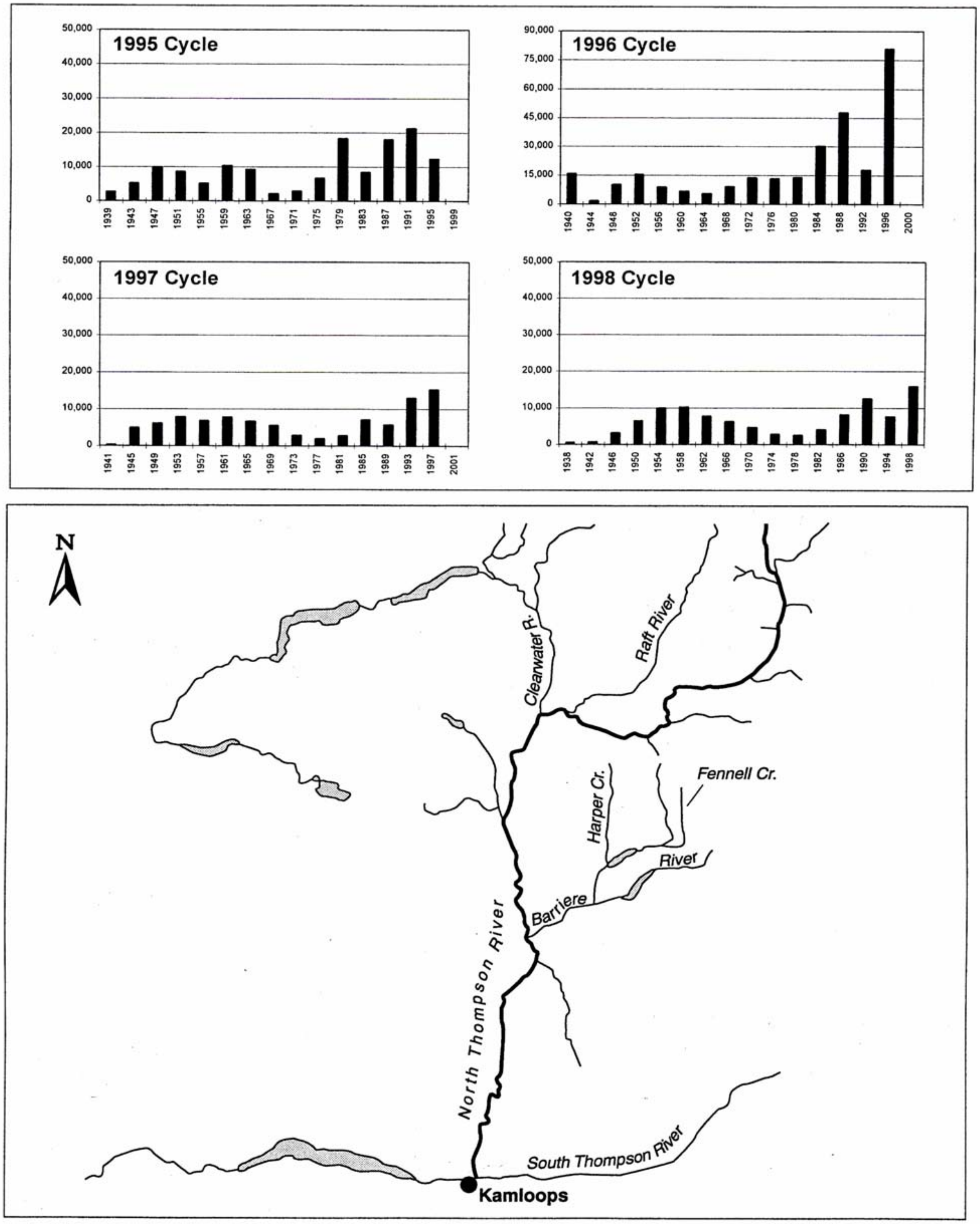


Fig. 9. Adult escapement by cycle and spawning distribution map for North Thompson sockeye salmon.

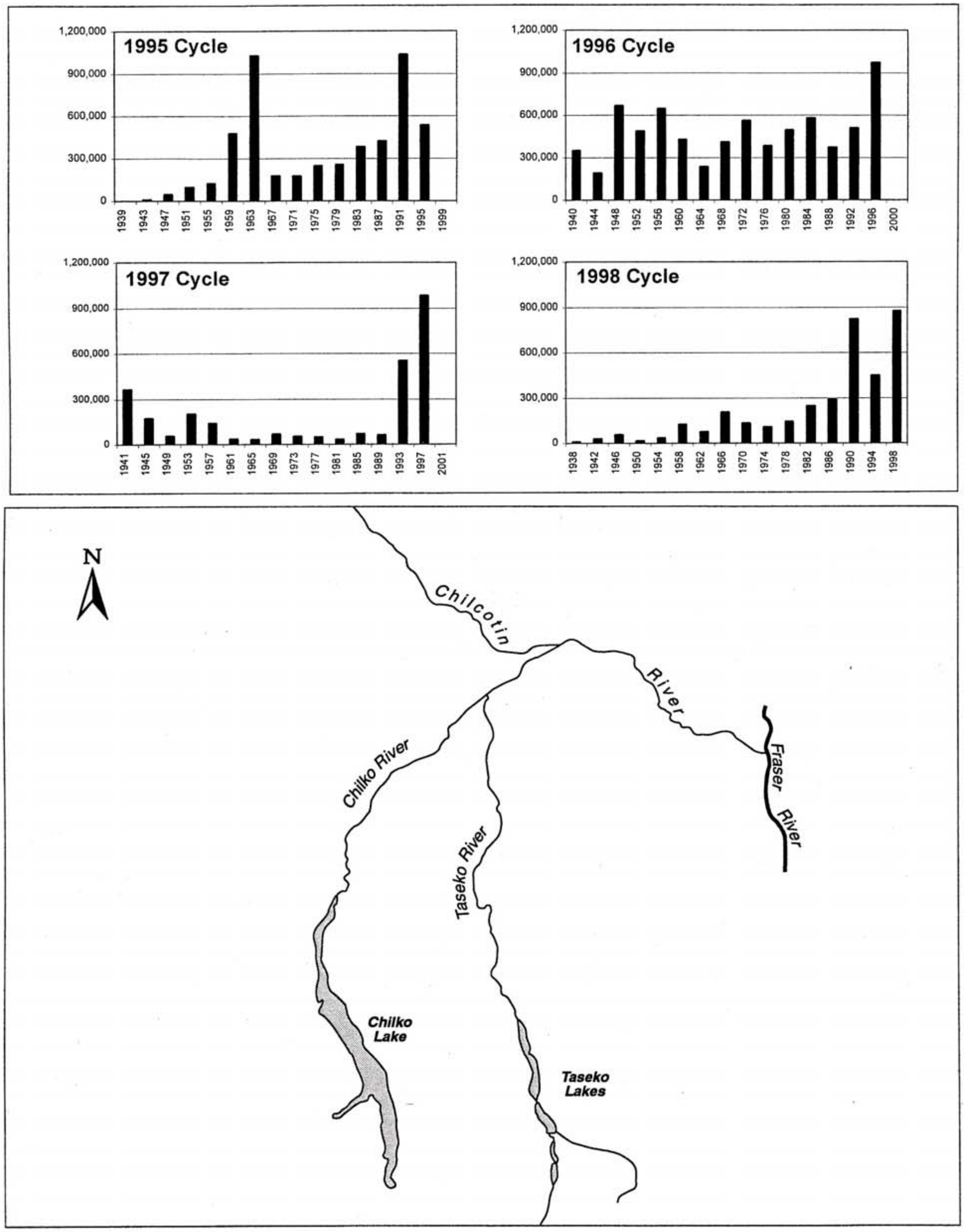


Fig. 10. Sockeye adult escapement by cycle and spawning distribution map for Chilcotin stocks.

### Quesnel

The Quesnel group consists of 47 Summer Run stocks that spawn the Horsefly River and Mitchell River systems, in smaller streams tributary to Quesnel Lake, and along the Quesnel Lake foreshore (Fig. 11). The largest stocks on the 1998 subdominant cycle spawn in the Horse-fly and Mitchell rivers and McKinley Creek. The two former stocks were assessed using mark-recapture studies; the latter was estimated at an enumeration fence (Appendix 7). The remaining stocks were surveyed visually, with 1-6 surveys per stock (Appendix 10).

The 1998 Quesnel group escapement of 1,179,252 adults (no jacks observed) comprises 27% of the Fraser River total (Table 13). The adult escapement increased by 72% from the record brood year escapement of 686,400. This continues the strong rebuilding trend on the subdominant cycle; the 1998 escapement is the largest ever observed on this cycle and the fifth largest regardless of cycle year (Fig. 11). Escapements are particularly strong in Mitchell River and Quesnel Lake, where they double and triple the brood year levels, respectively. The latter, however, likely reflects a change in survey technique. Since 1994, there has been a concerted effort to identify and assess abundance in previously undocumented spawning areas. Spawning success in the Horsefly (86%), Mitchell (94%) and Quesnel Lake (98%) systems declined from the brood year levels of 99%, 97% and 99%, respectively (Appendix 11).

The accuracy of the 1998 Quesnel escapement estimates depends largely on the Horsefly, McKinley and Mitchell estimates that comprise 97% of the total escapement. The McKinley Creek and Horsefly Channel populations were enumerated at the fences and are likely estimated with only a small negative bias. Our evaluation of sampling biases in the Horsefly and Mitchell mark-recapture estimates indicates relatively unbiased studies, although Horsefly and Mitchell males may be estimated with small negative and positive biases, respectively (Table 10). Given the relative sizes of the populations, this may introduce a small negative bias in the over-all group estimate.

### Stuart

**Early Run:** The early Stuart group consists of 38 Early Run stocks that spawn in streams tributary to the Middle River and Takla and Trembleur lakes (Fig. 12). The largest stocks on the 1998 off-cycle spawn in streams tributary to south Takla Lake (Gluske Creek) and Middle River (Forfar, Kynoch and Rossette creeks). Escapements were assessed from visual observations, with 1-14 surveys per stock (Appendix 10). The visual data were calibrated from a compari-son of visual observations and fence counts in Forfar, Gluske and Kynoch creeks (Appendix 7).

The 1998 early Stuart group escapement of 32,570 adults and 20 jacks comprises 1% and <1%, respectively, of the Fraser River total (Table 13). The adult escapement increased by 9% from the brood year escapement of 29,800, and is similar to levels reported for most previous cycle years (Fig. 12). Average spawning success (56%; range 0%-100%) declined from the brood year (93%; range 84%-100%) and is by far the lowest ever reported on this cycle (Appendix 11). Consequently, despite a female escapement (15,900) similar to the brood year (15,600), the number of effective females declined from 14,500 to 9,300. This decline is exacerbated by reduced egg fertilization success, which declined from over 90% in 1997 to slightly more than 70% in 1998 (S. MacDonald, pers. comm.). The geo-graphic distribution of the escapement shifted relative to previous cycle years. Relative to the 1994 brood year, the proportion spawning in the Takla System doubled, from 36% (10,700) to 73% (23,800), with the Driftwood System escapement increasing from 1,700 to 11,400, the largest reported on this cycle. Conversely, the proportion spawning in the Middle and Trembleur systems declined, from 45% (13,300) to 18% (5,800) and from 20% (5,900) to 9% (2,900), respectively. This distribution is similar to that observed on the dominant cycle, and may reflect the abnormal predominance of five year old sockeye in the escapement.

The 1998 Stuart early run escapement was assessed using visual surveys that were calibrated inseason within the system. The study design was well executed and likely results in relatively unbiased estimates in the streams tributary to Takla and Trembleur lakes and Middle River. We are concerned, however, that the Driftwood system was assessed using a single helicopter overflight. If the flight did not coincide with peak abundance, a negative bias of up to 8% would be introduced in the total escapement estimate,

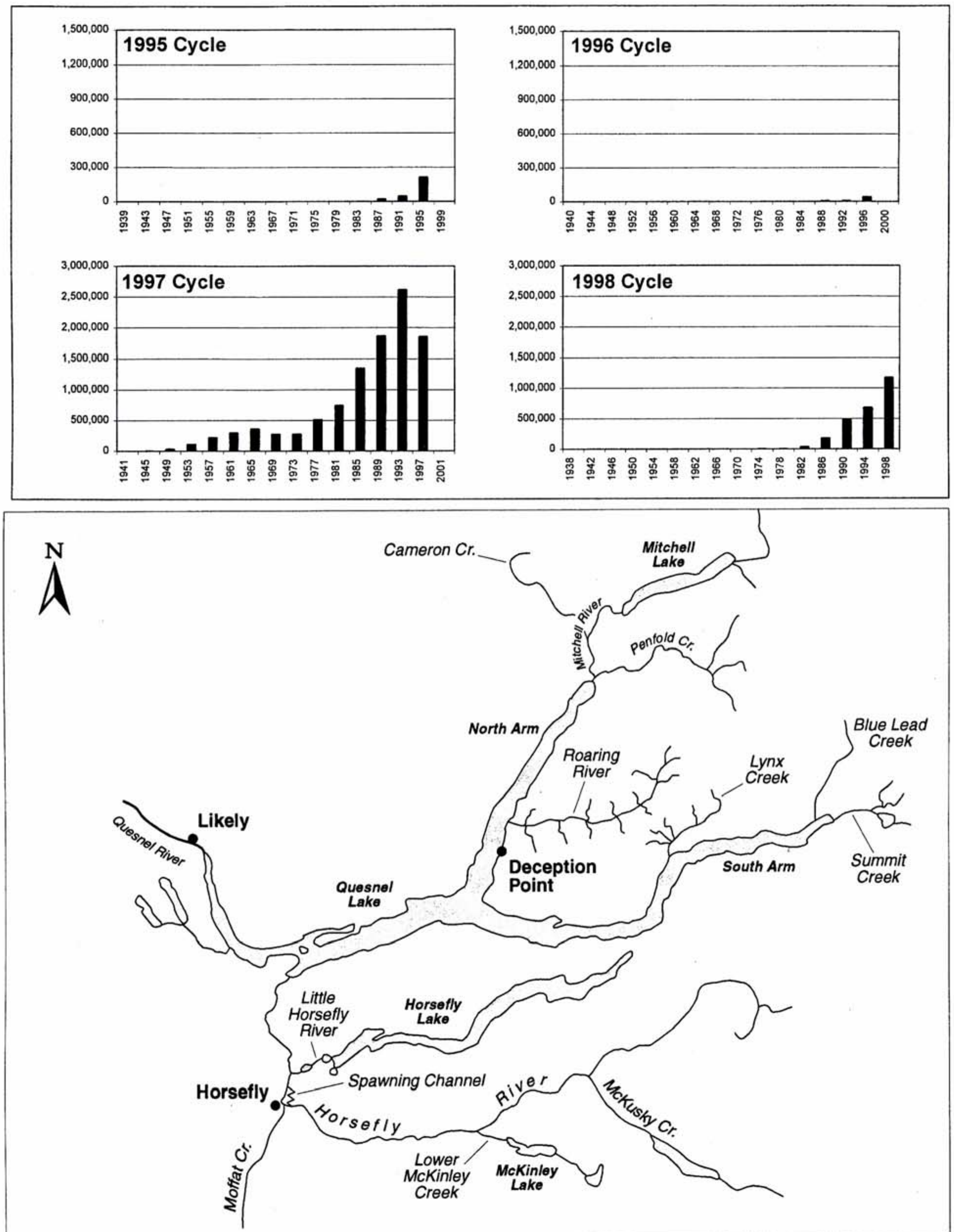


Fig. 11. Sockeye adult escapement by cycle and spawning distribution map for Quesnel stocks.

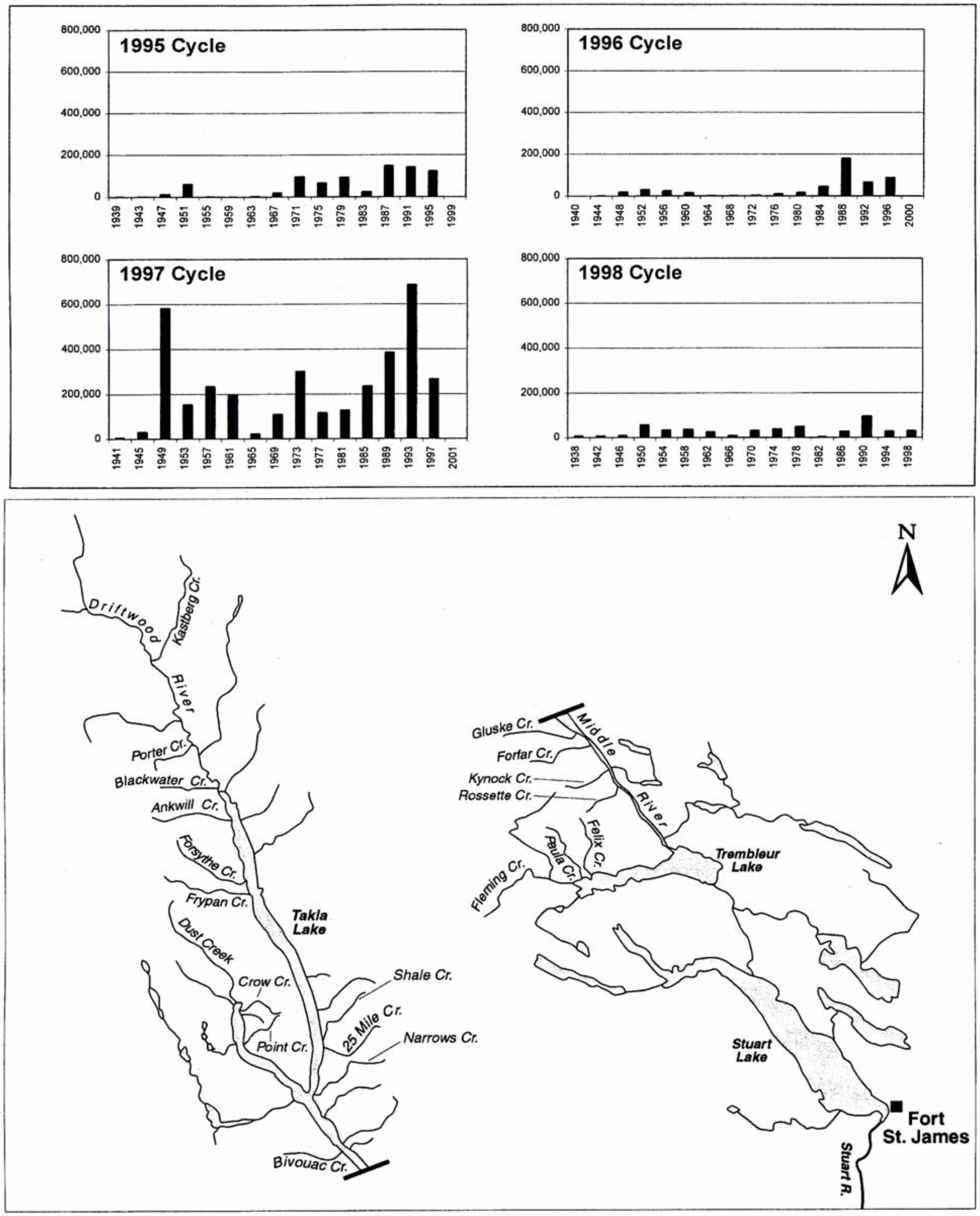


Fig. 12. Sockeye adult escapement by cycle and spawning distribution map for Stuart Early Run sockeye stocks.

**Summer Run:** The late Stuart group consists of seven stocks that spawn primarily Tachie and Middle rivers, and in several small streams tributary to Takla and Stuart lakes (Fig. 13). The largest stocks on the 1998 subdominant cycle spawn in Tachie and Middle rivers; both were assessed by mark-recapture studies. The Kuz-kwa River escapement was assessed using an enumeration fence (Appendix 7), and the re-maining stocks were assessed visually, with 3-8 surveys per stock (Appendix 10).

The 1998 late Stuart escapement of 138,397 adults and 1,024 jacks comprises 3% and 18%, respectively, of the Fraser River total (Table 13). The adult escapement increased by 78% and is the second largest reported on this cycle (Fig. 13). The increase largely reflects the Tachie River, where the escapement increased from 42,600 in 1994 to 93,000 in 1998. Average spawning success (98%; range 93%-99%) is unchanged from the brood year (98%; range 95%-100%) (Appendix 11).

Over 95% of the Stuart summer run escapement was estimated by mark-recapture studies in the Middle and Tachie rivers. Our evaluation of sampling biases indicates that, with the exception of a possible small bias among Middle River females, the studies are largely unbiased.

### Nechako

The Nechako group consists of a relatively small Early Summer Run (Nadina) and a larger Summer Run (Stellako) stock (Fig. 14). The Stel-lako was assessed at an enumeration fence (Ap-pendix 7); the Nadina Channel was censused (Appendix 8), and the Nadina River was asses-sed visually on two surveys (Appendix 10).

The 1998 Nechako group escapement of 189,346 adults and 75 jacks comprises 4% and 1%, respectively, of the Fraser River total (Table 13). The adult escapement increased by 35% (Fig. 14). The Stellako River escapement increased from 138,000 in 1994 to 185,600 in 1998, and is the largest since the record escape-ment of 245,200 in 1946. Escapement to the Nadina River also increased, from 2,000 in 1994 to 3,700 in 1998. Average spawning success (99%) is similar among stocks and higher than in the brood year (90%) (Appendix 11).

Over 99% of the escapement of this group was enumerated at a fence and in the spawning channel; consequently, its escapement is likely estimated with only a small negative bias.

### Upper Fraser

The Upper Fraser group consists of the Bowron River and tributaries (Fig. 15). Although sockeye previously have been observed spawning in the upper Fraser River and Swift Creek (L. W. Kalnin, DFO technician, pers. comm.), there is no evidence of sustained production from those areas. In 1998, the Bowron River was assessed visually on one helicopter flight (Appendix 10); the upper Bowron River was also assessed on one boat survey.

The 1998 Upper Fraser group escapement of 4,751 adults and 26 jacks comprises <1% and 1%, respectively, of the Fraser River total (Table 13). The adult escapement increased by 8% from the 1994 brood year escapement of 4,400 (Fig. 15). Average spawning success (100%) is identical to the brood year.

The Upper Fraser group was assessed using visual techniques, with a possible estimation error of up to ±30%.

## RUN TIMING GROUP

### Early Run

The Early Run consists of 38 stocks that spawn in the Stuart River system (Fig. 12). The largest stocks on the 1998 off-cycle typically spawn in streams tributary to south Takla Lake (Gluske Creek) and Middle River (Forfar, Kynoch and Rossette creeks). Escapements were esti-mated from enumeration fences in Forfar, Glus-ke and Kynoch creeks (Appendix 7) and visual surveys conducted in all streams every 1-14 days (Appendix 10). Escapement is estimated from the relationship between the visual data and the known escapement in the fenced streams. The 1998 escapements are reported in the *Stuart Early Run* section of this report and will not be repeated here.

### Early Summer Run

The Early Summer Run consists of 32 stocks that spawn throughout the Fraser River system. These stocks migrate through the lower Fraser

Ri-ver from mid July to mid August and spawn from late August to mid September. The largest stocks on the 1998 cycle are the upper Pitt River in the

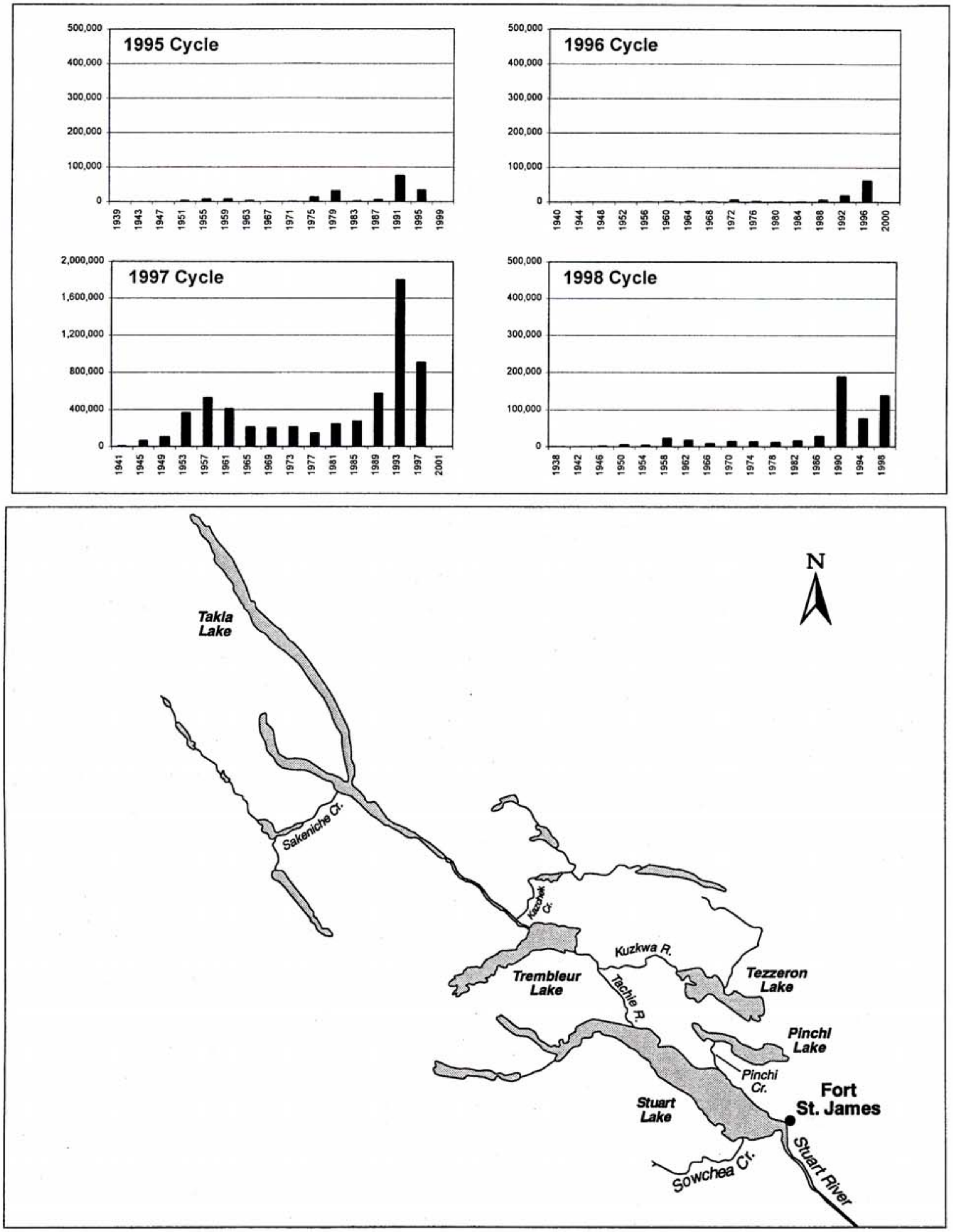


Fig. 13. Sockeye adult escapement by cycle and spawning distribution map for Stuart Summer Run sockeye stocks.

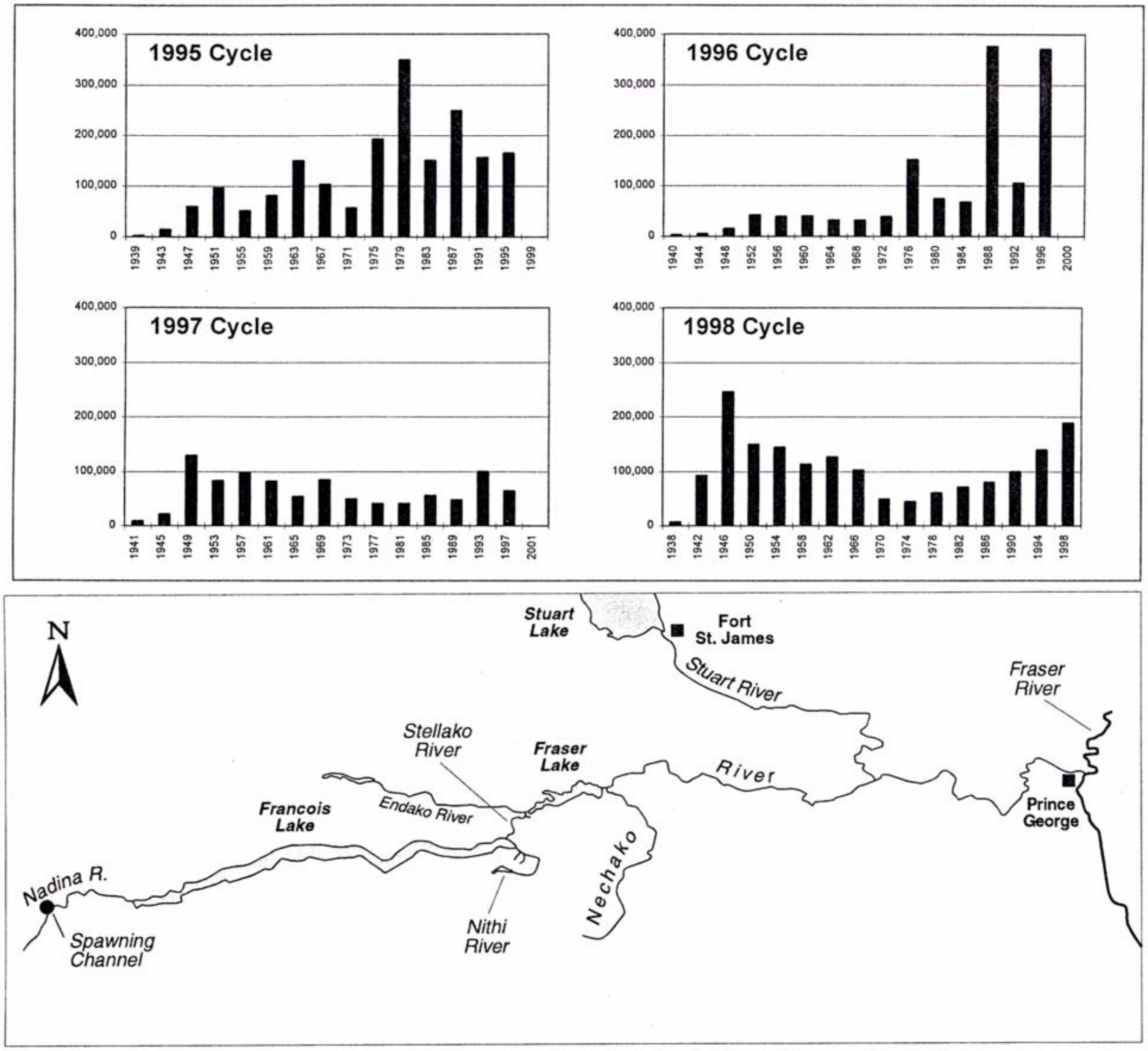


Fig. 14. Adult escapement by cycle and spawning distribution map for Nechako sockeye salmon

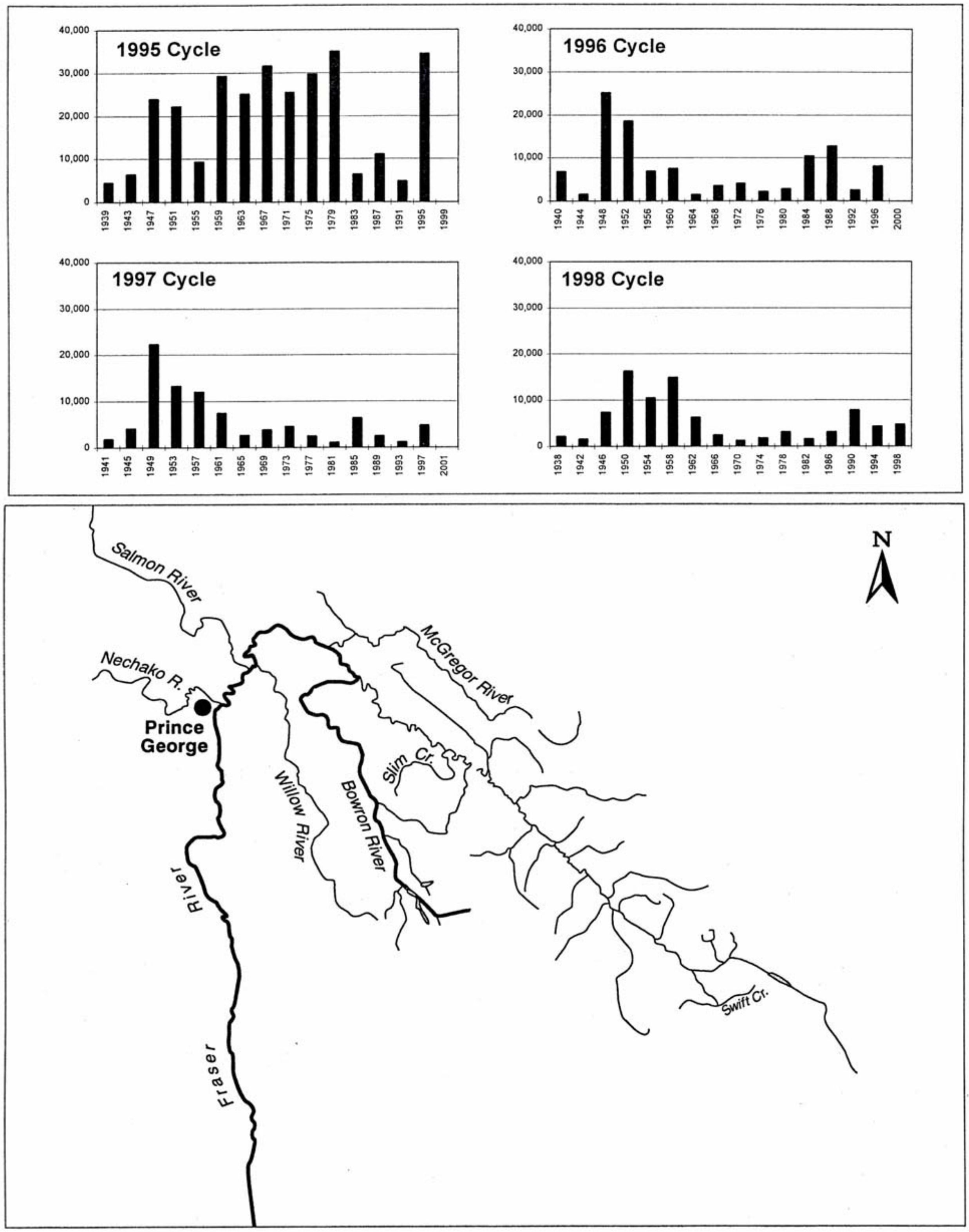


Fig. 15. Adult escapement by cycle and spawning distribution map for Upper Fraser sockeye salmon.

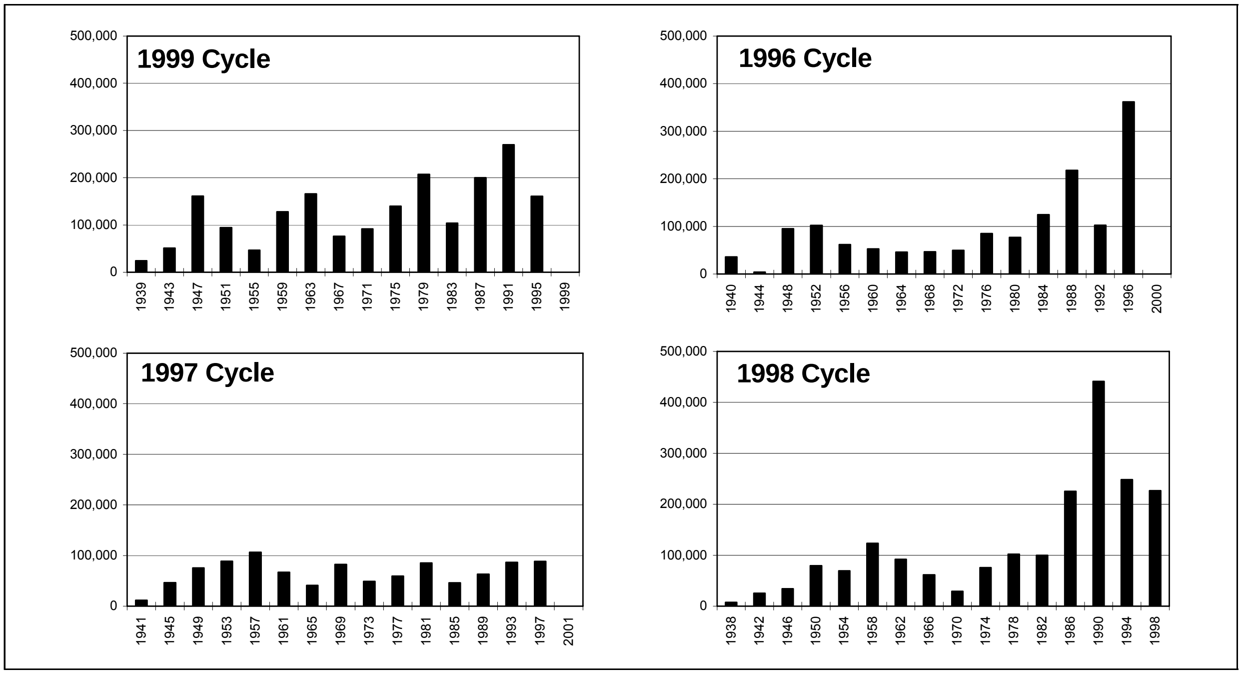


Fig. 16. Adult escapement by cycle for Early Summer Run Fraser River sockeye salmon.

Lower Fraser group, Gates in the Seton-Anderson group, Eagle and Seymour rivers and Scotch Creek in the South Thompson group, and Fennell Creek and Raft River in the North Thompson group. The escapement of all of the largest stocks except those in the North Thompson were esti-mated using either enumeration fences or mark-recapture studies; the escapement of the North Thompson and other stocks of were estimated visually.

The 1998 Early Summer Run escapement of 226,662 adults and 1,582 jacks comprises 5% and 28%, respectively, of the Fraser River total (Appendix 11). Adult escapement declined by 10% from the brood year escapement and is well below the record 1990 escapement on this cycle of 441,000 (Fig. 16); however, the escapement is the third largest on the cycle. Relative to the 1994 brood year, adult sockeye escapements increased in all areas except the South Thomp-son: in the Lower Fraser area, the upper Pitt Ri-ver escapement (76,900) is the largest on this cycle and comprises 34% of the Early Summer Run total; in the Seton-Anderson area, the Gates escapement increased from 3,400 to 7,200; in the North Thompson area, the total escapement (15,900) is the largest on this cycle; in the Ne-chako area, the Nadina escapement increased from 2,000 to 3,700; and in the Upper Fraser area, the Bowron escapement increased from 4,400 to 4,800. In contrast, escapement declined by 49% among the large dominant-cycle South Thompson stocks: the Scotch Creek escape-ment declined from 73,200 to 36,000; the Sey-mour River escapement declined from 56,200 to 33,400; and the Eagle River escapement declin-ed from 45,500 to 28,500. Spawning success averages 94% in 1998, ranging from 61% in the Gates system (where spawning success is frequently low) to up to 100% among several other stocks (Appendix 11). This is near the up-per end of the range of spawning success levels for this cycle; it occurred despite the adverse *en route* and spawning ground conditions that were reported for many of these populations. Water levels on all spawning grounds were low throughout the spawning period, obstructing access to many small creeks; extreme examples are in Ross and Onyx creeks, which remained dry through the spawning period. Water temperatures on the spawning grounds tended to be higher than normal, but not consistently so among all Early Summer Run stocks. For example, temperatures approached or exceeded 20° C in Chilliwack Lake, lower Adams, Momich, Seymour, and Raft rivers and Scotch Creek, while they typically remained below 15° C in the upper Pitt, upper Adams and Eagle rivers and

Cayenne Creek.

sessed visually.

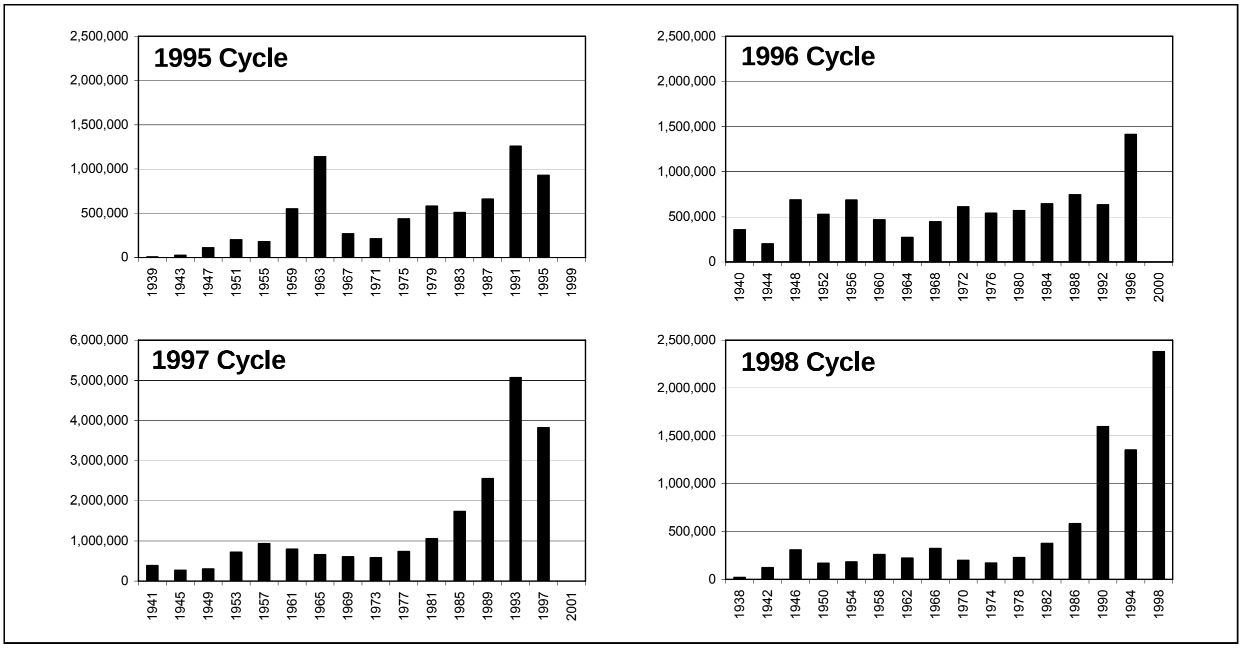


Fig. 17. Adult escapement by cycle for Summer Run Fraser River sockeye salmon.

The escapement of the Early Summer Run was intensively assessed in 1998, with mark-recapture studies on the Pitt, Eagle and Seymour rivers (61% of the estimated escapement), enumeration fences on Gates and Scotch creeks (16%), and channel counts at Gates and Nadina (5%). Assuming random error in the remaining visual estimates, the overall accuracy of the Early Summer Run group depends on the mark-recapture studies. Our evaluation of sampling biases suggests there is a potential for negative biases in the estimates for Pitt females, and Sey-mour males and females, and positive biases in the estimate for Eagle males (Table 10). Conse-quently, there is likely a small negative bias in the total escapement estimate for this group.

## Summer Run

The Summer Run consists of 57 stocks that spawn in the Chilcotin, Quesnel, Nechako and Stuart systems (Fig. 1). The escapement of the major stocks was estimated using either mark-recapture studies (Chilko, Horsefly, Mitchell, Tachie and Middle rivers) or enumeration fences (Stellako and Kuzkwa rivers and MacKinley Creek). The smaller stocks, such as Quesnel Lake foreshore and tributary spawners, were as-

The 1998 Summer Run escapement of 2,382,300 adults and 3,014 jacks comprises 54% and 53%, respectively, of the Fraser River total (Appendix 11). Adult escapements increased by 76% from the brood year escapement of 1,351,600 (Fig. 17); it is the largest escapement reported on this cycle, and the fourth largest on any cycle since 1938. Relative to the 1994 brood year, adult escapements increased in all four systems: from 451,000 to 879,500 in the Chilko System; from 686,400 to 1,179,300 in the Quesnel System; from 76,500 to 138,400 in the Stuart System; and from 138,000 to 185,600 in Stellako River. The escapements to the Chilcotin and Quesnel are records on this cycle, while the escapements to the Stellako and Stuart are the second largest on this cycle. Spawning success for Summer Run sockeye averages 91%, slightly below the long-term average of 93% on this cycle. Among the major stocks, success ranges from 75% in Mc-Kinley Creek to 99% in Middle and Stellako riv-ers, and tends to be lower among mid-Fraser (91% in Chilko; 89% in Quesnel) compared to upper Fraser (99% in Stellako; 98% in Stuart) stocks. Physical conditions in the natal areas generally reflect the unusually hot, dry weather. Water levels tended to be low throughout the spawning period, obstructing access to some smaller creeks (*e.g.,* Killdog, Devoe, Isaiah, Long, Sue, Trickle and Hazeltine creeks). Spawning ground water temperatures tended to be higher than normal, but not consistently so among all Summer Run stocks. For example, temperatures approached or exceeded 20° C in Horsefly and Stellako rivers and McKinley Creek, while they typically remained below 15° C in the Chilko, Mitchell, Tachie and Middle rivers. Chil-ko River flows and temperatures were anoma-lous among the Summer Run stocks; high flows and low temperatures reflect the increased glac-ial melt that resulted from the hot weather.

The escapement of Summer Run sockeye was intensively assessed in 1998, with mark-re-capture studies on the Chilko, Horsefly, Mitchell, Middle and Tachie rivers (86% of the estimated escapement), enumeration fences on McKinley Creek and Stellako and Kuzkwa rivers (11%), and channel counts at Horsefly (1%). The over-all accuracy of the Summer Run estimate again depends on the mark-recapture studies. Our evaluation of sampling biases suggests there is a potential for negative biases in the estimates for Horsefly males, and positive biases in the es-timate for Chilko males and females, Mitchell males and Middle females (Table 10). Conse-quently, there is likely a positive bias in the total escapement estimate for this group.

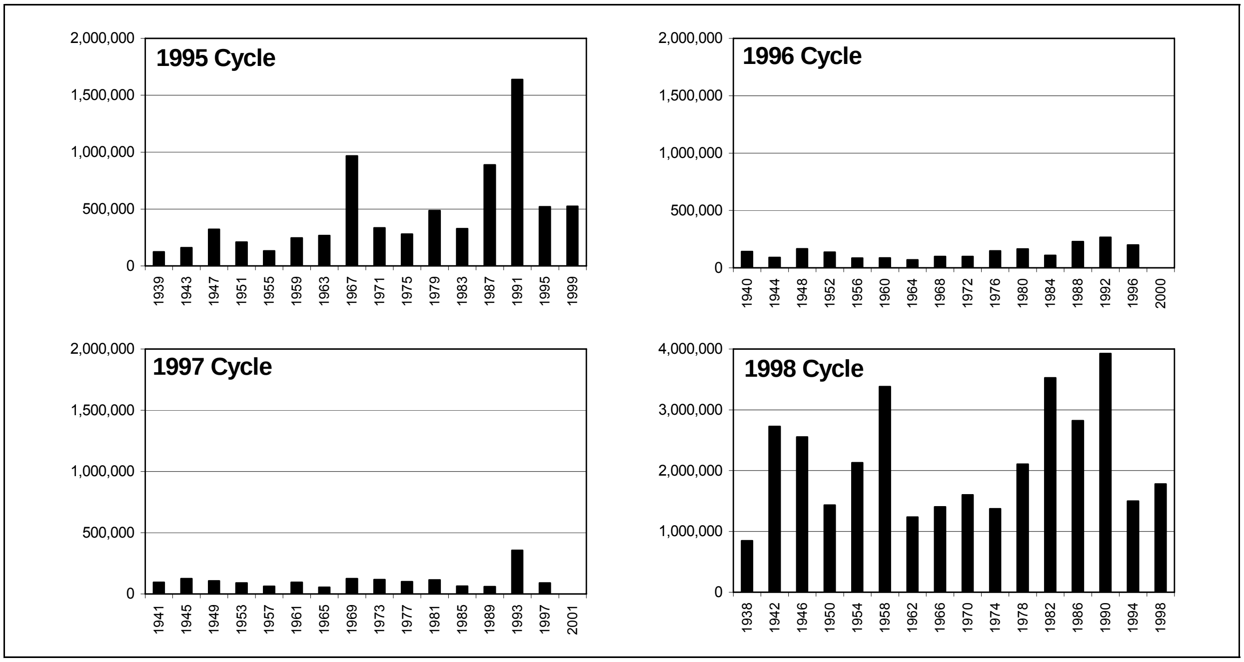


Figure 18. Adult escapement by cycle for Late Run Fraser River sockeye salmon.

**Late Run**

The Late Run consists of 52 stocks that spawn in the Lower Fraser, Harrison-Lillooet, Se-ton-Anderson and South Thompson areas. The largest stocks on the 1998 cycle are in Birken-head River and Weaver Creek in the Harrison-Lillooet group, Portage Creek in the Seton-An-derson group, and lower Adams, Little, and lower and middle Shuswap rivers in the South Thomp-son group. With the exception of Portage Creek, the escapements of the largest stocks were as-sessed by either enumeration fences or mark-recapture studies; the escapements of the re-maining stocks were estimated visually.

The Late Run escapement of 1,780,543 ad-ults and 988 jacks comprises 40% and 18%, respectively, of the Fraser River total (Appendix 11). The adult escapement increased by 19% from the brood year escapement of 1,499,000 (Fig. 18). The adult escapement is only the ninth largest on this or any cycle since 1938; the jack escapement is the second smallest on this cycle since 1938, continuing the long-term decline among jack populations. Relative to the brood year, adult escapements increased in three of the four geographic groups: from 114,400 to 364,100 in the Harrison-Lillooet; from 9,300 to 25,200 in the Seton-Anderson; and from 1,370,700 to 1,389,300 in the South Thompson. Only the adult escapement in the Lower Fraser declined, from 4,600 to 2,000, continuing the long-term decline for this group. Spawning suc-cess averages 97% in 1998, slightly above long-term average of 95% on this cycle. Among the major stocks, spawning success ranges from 91% in Weaver and Portage creeks to 96% in Adams River. Physical conditions in the natal areas were generally good; only the Adams Ri-ver and a few smaller streams exceeded 15° C for extended periods.

The escapement of Late Run sockeye was also intensively assessed, with mark-recapture studies on Birkenhead, Weaver, Adams, Little, and Shuswap rivers (95% of the estimated es-capement), enumeration fences on Sweltzer, Eagle and Salmon rivers (1%), and channel counts at Weaver (2%). The accuracy of the Late Run estimate again depends on the mark-recapture studies. Our evaluation of sampling biases suggests there is a potential for negative bias in the estimate for Weaver females, and positive biases in the estimates for Birkenhead males and females, Weaver males, and Adams females (Table 10). While the potential biases off-set each other to some extent, the relative size of the Adams and Birkenhead escapements indicates there is likely a positive bias in the total escapement estimate for this group.

## CONCLUSIONS

*1. Estimation Biases:* It is not possible to quanti-fy the magnitude of bias (*i.e*. the accuracy) of the 1998 Fraser River sockeye escapement estimat-es. Instead, we focus on identifying probable bi-ases in each of the survey techniques in order to provide a qualitative estimate of the direction of the overall bias in the estimates for specific popu-lations as well as geographic and run timing ag-gregates. We note that understanding the poten-tial biases in the mark-recapture technique is criti-cal because it is used to estimate a large propor-tion of the total system-wide escapement. New study designs and improved study design ex-ecution have substantially reduced biases. New analytic tools, including complementary two-sam-ple stratifications to investigate bias, have also improved the reliability of the technique; however, the approach needs refinement to make it study-specific and to permit the quantification of results.

*2. Mark-Recapture Studies*: We use a three step process to evaluate potential bias in the mark-recapture estimates; an evaluation of: a) study design execution; b) biases in complementary two-sample data stratifications; and c) differences in the maximum likelihood Darroch and pooled Petersen estimates. In our evaluation of (a), we conclude that the studies were well designed and executed in 1998 and incorporated substantial improvements over recent years. Despite defic-iencies in the Eagle and Pitt studies, there were no overall problems in the implementation of the studies that are likely to introduce serious bias in the overall estimates.

In our evaluation of (b), we note the potential for bi-directional (both positive and negative) bi-ases in the population estimates. This is incon-sistent with the traditional bias structure in mark-recapture studies where positive biases are com-mon. Evidence from the Stellako River study in-dicates that positive biases likely result from a de-creasing probability of tagging with distance up-stream coupled with a complementary increasing probability of recovery. We conclude that study design changes since 1994 that make tag inci-dence spatially more representative have chang-ed the bias structure of the estimates. This has important implications to the overall bias structure of the annual management-assessment process.

In our evaluation of (c), we conclude that a comparison of MLE and PPE estimates provides an indication of the direction of possible error in the PPE but overstates its magnitude. We fur-ther conclude that the magnitude of the bias in the mark-recapture studies is not quantifiable but, because the biases across studies are bi-direc-tional, their overall magnitude is likely to be small. Because mark-recapture studies were used to estimate 87% of the escapement, bias in the total escapement is also likely to be small.

*3. Enumeration Fences and Visual Surveys*: Potential biases in the estimates generated from the enumeration fences and visual surveys are small. The enumeration fence studies were well executed and provide estimates of population size that are unlikely to have negative biases as large as 5%. Similarly, while the individual visual survey estimates are prone to errors of ±30%, central tendency among a wide range of positive and negative errors in the 144 estimates is likely to li-mit the overall biases in total. The exceptions are the Driftwood, Portage, Harrison and South Thompson, where inadequate study designs or poor survey conditions are likely to result in substantial underestimates. We note, however, that the likely impact of these biases is small given that only 4% of the escapement is estimated using this technique.

*5. Stress Effects*: Despite record high water temperatures on the migratory route and in some natal areas, we do not identify a clear pattern of stress effects in any population with the exception of the early Stuart, a population that undertook one of the longest riverine migrations at a time when the temperature deviations from normal were greatest. While we acknowledge that *en route* conditions certainly resulted in physiological stress and mortality in other populations, we conclude that these conditions are unlikely to have changed the behaviour of the fish that were able to reach the spawning grounds to an extent that would introduce significant biases in the population estimates.

**ACKNOWLEDGEMENTS**

The analyses presented in this report are generated as part of a standard post-season process that has been developed by Fraser River stock assessment staff since 1994. In 1998, there was considerable concern among management agencies and stakeholders when a smaller than expected number of sockeye reach-ed the spawning grounds. Consequently, the post-season analyses and report was reviewed by an *ad hoc* group, termed the Spawning Escapement Estimation Working Group, formed by the Pacific Salmon Commission (PSC). The Working Group consisted of the authors as well as Al Cass (Pacific Biological Station), Jim Cave (PSC) and Mike Galesloot (Shuswap Nation Fisheries Commission). Their review comments greatly improved the quality of the final report.

The 1998 projects were conducted under the direction of Lanny Kalnin. The individual field projects were conducted under the direction of Brad Fanos, Ken Peters and Garry Zwack. The field crews were supervised by Ian Barnes, Rob Bemister, Keri Benner, Garry Boak, Richard Ger-ard, Dennis Klassen, Colin Nettles, Tony Rath-bone, Rick Remple, Greg Schuler, Rob Tadey, Jason Wiebe and Bill Wyett. Data entry and verification was conducted under the direction of Tracy Cone. XY3 Graphics provided the maps.

Crew members for the 1998 sockeye studies included: T. Abbott, L. Anderson, R. Armstrong, P. Arnouse, L. Beron, C. Bland, M. Bloudell, O. Brockwell Jr., C. Brooks, S. Brown, L. Candall, W. Chandler, M. Chimenti, E. Cohen, W. Dale, L. Davidson, B.Davis, C. Elwick, J. Evans, T. Ewanyshyn, S. Fancy, J. Gagnon, A. Gignac, K. Gray, E. Hansen, W. Harbridge, D. Hicks, C. Huska, P. Janos, S. Janzen, R. Joseph, D. Jarvis, N. John, C. Kirkpatrick, D. Klassen, R. Lapointe, W. Leveque, C. Locke, D. MacDonald, R. McBurney, M. McIntyre, M. McMyn, J. Mahoney, J. Mann, S. Markin, H. Melnichuk, J. Meyers, H. Moore, L. Myer, H. Narcisse, A. Nelson, J. Paddison, T. Pariler, C. Parken, D. Pearson, J. Peters, T. Peterson, L. Philpot, M. Prevost, H. Pulvermacher, B. Qudman, J. Raume, L. Richie, C. Ridley, E. Robinson, B. Sampo-gna, T. Smith, B. Solonas, R. Tadey, N. Vivian, T. Welch, F. Wells, J. Wideman, K. Wiebe, C. Williams, G. Witzky, M. Wyeth, and B. Zis-serson. Data entry and preliminary analyses were conducted by K. Benner, B. Klassen and G. Schuler.

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# APPENDICES

Appendix 1. Results of statistical tests for sampling bias in Fraser River sockeye mark-recapture studies, 1995-1998. *Bias* indicates a significant chi-square test result ($p < 0.05$), except Kolmogorov-Smirnov 2-sample test used for size.

| | | 1995 | | 1996 | | 1997 | | 1998 | |
|---|---|---|---|---|---|---|---|---|---|
| Study | Test type | Male | Female | Male | Female | Male | Female | Male | Female |
| Pitt | *Application* | - | - | No bias | No bias | Bias | Bias | No bias | Bias |
| | Temporal | - | - | Bias | Bias | No bias | No bias | No bias | Bias |
| | Spatial | - | - | Bias | Bias | No bias | No bias | No bias | No bias |
| | Sex | - | - | | | | | | |
| | *Recovery* | | | | | | | | |
| | Temporal | - | - | Bias | Bias | No bias | Bias | No bias | Bias |
| | Spatial | - | - | Bias | Bias | No bias | Bias | ? | ? |
| | Sex | - | - | No bias | No bias | No bias | No bias | No bias | No bias |
| | Size | - | - | Bias | Bias | No bias | Bias | No bias | Bias |
| Birkenhead | *Application* | | | | | | | | |
| | Temporal | Bias | Bias | Bias | Bias | No bias | No bias | Bias | Bias |
| | Spatial | Bias | Bias | Bias | Bias | No bias | No bias | No bias | Bias |
| | Sex | No bias | Bias | No bias | No bias | No bias | No bias | No bias | No bias |
| | *Recovery* | | | | | | | | |
| | Temporal | Bias | No bias | Bias | Bias | No bias | No bias | No bias | No bias |
| | Spatial | No bias | No bias | No bias | No bias | No bias | No bias | Bias | No bias |
| | Sex | No bias | Bias | Bias | Bias | No bias | No bias | Bias | No bias |
| | Size | Bias | No bias | Bias | No bias | No bias | Bias | No bias | No bias |
| Weaver | *Application* | | | | | | | | |
| | Temporal | - | - | n/a | n/a | - | - | Bias | Bias |
| | Spatial | - | - | n/a | n/a | - | - | No bias | No bias |
| | Sex | - | - | n/a | n/a | - | - | No bias | No bias |
| | *Recovery* | | | | | | | | |
| | Temporal | - | - | n/a | n/a | - | - | Bias | Bias |
| | Spatial | - | - | n/a | n/a | - | - | ? | ? |
| | Sex | - | - | n/a | n/a | - | - | Bias | Bias |
| | Size | - | - | n/a | n/a | - | - | No bias | No bias |
| Adams | *Application* | | | | | | | | |
| | Temporal | Bias | No bias | - | - | - | - | Bias | Bias |
| | Spatial | No bias | Bias | - | - | - | - | Bias | Bias |
| | Sex | No bias | No bias | - | - | - | - | No bias | No bias |
| | *Recovery* | | | | | | | | |
| | Temporal | No bias | Bias | - | - | - | - | No bias | Bias |
| | Spatial | Bias | Bias | - | - | - | - | Bias | Bias |
| | Sex | No bias | No bias | - | - | - | - | No bias | No bias |
| | Size | No bias | No bias | - | - | - | - | No bias | No bias |
| Eagle | *Application* | | | | | | | | |
| | Temporal | - | - | - | - | - | - | No bias | No bias |
| | Spatial | - | - | - | - | - | - | No bias | No bias |
| | Sex | - | - | - | - | - | - | No bias | No bias |
| | *Recovery* | | | | | | | | |
| | Temporal | - | - | - | - | - | - | No bias | No bias |
| | Spatial | - | - | - | - | - | - | No bias | No bias |
| | Sex | - | - | - | - | - | - | No bias | No bias |
| | Size | - | - | - | - | - | - | No bias | No bias |
| Seymour | *Application* | | | | | | | | |
| | Temporal | No bias | No bias | - | - | - | - | No bias | No bias |
| | Spatial | Bias | Bias | - | - | - | - | No bias | No bias |
| | Sex | Bias | No bias | - | - | - | - | No bias | No bias |
| | *Recovery* | | | | | | | | |
| | Temporal | Bias | Bias | - | - | - | - | Bias | No bias |
| | Spatial | Bias | No bias | - | - | - | - | ? | ? |
| | Sex | No bias | No bias | - | - | - | - | No bias | No bias |
| | Size | No bias | No bias | - | - | - | - | No bias | No bias |

Continued

Appendix 1. Results of statistical tests for sampling bias in Fraser River sockeye mark-recapture studies, 1995-1998. *Bias* indicates a significant chi-square test result ($p < 0.05$), except Kolmogorov-Smirnov 2-sample test used for size.

| | | 1995 | | 1996 | | 1997 | | 1998 | |
|---|---|---|---|---|---|---|---|---|---|
| Study | Test type | Male | Female | Male | Female | Male | Female | Male | Female |
| Chilko | *Application* | | | | | | | | |
| | Temporal | Bias | Bias | n/a | n/a | n/a | n/a | No bias | Bias |
| | Spatial | No bias | No bias | n/a | n/a | n/a | n/a | No bias | No bias |
| | Sex | Bias | Bias | n/a | n/a | n/a | n/a | No bias | No bias |
| | *Recovery* | | | | | | | | |
| | Temporal | No bias | Bias | n/a | n/a | n/a | n/a | Bias | Bias |
| | Spatial | ? | ? | n/a | n/a | n/a | n/a | ? | ? |
| | Sex | No bias | No bias | n/a | n/a | n/a | n/a | Bias | No bias |
| | Size | Bias | Bias | n/a | n/a | n/a | n/a | No bias | No bias |
| Horsefly | *Application* | | | | | | | | |
| | Temporal | Bias | Bias | - | - | Bias | Bias | No bias | Bias |
| | Spatial | Bias | No bias | - | - | No bias | Bias | Bias | Bias |
| | Sex | No bias | No bias | - | - | No bias | No bias | Bias | Bias |
| | *Recovery* | | | | | | | | |
| | Temporal | No bias | Bias | - | - | Bias | Bias | Bias | No bias |
| | Spatial | ? | ? | - | - | ? | ? | ? | ? |
| | Sex | No bias | No bias | - | - | Bias | Bias | No bias | No bias |
| | Size | No bias | No bias | - | - | Bias | No bias | No bias | No bias |
| Mitchell | *Application* | | | | | | | | |
| | Temporal | - | - | - | - | Bias | Bias | Bias | Bias |
| | Spatial | - | - | - | - | Bias | No bias | Bias | No bias |
| | Sex | - | - | - | - | Bias | Bias | No bias | No bias |
| | *Recovery* | | | | | | | | |
| | Temporal | - | - | - | - | No bias | No bias | No bias | No bias |
| | Spatial | - | - | - | - | No bias | No bias | ? | ? |
| | Sex | - | - | - | - | No bias | No bias | No bias | No bias |
| | Size | - | - | - | - | No bias | No bias | No bias | No bias |
| Middle | *Application* | | | | | | | | |
| | Temporal | - | - | - | - | n/a | n/a | No bias | Bias |
| | Spatial | - | - | - | - | n/a | n/a | Bias | Bias |
| | Sex | - | - | - | - | n/a | n/a | No bias | No bias |
| | *Recovery* | | | | | | | | |
| | Temporal | - | - | - | - | n/a | n/a | No bias | No bias |
| | Spatial | - | - | - | - | n/a | n/a | No bias | No bias |
| | Sex | - | - | - | - | n/a | n/a | No bias | No bias |
| | Size | - | - | - | - | n/a | n/a | No bias | No bias |
| Tachie | *Application* | | | | | | | | |
| | Temporal | - | - | - | - | No bias | No bias | No bias | No bias |
| | Spatial | - | - | - | - | Bias | No bias | No bias | No bias |
| | Sex | - | - | - | - | Bias | Bias | No bias | No bias |
| | *Recovery* | | | | | | | | |
| | Temporal | - | - | - | - | Bias | Bias | No bias | No bias |
| | Spatial | - | - | - | - | Bias | No bias | No bias | No bias |
| | Sex | - | - | - | - | Bias | Bias | No bias | No bias |
| | Size | - | - | - | - | No bias | No bias | No bias | No bias |

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Adams study area: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 1,031 | 1 | 0.1% | 63 | 6.1% | 233 | 12.5 | 0.3 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 4,189 | 10 | 0.2% | 190 | 4.5% | 623 | 12.3 | 0.2 | | | |
| Standard | 1994 | 4,784 | 1 | 0.0% | 407 | 8.5% | 964 | 12.8 | 0.4 | | | |
| | 1995 | 1,097 | 1 | 0.1% | 62 | 5.7% | 210 | 12.9 | 0.3 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 4,784 | 1 | 0.0% | 407 | 8.5% | 964 | 12.8 | 0.4 | 2 | 0.2% | 99.5% |
| | 1995 | 2,128 | 2 | 0.1% | 125 | 5.9% | 443 | 12.7 | 0.3 | 14 | 3.2% | 93.7% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 91.5% |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 94.7% |
| | 1998 | 4,189 | 10 | 0.2% | 190 | 4.5% | 623 | 12.3 | 0.2 | 5 | 0.8% | 97.7% |
| *Adams study area: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 1,201 | 1 | 0.1% | 101 | 8.4% | 230 | 13.2 | 0.3 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 4,941 | 13 | 0.3% | 242 | 4.9% | 787 | 13.3 | 0.2 | | | |
| Standard | 1994 | 5,430 | 6 | 0.1% | 656 | 12.1% | 1,099 | 14.7 | 0.4 | | | |
| | 1995 | 1,132 | 1 | 0.1% | 79 | 7.0% | 242 | 16.1 | 2.3 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 5,430 | 6 | 0.1% | 656 | 12.1% | 1,099 | 14.7 | 0.4 | 6 | 0.5% | - |
| | 1995 | 2,333 | 2 | 0.1% | 180 | 7.7% | 472 | 14.7 | 1.6 | 23 | 4.9% | - |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1998 | 4,941 | 13 | 0.3% | 242 | 4.9% | 787 | 13.3 | 0.2 | 14 | 1.8% | - |
| *Adams study area: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 10,214 | 7 | 0.1% | 1,063 | 10.4% | 2,063 | 13.8 | 0.4 | 8 | 0.4% | 99.5% |
| | 1995 | 4,461 | 4 | 0.1% | 305 | 6.8% | 915 | 13.7 | 1.2 | 37 | 4.0% | 93.7% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 91.5% |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 94.7% |
| | 1998 | 9,130 | 23 | 0.3% | 432 | 4.7% | 1,410 | 12.8 | 0.2 | 19 | 1.3% | 97.7% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Birkenhead River: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 458 | 0 | 0.0% | 37 | 8.1% | 179 | 15.3 | 0.4 | | | |
| | 1996 | 901 | 2 | 0.2% | 147 | 16.3% | 294 | 19.3 | 0.3 | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 1,609 | 4 | 0.2% | 49 | 3.0% | 412 | 21.1 | 0.3 | | | |
| Standard | 1994 | 1,060 | 14 | 1.3% | 98 | 9.2% | 270 | 17.1 | 0.3 | | | |
| | 1995 | 453 | 0 | 0.0% | 40 | 8.8% | 182 | 15.1 | 0.4 | | | |
| | 1996 | 845 | 0 | 0.0% | 171 | 20.2% | 270 | 19.5 | 0.4 | | | |
| | 1997 | 1,252 | 9 | 0.7% | 229 | 18.3% | 180 | 21.1 | 0.5 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 1,060 | 14 | 1.3% | 98 | 9.2% | 270 | 17.1 | 0.3 | 0 | 0.0% | 99.8% |
| | 1995 | 911 | 0 | 0.0% | 77 | 8.5% | 361 | 15.2 | 0.4 | 4 | 1.1% | 92.0% |
| | 1996 | 1,746 | 2 | 0.1% | 318 | 18.2% | 564 | 19.4 | 0.3 | 3 | 0.5% | 91.9% |
| | 1997 | 1,252 | 9 | 0.7% | 229 | 18.3% | 180 | 21.1 | 0.5 | 2 | 1.1% | 94.8% |
| | 1998 | 1,609 | 4 | 0.2% | 49 | 3.0% | 412 | 21.1 | 0.3 | 1 | 0.2% | 95.4% |
| *Birkenhead River: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 351 | 0 | 0.0% | 32 | 9.1% | 96 | 17.2 | 0.7 | | | |
| | 1996 | 746 | 1 | 0.1% | 131 | 17.6% | 217 | 18.8 | 0.4 | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 1,232 | 3 | 0.2% | 51 | 4.1% | 383 | 22.1 | 0.3 | | | |
| Standard | 1994 | 729 | 16 | 2.2% | 72 | 9.9% | 150 | 18.1 | 0.4 | | | |
| | 1995 | 382 | 0 | 0.0% | 44 | 11.5% | 121 | 16.8 | 0.5 | | | |
| | 1996 | 841 | 2 | 0.2% | 165 | 19.6% | 219 | 19.0 | 0.3 | | | |
| | 1997 | 1,466 | 23 | 1.6% | 289 | 19.7% | 227 | 22.1 | 0.4 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 729 | 16 | 2.2% | 72 | 9.9% | 150 | 18.1 | 0.4 | 0 | 0.0% | - |
| | 1995 | 733 | 0 | 0.0% | 76 | 10.4% | 217 | 17.0 | 0.6 | 7 | 3.2% | - |
| | 1996 | 1,587 | 3 | 0.2% | 296 | 18.7% | 436 | 18.9 | 0.4 | 3 | 0.7% | - |
| | 1997 | 1,466 | 23 | 1.6% | 289 | 19.7% | 227 | 22.1 | 0.4 | 3 | 1.3% | - |
| | 1998 | 1,232 | 3 | 0.2% | 51 | 4.1% | 383 | 22.1 | 0.3 | 0 | 0.0% | - |
| *Birkenhead River: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 1,789 | 30 | 1.7% | 170 | 9.5% | 420 | 17.5 | 0.3 | 0 | 0.0% | 99.8% |
| | 1995 | 1,644 | 0 | 0.0% | 153 | 9.3% | 578 | 15.9 | 0.5 | 11 | 1.9% | 92.0% |
| | 1996 | 3,333 | 5 | 0.2% | 614 | 18.4% | 1,000 | 19.2 | 0.4 | 6 | 0.6% | 91.9% |
| | 1997 | 2,718 | 32 | 1.2% | 518 | 19.1% | 407 | 21.7 | 0.5 | 5 | 1.2% | 94.8% |
| | 1998 | 2,841 | 7 | 0.2% | 100 | 3.5% | 795 | 21.5 | 0.3 | 1 | 0.1% | 95.4% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Chilko System: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 1,319 | 0 | 0.0% | 0 | 0.0% | 383 | 31.8 | 0.4 | | | |
| | 1996 | 3,053 | 1 | 0.0% | 15 | 0.5% | 712 | 32.1 | 0.3 | | | |
| | 1997 | 2,955 | 13 | 0.4% | 3 | 0.1% | 453 | 27.5 | 0.4 | | | |
| | 1998 | 3,765 | 45 | 1.2% | 9 | 0.2% | 843 | 31.7 | 0.3 | | | |
| Standard | 1994 | 2,075 | 9 | 0.4% | 4 | 0.2% | 473 | 28.8 | 0.3 | | | |
| | 1995 | 1,380 | 2 | 0.1% | 0 | 0.0% | 419 | 31.6 | 0.3 | | | |
| | 1996 | 3,064 | 5 | 0.2% | 22 | 0.7% | 638 | 32.6 | 0.3 | | | |
| | 1997 | 3,309 | 25 | 0.8% | 27 | 0.8% | 528 | 27.2 | 0.4 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 2,075 | 9 | 0.4% | 4 | 0.2% | 473 | 28.8 | 0.3 | 3 | 0.6% | 97.1% |
| | 1995 | 2,699 | 2 | 0.1% | 0 | 0.0% | 802 | 31.7 | 0.3 | 0 | 0.0% | 93.5% |
| | 1996 | 6,117 | 6 | 0.1% | 37 | 0.6% | 1,350 | 32.3 | 0.3 | 1 | 0.1% | 94.8% |
| | 1997 | 6,264 | 38 | 0.6% | 30 | 0.5% | 981 | 27.3 | 0.4 | 4 | 0.4% | 91.5% |
| | 1998 | 3,765 | 45 | 1.2% | 9 | 0.2% | 843 | 31.7 | 0.3 | 3 | 0.4% | 92.2% |
| *Chilko System: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 869 | 0 | 0.0% | 0 | 0.0% | 294 | 31.1 | 0.4 | | | |
| | 1996 | 2,581 | 0 | 0.0% | 16 | 0.6% | 647 | 31.9 | 0.3 | | | |
| | 1997 | 2,401 | 6 | 0.2% | 11 | 0.5% | 329 | 27.0 | 0.5 | | | |
| | 1998 | 3,109 | 23 | 0.7% | 12 | 0.4% | 724 | 31.5 | 0.3 | | | |
| Standard | 1994 | 1,512 | 5 | 0.3% | 0 | 0.0% | 286 | 28.2 | 0.4 | | | |
| | 1995 | 817 | 3 | 0.4% | 0 | 0.0% | 279 | 31.7 | 0.4 | | | |
| | 1996 | 2,627 | 0 | 0.0% | 15 | 0.6% | 677 | 31.8 | 0.3 | | | |
| | 1997 | 2,364 | 9 | 0.4% | 8 | 0.3% | 357 | 27.4 | 0.5 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 1,512 | 5 | 0.3% | 0 | 0.0% | 286 | 28.2 | 0.4 | 0 | 0.0% | - |
| | 1995 | 1,686 | 3 | 0.2% | 0 | 0.0% | 573 | 31.4 | 0.4 | 1 | 0.2% | - |
| | 1996 | 5,208 | 0 | 0.0% | 31 | 0.6% | 1,324 | 31.9 | 0.3 | 0 | 0.0% | - |
| | 1997 | 4,765 | 15 | 0.3% | 19 | 0.4% | 686 | 27.2 | 0.5 | 0 | 0.0% | - |
| | 1998 | 3,109 | 23 | 0.7% | 12 | 0.4% | 724 | 31.5 | 0.3 | 2 | 0.3% | - |
| *Chilko System: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 3,587 | 14 | 0.4% | 4 | 0.1% | 759 | 28.6 | 0.3 | 3 | 0.4% | 97.1% |
| | 1995 | 4,385 | 5 | 0.1% | 0 | 0.0% | 1,375 | 31.6 | 0.4 | 1 | 0.1% | 93.5% |
| | 1996 | 11,325 | 6 | 0.1% | 68 | 0.6% | 2,674 | 32.1 | 0.3 | 1 | 0.0% | 94.8% |
| | 1997 | 11,029 | 53 | 0.5% | 49 | 0.4% | 1,667 | 27.3 | 0.5 | 4 | 0.2% | 91.5% |
| | 1998 | 6,874 | 68 | 1.0% | 21 | 0.3% | 1,567 | 31.6 | 0.3 | 5 | 0.3% | 92.2% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Early Stuart creeks: females* | | | | | | | | | | | | |
| Fence | 1994 | 0 | 0 | - | - | - | 0 | - | 0.0 | 0.0 | - | 91.6% |
| | 1995 | 0 | 0 | - | - | - | 0 | - | 0.0 | 0 | - | 88.7% |
| | 1996 | 138 | 0 | 0.0% | - | - | 51 | 11.1 | 0.4 | 1 | 2.0% | 96.5% |
| | 1997 | 112 | 4 | 3.6% | - | - | 67 | 5.8 | 0.6 | 30 | 44.8% | 76.0% |
| | 1998 | 14 | 0 | 0.0% | - | - | 9 | 6.8 | 0.4 | 1 | 11.1% | 52.0% |
| *Early Stuart creeks: males* | | | | | | | | | | | | |
| Fence | 1994 | 0 | 0 | - | - | - | 0 | - | - | 0 | - | |
| | 1995 | 0 | 0 | - | - | - | 0 | - | - | 0 | - | |
| | 1996 | 147 | 1 | 0.7% | - | - | 61 | 11.7 | 0.4 | 1 | 1.6% | |
| | 1997 | 222 | 14 | 6.3% | - | - | 129 | 5.8 | 0.6 | 34 | 26.4% | |
| | 1998 | 23 | 4 | 17.4% | - | - | 10 | 10.4 | 0.2 | 2 | 20.0% | |
| *Early Stuart creeks: males and females combined* | | | | | | | | | | | | |
| Fence | 1994 | 0 | 0 | - | - | - | 0 | - | - | 0 | - | 91.6% |
| | 1995 | 0 | 0 | - | - | - | 0 | - | - | 0 | - | 88.7% |
| | 1996 | 285 | 1 | 0.4% | - | - | 112 | 11.4 | 0.4 | 2 | 1.8% | 96.5% |
| | 1997 | 334 | 18 | 5.4% | - | - | 196 | 5.8 | 0.6 | 64 | 32.7% | 76.0% |
| | 1998 | 37 | 4 | 10.8% | - | - | 19 | 8.7 | 0.3 | 3 | 15.8% | 52.0% |
| *Eagle River: females* | | | | | | | | | | | | |
| | 1998 | - | - | - | - | - | - | - | - | - | - | - |
| *Eagle River: males* | | | | | | | | | | | | |
| | 1998 | - | - | - | - | - | - | - | - | - | - | - |
| *Eagle River: males and females combined* | | | | | | | | | | | | |
| Low stress | 1994 | | | | | | | | | | | 87.5% |
| | 1995 | | | | | | | | | | | 100.0% |
| | 1996 | | | | | | | | | | | 96.3% |
| | 1997 | | | | | | | | | | | 90.1% |
| | 1998 | - | - | - | - | - | - | - | - | - | - | 97.3% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Horsefly System: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 417 | 0 | 0.0% | 16 | 3.8% | 90 | 16.4 | 0.5 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 3,102 | 0 | 0.0% | 216 | 7.0% | 256 | 15.8 | 0.4 | | | |
| | 1998 | 4,858 | 46 | 0.9% | 395 | 8.1% | 645 | 16.0 | 0.3 | | | |
| Standard | 1994 | 2,914 | 52 | 1.8% | 106 | 3.6% | 428 | 17.6 | 0.3 | | | |
| | 1995 | 424 | 7 | 1.7% | 23 | 5.4% | 79 | 15.7 | 0.5 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 3,223 | 11 | 0.3% | 234 | 7.3% | 244 | 15.3 | 0.3 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 2,914 | 52 | 1.8% | 106 | 3.6% | 428 | 17.6 | 0.3 | 2 | 0.5% | 99.0% |
| | 1995 | 841 | 7 | 0.8% | 39 | 4.6% | 169 | 16.0 | 0.5 | 0 | 0.0% | 97.3% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 94.7% |
| | 1997 | 6,325 | 11 | 0.2% | 450 | 7.1% | 500 | 15.6 | 0.4 | 1 | 0.2% | 93.3% |
| | 1998 | 4,858 | 46 | 0.9% | 395 | 8.1% | 645 | 16.0 | 0.3 | 4 | 0.6% | 89.1% |
| *Horsefly System: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 325 | 1 | 0.3% | 12 | 3.7% | 58 | 15.9 | 0.7 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 2,607 | 1 | 0.0% | 204 | 7.8% | 244 | 16.1 | 0.4 | | | |
| | 1998 | 5,307 | 64 | 1.2% | 471 | 8.9% | 788 | 16.0 | 0.2 | | | |
| Standard | 1994 | 2,431 | 54 | 2.2% | 84 | 3.5% | 356 | 17.4 | 0.3 | | | |
| | 1995 | 317 | 8 | 2.5% | 18 | 5.7% | 46 | 15.6 | 0.7 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 2,644 | 9 | 0.3% | 169 | 6.4% | 201 | 15.7 | 0.4 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 2,431 | 54 | 2.2% | 84 | 3.5% | 356 | 17.4 | 0.3 | 0 | 0.0% | - |
| | 1995 | 642 | 9 | 1.4% | 30 | 4.7% | 104 | 15.7 | 0.7 | 0 | 0.0% | - |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1997 | 5,251 | 10 | 0.2% | 373 | 7.1% | 445 | 15.9 | 0.4 | 1 | 0.2% | - |
| | 1998 | 5,307 | 64 | 1.2% | 471 | 8.9% | 788 | 16.0 | 0.2 | 4 | 0.5% | - |
| *Horsefly System: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 5,345 | 106 | 2.0% | 190 | 3.6% | 784 | 17.5 | 0.3 | 2 | 0.3% | 99.0% |
| | 1995 | 1,483 | 16 | 1.1% | 69 | 4.7% | 273 | 15.9 | 0.6 | 0 | 0.0% | 97.3% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 94.7% |
| | 1997 | 11,576 | 21 | 0.2% | 823 | 7.1% | 945 | 15.7 | 0.4 | 2 | 0.2% | 93.3% |
| | 1998 | 10,165 | 110 | 1.1% | 866 | 8.5% | 1,433 | 16.0 | 0.2 | 8 | 0.6% | 89.1% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Middle River: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 1,110 | 5 | 0.5% | 18 | 1.6% | 211 | 17.9 | 0.4 | | | |
| | 1998 | 364 | 41 | 11.3% | 29 | 8.0% | 364 | 17.5 | 0.2 | | | |
| Standard | 1994 | 116 | 10 | 8.6% | 32 | 27.6% | 16 | 13.4 | 0.9 | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 1,457 | 13 | 0.9% | 19 | 1.3% | 254 | 17.1 | 0.3 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 116 | 10 | 8.6% | 32 | 27.6% | 16 | 13.4 | 0.9 | 0 | 0.0% | 99.5% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 100.0% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 86.4% |
| | 1997 | 2,567 | 18 | 0.7% | 37 | 1.4% | 465 | 17.5 | 0.4 | 1 | 0.2% | 95.5% |
| | 1998 | 364 | 41 | 11.3% | 29 | 8.0% | 364 | 17.5 | 0.2 | 0 | 0.0% | 98.6% |
| *Middle River: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 787 | 2 | 0.3% | 28 | 3.6% | 136 | 21.0 | 0.6 | | | |
| | 1998 | 354 | 6 | 1.7% | 45 | 12.7% | 354 | 17.7 | 0.3 | | | |
| Standard | 1994 | 113 | 11 | 9.7% | 47 | 41.6% | 20 | 15.3 | 1.2 | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 838 | 3 | 0.4% | 15 | 1.8% | 176 | 19.6 | 0.5 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 113 | 11 | 9.7% | 47 | 41.6% | 20 | 15.3 | 1.2 | 0 | 0.0% | - |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | - | - | - |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | - | - | - |
| | 1997 | 1,625 | 5 | 0.3% | 43 | 2.6% | 312 | 20.2 | 0.6 | 1 | 0.3% | - |
| | 1998 | 354 | 6 | 1.7% | 45 | 12.7% | 354 | 17.7 | 0.3 | 0 | 0.0% | - |
| *Middle River: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 229 | 21 | 9.2% | 79 | 34.5% | 36 | 14.4 | 1.0 | 0 | 0.0% | 99.5% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 100.0% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 86.4% |
| | 1997 | 4,192 | 23 | 0.5% | 80 | 1.9% | 777 | 18.6 | 0.5 | 2 | 0.3% | 95.5% |
| | 1998 | 718 | 47 | 6.5% | 74 | 10.3% | 718 | 17.6 | 0.3 | 0 | 0.0% | 98.6% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Mitchell River: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 851 | 2 | 0.2% | 52 | 6.1% | 82 | 13.3 | 0.8 | | | |
| | 1998 | 1,707 | 1 | 0.1% | 26 | 1.5% | 201 | 15.1 | 0.4 | | | |
| Standard | 1994 | 539 | 1 | 0.2% | 4 | 0.7% | 74 | 14.8 | 0.7 | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 846 | 13 | 1.5% | 58 | 6.9% | 91 | 13.1 | 0.5 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 539 | 1 | 0.2% | 4 | 0.7% | 74 | 14.8 | 0.7 | 2 | 2.7% | 99.7% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 97.4% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 100.0% |
| | 1997 | 1,697 | 15 | 0.9% | 110 | 6.5% | 173 | 13.2 | 0.7 | 3 | 1.7% | 92.7% |
| | 1998 | 1,707 | 1 | 0.1% | 26 | 1.5% | 201 | 15.1 | 0.4 | 1 | 0.5% | 94.6% |
| *Mitchell River: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 1,175 | 5 | 0.4% | 133 | 11.3% | 110 | 13.0 | 0.5 | | | |
| | 1998 | 1,724 | 4 | 0.2% | 59 | 3.4% | 218 | 14.3 | 0.4 | | | |
| Standard | 1994 | 459 | 0 | 0.0% | 3 | 0.7% | 46 | 14.4 | 0.7 | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 1,186 | 20 | 1.7% | 102 | 8.6% | 126 | 14.3 | 0.5 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 459 | 0 | 0.0% | 3 | 0.7% | 46 | 14.4 | 0.7 | 0 | 0.0% | - |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1997 | 2,361 | 25 | 1.1% | 235 | 10.0% | 236 | 13.7 | 0.5 | 2 | 0.8% | - |
| | 1998 | 1,724 | 4 | 0.2% | 59 | 3.4% | 218 | 14.3 | 0.4 | 2 | 0.9% | - |
| *Mitchell River: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 998 | 1 | 0.1% | 7 | 0.7% | 120 | 14.7 | 0.7 | 2 | 1.7% | 99.7% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 97.4% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 100.0% |
| | 1997 | 4,058 | 40 | 1.0% | 345 | 8.5% | 409 | 13.5 | 0.6 | 5 | 1.2% | 92.7% |
| | 1998 | 3,431 | 5 | 0.1% | 85 | 2.5% | 419 | 14.7 | 0.4 | 3 | 0.7% | 94.6% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pitt River, upper: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 222 | 0 | 0.0% | 0 | 0.0% | 96 | 14.0 | 0.3 | | | |
| | 1997 | 451 | 14 | 3.1% | 19 | 4.2% | 60 | 17.1 | 0.6 | | | |
| | 1998 | 559 | 0 | 0.0% | 45 | 8.1% | 46 | 39.7 | 0.7 | | | |
| Standard | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 98.3% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 90.0% |
| | 1996 | 222 | 0 | 0.0% | 0 | 0.0% | 96 | 14.0 | 0.3 | 0 | 0.0% | 95.7% |
| | 1997 | 451 | 14 | 3.1% | 19 | 4.2% | 60 | 17.1 | 0.6 | 1 | 1.7% | 91.2% |
| | 1998 | 559 | 0 | 0.0% | 45 | 8.1% | 46 | 39.7 | 0.7 | 0 | 0.0% | 96.9% |
| *Pitt River, upper: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 223 | 3 | 1.3% | 4 | 1.8% | 62 | 13.9 | 0.4 | | | |
| | 1997 | 490 | 13 | 2.7% | 29 | 5.9% | 46 | 20.7 | 0.4 | | | |
| | 1998 | 368 | 1 | 0.3% | 25 | 6.8% | 36 | 34.7 | 0.8 | | | |
| Standard | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1996 | 223 | 3 | 1.3% | 4 | 1.8% | 62 | 13.9 | 0.4 | 1 | 1.6% | - |
| | 1997 | 490 | 13 | 2.7% | 29 | 5.9% | 46 | 20.7 | 0.4 | 0 | 0.0% | - |
| | 1998 | 368 | 1 | 0.3% | 25 | 6.8% | 36 | 34.7 | 0.8 | 0 | 0.0% | - |
| *Pitt River, upper: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 98.3% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 90.0% |
| | 1996 | 445 | 3 | 0.7% | 4 | 0.9% | 158 | 14.0 | 0.3 | 1 | 0.6% | 95.7% |
| | 1997 | 941 | 27 | 2.9% | 48 | 5.1% | 106 | 18.7 | 0.5 | 1 | 0.9% | 91.2% |
| | 1998 | 927 | 1 | 0.1% | 70 | 7.6% | 82 | 37.5 | 0.7 | 0 | 0.0% | 96.9% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Seymour River: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 221 | 0 | 0.0% | 18 | 8.1% | 41 | 13.9 | 0.5 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 430 | 4 | 0.9% | 75 | 17.4% | 72 | 12.7 | 0.6 | | | |
| Standard | 1994 | 359 | 2 | 0.6% | 15 | 4.2% | 62 | 11.3 | 0.5 | | | |
| | 1995 | 167 | 0 | 0.0% | 9 | 5.4% | 32 | 12.6 | 0.6 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 359 | 2 | 0.6% | 15 | 4.2% | 62 | 11.3 | 0.5 | 2 | 3.2% | 98.9% |
| | 1995 | 388 | 0 | 0.0% | 27 | 7.0% | 73 | 13.3 | 0.6 | 1 | 1.4% | 98.3% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 95.0% |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 84.6% |
| | 1998 | 430 | 4 | 0.9% | 75 | 17.4% | 72 | 12.7 | 0.6 | 2 | 2.8% | 96.7% |
| *Seymour River: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 247 | 1 | 0.4% | 16 | 6.5% | 54 | 12.1 | 0.4 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 466 | 4 | 0.9% | 103 | 22.1% | 54 | 12.3 | 0.6 | | | |
| Standard | 1994 | 624 | 5 | 0.8% | 35 | 5.6% | 54 | 12.1 | 0.5 | | | |
| | 1995 | 304 | 0 | 0.0% | 24 | 7.9% | 54 | 13.2 | 0.5 | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 624 | 5 | 0.8% | 35 | 5.6% | 54 | 12.1 | 0.5 | 0 | 0.0% | - |
| | 1995 | 551 | 1 | 0.2% | 40 | 7.3% | 108 | 12.7 | 0.5 | 1 | 0.9% | - |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1998 | 466 | 4 | 0.9% | 103 | 22.1% | 54 | 12.3 | 0.6 | 2 | 3.7% | - |
| *Seymour River: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 983 | 7 | 0.7% | 50 | 5.1% | 116 | 11.7 | 0.5 | 2 | 1.7% | 98.9% |
| | 1995 | 939 | 1 | 0.1% | 67 | 7.1% | 181 | 12.9 | 0.5 | 2 | 1.1% | 98.3% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 95.0% |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 84.6% |
| | 1998 | 896 | 8 | 0.9% | 178 | 19.9% | 126 | 12.5 | 0.6 | 4 | 3.2% | 96.7% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Shuswap System: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 1,415 | 1 | 0.1% | 40 | 2.8% | 283 | 15.0 | 0.3 | | | |
| Standard | 1994 | 1,919 | 5 | 0.3% | 3 | 0.2% | 502 | 14.2 | 0.2 | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 1,919 | 5 | 0.3% | 3 | 0.2% | 502 | 14.2 | 0.2 | 0 | 0.0% | 99.1% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 100.0% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 89.3% |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 66.7% |
| | 1998 | 1,415 | 1 | 0.1% | 40 | 2.8% | 283 | 15.0 | 0.3 | 2 | 0.7% | 96.3% |
| *Shuswap System: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 1,620 | 6 | 0.4% | 45 | 2.8% | 353 | 16.5 | 0.3 | | | |
| Standard | 1994 | 2,167 | 19 | 0.9% | 11 | 0.5% | 720 | 16.8 | 0.2 | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 2,167 | 19 | 0.9% | 11 | 0.5% | 720 | 16.8 | 0.2 | 1 | 0.1% | - |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1998 | 1,620 | 6 | 0.4% | 45 | 2.8% | 353 | 16.5 | 0.3 | 5 | 1.4% | - |
| *Shuswap System: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 4,086 | 24 | 0.6% | 14 | 0.3% | 1,222 | 15.7 | 0.2 | 1 | 0.1% | 99.1% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 100.0% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 89.3% |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 66.7% |
| | 1998 | 3,035 | 7 | 0.2% | 85 | 2.8% | 636 | 15.8 | 0.3 | 7 | 1.1% | 96.3% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Stellako River: females* | | | | | | | | | | | | |
| Fence | 1994 | 990 | 78 | 7.9% | 0 | 0.0% | 289 | 21.6 | 0.3 | 1 | 0.3% | 89.1% |
| and | 1995 | 497 | 24 | 4.8% | 0 | 0.0% | 147 | 15.2 | 0.3 | 9 | 6.1% | 74.9% |
| Standard | 1996 | 1,930 | 25 | 1.3% | 0 | 0.0% | 625 | 25.5 | 0.2 | 0 | 0.0% | 93.4% |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1998 | 1,105 | 4 | 0.4% | 0 | 0.0% | 392 | 22.2 | 0.3 | 0 | 0.0% | 98.4% |
| *Stellako River: males* | | | | | | | | | | | | |
| Fence | 1994 | 409 | 36 | 8.8% | 0 | 0.0% | 90 | 21.5 | 0.6 | 0 | 0.0% | - |
| and | 1995 | 714 | 22 | 3.1% | 0 | 0.0% | 297 | 19.5 | 0.2 | 5 | 1.7% | - |
| Standard | 1996 | 1,341 | 31 | 2.3% | 0 | 0.0% | 410 | 27.1 | 0.2 | 0 | 0.0% | - |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1998 | 750 | 4 | 0.5% | 0 | 0.0% | 276 | 22.3 | 0.3 | 0 | 0.0% | - |
| *Stellako River: males and females combined* | | | | | | | | | | | | |
| Fence | 1994 | 1,399 | 114 | 8.1% | 0 | 0.0% | 379 | 21.6 | 0.4 | 1 | 0.3% | 89.1% |
| and | 1995 | 1,211 | 46 | 3.8% | 0 | 0.0% | 444 | 18.1 | 0.3 | 14 | 3.2% | 74.9% |
| Standard | 1996 | 3,271 | 56 | 1.7% | 0 | 0.0% | 1,035 | 26.1 | 0.2 | 0 | 0.0% | 93.4% |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1998 | 1,855 | 8 | 0.4% | 0 | 0.0% | 668 | 22.2 | 0.3 | 0 | 0.0% | 98.4% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Tachie River: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 2,388 | 10 | 0.4% | 93 | 3.9% | 505 | 15.2 | 0.3 | | | |
| | 1998 | 408 | 5 | 1.2% | 35 | 8.6% | 64 | 14.8 | 0.6 | | | |
| Standard | 1994 | 950 | 22 | 2.3% | 82 | 8.6% | 175 | 16.4 | 0.4 | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 2,318 | 11 | 0.5% | 86 | 3.7% | 447 | 14.8 | 0.3 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 950 | 22 | 2.3% | 82 | 8.6% | 175 | 16.4 | 0.4 | 3 | 1.7% | 97.0% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 100.0% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 84.7% |
| | 1997 | 4,706 | 21 | 0.4% | 179 | 3.8% | 952 | 15.0 | 0.3 | 25 | 2.6% | 87.5% |
| | 1998 | 408 | 5 | 1.2% | 35 | 8.6% | 64 | 14.8 | 0.6 | 1 | 1.6% | 98.4% |
| *Tachie River: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 1,645 | 10 | 0.6% | 101 | 6.1% | 292 | 18.4 | 0.4 | | | |
| | 1998 | 326 | 4 | 1.2% | 22 | 6.7% | 41 | 16.3 | 0.8 | | | |
| Standard | 1994 | 849 | 28 | 3.3% | 120 | 14.1% | 168 | 17.5 | 0.4 | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 1,508 | 9 | 0.6% | 94 | 6.2% | 275 | 18.8 | 0.4 | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 849 | 28 | 3.3% | 120 | 14.1% | 168 | 17.5 | 0.4 | 2 | 1.2% | - |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1997 | 3,153 | 19 | 0.6% | 195 | 6.2% | 567 | 18.6 | 0.4 | 3 | 0.5% | - |
| | 1998 | 326 | 4 | 1.2% | 22 | 6.7% | 41 | 16.3 | 0.8 | 1 | 2.4% | - |
| *Tachie River: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 1,799 | 50 | 2.8% | 202 | 11.2% | 343 | 17.0 | 0.4 | 5 | 1.5% | 97.0% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 100.0% |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 84.7% |
| | 1997 | 7,859 | 40 | 0.5% | 374 | 4.8% | 1,519 | 16.4 | 0.3 | 28 | 1.8% | 87.5% |
| | 1998 | 734 | 9 | 1.2% | 57 | 7.8% | 105 | 15.4 | 0.7 | 2 | 1.9% | 98.4% |

Continued

Appendix 2. Indicators of the condition of sockeye salmon spawning in mark recapture study areas, from 1994 to 1998, continued.

| Tagging method | Year | No. tagged | Requiring ventilation No. | Requiring ventilation % | Recaptured 1 or more times No. | Recaptured 1 or more times % | No. rec'd | 'Days out' Mean | 'Days out' S.E. | <5 'days out' No. | <5 'days out' % | Mean spawning success (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Weaver Creek: females* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 684 | 2 | 0.3% | 8 | 1.2% | 259 | 7.3 | 0.2 | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 203 | 14 | 6.9% | 4 | 2.0% | 91 | 5.4 | 0.3 | | | |
| Standard | 1994 | 0 | 0 | - | 0 | - | 21 | 7.6 | 0.0 | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 0 | 0 | - | 0 | - | 21 | 7.6 | 0.0 | 11 | 52.4% | 97.9% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 56.0% |
| | 1996 | 684 | 2 | 0.3% | 8 | 1.2% | 259 | 7.3 | 0.2 | 77 | 29.7% | 48.7% |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 50.7% |
| | 1998 | 203 | 14 | 6.9% | 4 | 2.0% | 91 | 5.4 | 0.3 | 44 | 48.4% | 90.4% |
| *Weaver Creek: males* | | | | | | | | | | | | |
| Low stress | 1994 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 934 | 4 | 0.4% | 19 | 2.0% | 469 | 9.0 | 0.0 | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 191 | 12 | 6.3% | 2 | 1.0% | 108 | 6.5 | 0.0 | | | |
| Standard | 1994 | 0 | 0 | - | 0 | - | 29 | 10.2 | 0.0 | | | |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1996 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| | 1998 | 0 | 0 | - | 0 | - | 0 | - | - | | | |
| Pooled | 1994 | 0 | 0 | - | 0 | - | 29 | 10.2 | 0.0 | 6 | 20.7% | - |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1996 | 934 | 4 | 0.4% | 19 | 2.0% | 469 | 9.0 | 0.0 | 100 | 21.3% | - |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | - |
| | 1998 | 191 | 12 | 6.3% | 2 | 1.0% | 108 | 6.5 | 0.0 | 44 | 40.7% | - |
| *Weaver Creek: males and females combined* | | | | | | | | | | | | |
| Pooled | 1994 | 0 | 0 | - | 0 | - | 50 | 9.1 | 0.0 | 17 | 34.0% | 97.9% |
| | 1995 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 56.0% |
| | 1996 | 1,618 | 6 | 0.4% | 27 | 1.7% | 728 | 8.4 | 0.1 | 177 | 24.3% | 48.7% |
| | 1997 | 0 | 0 | - | 0 | - | 0 | - | - | 0 | - | 50.7% |
| | 1998 | 394 | 26 | 6.6% | 6 | 1.5% | 199 | 6.0 | 0.2 | 88 | 44.2% | 90.4% |

Appendix 3. Recovery rates of Fraser River sockeye salmon in high and low stress categories, and the fraction of tagged and untagged sockeye salmon that spawned fully, in mark recapture studies from 1994 to 1998. Italics indicate cases with N>10 in the high stress category.

| | Recovery rates | | | | | | Fraction completely spawned | | |
|---|---|---|---|---|---|---|---|---|---|
| | Required ventilation upon release? | | | Recaptured? | | | Tagged? | | |
| Year | No | Yes | Difference | No | Yes | Difference | Yes | No | Difference |
| *Adams study area: females* | | | | | | | | | |
| 1994 | 20.2% | 0.0% | -20.2% | *20.4%* | *17.4%* | *- 3.0%* | *97.3%* | *99.3%* | *2.0%* |
| 1995 | 20.8% | 0.0% | -20.8% | *20.4%* | *28.0%* | *7.6%* | *92.3%* | *75.9%* | *-16.4%* |
| 1996 | - | - | - | - | - | - | - | - | - |
| 1997 | - | - | - | - | - | - | - | - | - |
| 1998 | *14.8%* | *30.0%* | *15.2%* | *14.8%* | *15.8%* | *1.0%* | *94.0%* | *95.4%* | *1.4%* |
| *Adams study area: males* | | | | | | | | | |
| 1994 | 20.2% | 16.7% | - 3.6% | *20.6%* | *17.5%* | *- 3.1%* | | | |
| 1995 | 20.2% | 0.0% | -20.2% | *19.4%* | *30.6%* | *11.2%* | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | *15.9%* | *23.1%* | *7.2%* | *16.1%* | *12.0%* | *- 4.1%* | | | |
| *Adams study area: pooled* | | | | | | | | | |
| 1994 | 20.2% | 14.3% | - 5.9% | *20.5%* | *17.5%* | *- 3.0%* | | | |
| 1995 | 20.5% | 0.0% | -20.5% | *19.9%* | *29.5%* | *9.7%* | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | *15.4%* | *26.1%* | *10.7%* | *15.5%* | *13.7%* | *- 1.9%* | | | |
| *Birkenhead River: females* | | | | | | | | | |
| 1994 | *25.4%* | *35.7%* | *10.4%* | *24.6%* | *33.7%* | *9.0%* | *100.0%* | *99.8%* | *- 0.2%* |
| 1995 | 39.5% | - | - | *39.3%* | *42.9%* | *3.5%* | *92.5%* | *90.2%* | *- 2.3%* |
| 1996 | 32.2% | 50.0% | 17.8% | *32.7%* | *30.5%* | *- 2.2%* | *88.3%* | *91.7%* | *3.4%* |
| 1997 | 14.4% | 11.1% | - 3.3% | *13.9%* | *16.6%* | *2.7%* | *92.4%* | *94.5%* | *2.0%* |
| 1998 | 25.5% | 25.0% | - 0.5% | *25.5%* | *28.6%* | *3.1%* | *91.9%* | *95.3%* | *3.5%* |
| *Birkenhead River: males* | | | | | | | | | |
| 1994 | *20.2%* | *31.3%* | *11.1%* | *20.2%* | *23.6%* | *3.4%* | | | |
| 1995 | 29.6% | - | - | *29.2%* | *32.9%* | *3.7%* | | | |
| 1996 | 27.5% | 33.3% | 5.9% | *28.0%* | *25.0%* | *- 3.0%* | | | |
| 1997 | *15.6%* | *8.7%* | *- 6.9%* | *16.4%* | *11.8%* | *- 4.6%* | | | |
| 1998 | 30.7% | 33.3% | 2.6% | *31.5%* | *21.6%* | *- 9.9%* | | | |
| *Birkenhead River: pooled* | | | | | | | | | |
| 1994 | 23.2% | 33.3% | *10.1%* | *22.9%* | *29.4%* | *6.6%* | | | |
| 1995 | 35.1% | - | - | *34.9%* | *37.9%* | *3.0%* | | | |
| 1996 | 29.9% | 40.0% | 10.1% | *30.5%* | *27.9%* | *- 2.6%* | | | |
| 1997 | *15.0%* | *9.4%* | *- 5.7%* | *15.2%* | *13.9%* | *- 1.3%* | | | |
| 1998 | 27.7% | 28.6% | 0.8% | *28.1%* | *25.0%* | *- 3.1%* | | | |

Continued

Appendix 3. Recovery rates of Fraser River sockeye salmon in high and low stress categories, and the fraction of tagged and untagged sockeye salmon that spawned fully, in mark recapture studies from 1994 to 1998. Italics indicate cases with N>10 in the high stress category.

| | Recovery rates | | | | | | Fraction completely spawned | | |
|---|---|---|---|---|---|---|---|---|---|
| | Required ventilation upon release? | | | Recaptured? | | | Tagged? | | |
| Year | No | Yes | Difference | No | Yes | Difference | Yes | No | Difference |
| *Chilko System: females* | | | | | | | | | |
| 1994 | 22.7% | 33.3% | 10.7% | 22.1% | 50.0% | 27.9% | *92.7%* | *95.8%* | *3.1%* |
| 1995 | 29.7% | 50.0% | 20.3% | 29.7% | - | - | *94.9%* | *93.1%* | *- 1.8%* |
| 1996 | 22.1% | 0.0% | -22.1% | *22.0%* | *29.7%* | *7.7%* | *93.6%* | *87.7%* | *- 5.9%* |
| 1997 | *15.6%* | *18.4%* | *2.8%* | *15.7%* | *6.7%* | *- 9.0%* | *93.7%* | *83.0%* | *-10.7%* |
| 1998 | *22.5%* | *11.1%* | *-11.4%* | 22.4% | 0.0% | -22.4% | *94.9%* | *85.7%* | *- 9.2%* |
| *Chilko System: males* | | | | | | | | | |
| 1994 | 18.9% | 0.0% | -18.9% | 18.4% | - | - | | | |
| 1995 | 33.9% | 66.7% | 32.7% | 34.0% | - | - | | | |
| 1996 | 25.4% | - | - | *25.4%* | *25.8%* | *0.4%* | | | |
| 1997 | *14.4%* | *6.7%* | *- 7.8%* | *14.4%* | *10.5%* | *- 3.9%* | | | |
| 1998 | *23.3%* | *26.1%* | *2.8%* | *23.3%* | *8.3%* | *-15.0%* | | | |
| *Chilko System: pooled* | | | | | | | | | |
| 1994 | *21.1%* | *21.4%* | *0.3%* | 20.5% | 50.0% | 29.5% | | | |
| 1995 | 31.3% | 60.0% | 28.7% | 31.4% | - | - | | | |
| 1996 | 23.6% | 0.0% | -23.6% | *23.6%* | *27.9%* | *4.4%* | | | |
| 1997 | *15.1%* | *15.1%* | *0.0%* | *15.1%* | *8.2%* | *- 7.0%* | | | |
| 1998 | *22.9%* | *16.2%* | *- 6.7%* | *22.9%* | *4.8%* | *-18.1%* | | | |
| *Eagle River: females* | | | | | | | | | |
| 1994 | - | - | - | - | - | - | - | - | - |
| 1995 | - | - | - | - | - | - | - | - | - |
| 1996 | - | - | - | - | - | - | - | - | - |
| 1997 | - | - | - | - | - | - | - | - | - |
| 1998 | 12.3% | 100.0% | 87.7% | 13.5% | - | - | 90.0% | 96.9% | 6.9% |
| *Eagle River: males* | | | | | | | | | |
| 1994 | - | - | - | - | - | - | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | 13.0% | 25.0% | 12.0% | 13.4% | 16.7% | 3.2% | | | |
| *Eagle River: pooled* | | | | | | | | | |
| 1994 | - | - | - | - | - | - | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | 12.7% | 40.0% | 27.3% | 13.5% | 16.7% | 3.2% | | | |

Continued

Appendix 3. Recovery rates of Fraser River sockeye salmon in high and low stress categories, and the fraction of tagged and untagged sockeye salmon that spawned fully, in mark recapture studies from 1994 to 1998. Italics indicate cases with N>10 in the high stress category.

| | Recovery rates | | | | | | Fraction completely spawned | | |
|---|---|---|---|---|---|---|---|---|---|
| | Required ventilation upon release? | | | Recaptured? | | | Tagged? | | |
| Year | No | Yes | Difference | No | Yes | Difference | Yes | No | Difference |
| *Early Stuart creeks: females* | | | | | | | | | |
| 1994 | - | - | - | - | - | - | - | 92.6% | - |
| 1995 | - | - | - | - | - | - | - | 87.7% | - |
| 1996 | 37.0% | - | - | - | - | - | *95.9%* | *95.6%* | *- 0.4%* |
| 1997 | 59.3% | 75.0% | 15.7% | - | - | - | *53.0%* | *71.3%* | *18.3%* |
| 1998 | 64.3% | - | - | - | - | - | 22.2% | 50.0% | 27.8% |
| *Early Stuart creeks: males* | | | | | | | | | |
| 1994 | - | - | - | - | - | - | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | 41.1% | 100.0% | 58.9% | - | - | - | | | |
| 1997 | *58.2%* | *57.1%* | *- 1.0%* | - | - | - | | | |
| 1998 | *42.1%* | *50.0%* | 7.9% | - | - | - | | | |
| *Early Stuart creeks: pooled* | | | | | | | | | |
| 1994 | - | - | - | - | - | - | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | 39.1% | 100.0% | 60.9% | - | - | - | | | |
| 1997 | *58.5%* | *61.1%* | *2.6%* | - | - | - | | | |
| 1998 | 51.5% | 50.0% | - 1.5% | - | - | - | | | |
| *Horsefly System: females* | | | | | | | | | |
| 1994 | *14.7%* | *11.5%* | *- 3.2%* | *15.2%* | *12.3%* | *- 3.0%* | *92.0%* | *98.9%* | *6.9%* |
| 1995 | 19.8% | 57.1% | 37.3% | *20.6%* | *12.8%* | *- 7.8%* | *98.8%* | *97.3%* | *- 1.5%* |
| 1996 | - | - | - | - | - | - | - | - | - |
| 1997 | *9.4%* | *0.0%* | *- 9.4%* | *9.4%* | *8.4%* | *- 1.0%* | *83.6%* | *88.6%* | *5.0%* |
| 1998 | *10.2%* | *8.7%* | *- 1.5%* | *10.2%* | *10.9%* | *0.7%* | *80.1%* | *83.6%* | *3.5%* |
| *Horsefly System: males* | | | | | | | | | |
| 1994 | *10.9%* | *11.1%* | *0.2%* | *15.3%* | *15.5%* | *0.1%* | | | |
| 1995 | 16.4% | 0.0% | -16.4% | *16.5%* | *6.7%* | *- 9.8%* | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | *10.0%* | *0.0%* | *-10.0%* | *9.9%* | *10.7%* | *0.8%* | | | |
| 1998 | *10.9%* | *12.5%* | *1.6%* | *11.0%* | *10.2%* | *- 0.8%* | | | |
| *Horsefly System: pooled* | | | | | | | | | |
| 1994 | *13.0%* | *11.3%* | *- 1.7%* | *15.3%* | *13.7%* | *- 1.6%* | | | |
| 1995 | *18.3%* | *25.0%* | *6.7%* | *18.8%* | *10.1%* | *- 8.7%* | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | *9.7%* | *0.0%* | *- 9.7%* | *9.7%* | *9.5%* | *- 0.2%* | | | |
| 1998 | *10.6%* | *10.9%* | *0.3%* | *10.6%* | *10.5%* | *- 0.1%* | | | |

Continued

Appendix 3. Recovery rates of Fraser River sockeye salmon in high and low stress categories, and the fraction of tagged and untagged sockeye salmon that spawned fully, in mark recapture studies from 1994 to 1998. Italics indicate cases with N>10 in the high stress category.

| | Recovery rates | | | | | | Fraction completely spawned | | |
|---|---|---|---|---|---|---|---|---|---|
| | Required ventilation upon release? | | | Recaptured? | | | Tagged? | | |
| Year | No | Yes | Difference | No | Yes | Difference | Yes | No | Difference |
| *Middle River: females* | | | | | | | | | |
| 1994 | *13.2%* | *20.0%* | *6.8%* | *66.3%* | *33.7%* | -32.6% | 100.0% | - | - |
| 1995 | - | - | - | - | - | - | - | - | - |
| 1996 | - | - | - | - | - | - | - | - | - |
| 1997 | *18.8%* | *27.8%* | *9.0%* | *18.8%* | *24.3%* | 5.5% | 84.0% | 94.8% | 10.8% |
| 1998 | *33.1%* | *2.4%* | *-30.7%* | *29.0%* | *37.9%* | 9.0% | 97.1% | 98.4% | 1.3% |
| *Middle River: males* | | | | | | | | | |
| 1994 | *16.7%* | *18.2%* | *1.5%* | *64.7%* | *35.3%* | *-29.3%* | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | 21.4% | 20.0% | - 1.4% | *21.3%* | *25.6%* | *4.3%* | | | |
| 1998 | 27.6% | 33.3% | 5.7% | *25.6%* | *42.2%* | *16.7%* | | | |
| *Middle River: pooled* | | | | | | | | | |
| 1994 | *14.9%* | *19.0%* | *4.1%* | *65.4%* | *34.6%* | *-30.7%* | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | *19.8%* | *26.1%* | *6.3%* | *19.7%* | *25.0%* | *5.3%* | | | |
| 1998 | *30.3%* | *6.4%* | *-23.9%* | *27.3%* | *40.5%* | *13.2%* | | | |
| *Mitchell River: females* | | | | | | | | | |
| 1994 | 13.1% | 0.0% | -13.1% | 13.3% | 0.0% | -13.3% | - | - | - |
| 1995 | - | - | - | - | - | - | - | - | - |
| 1996 | - | - | - | - | - | - | - | - | - |
| 1997 | *12.4%* | *0.0%* | *-12.4%* | *12.1%* | *14.5%* | *2.4%* | *85.3%* | *90.8%* | *5.5%* |
| 1998 | 11.5% | 0.0% | -11.5% | *11.7%* | *7.7%* | *- 4.0%* | *94.6%* | *92.1%* | *- 2.5%* |
| *Mitchell River: males* | | | | | | | | | |
| 1994 | 10.6% | - | - | 9.9% | 33.3% | 23.5% | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | *11.1%* | *4.0%* | *- 7.1%* | *11.6%* | *7.2%* | *- 4.4%* | | | |
| 1998 | 12.6% | 25.0% | 12.4% | *12.7%* | *10.2%* | *- 2.6%* | | | |
| *Mitchell River: pooled* | | | | | | | | | |
| 1994 | 12.0% | 0.0% | -12.0% | 11.7% | 14.3% | 2.6% | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | *11.6%* | *2.5%* | *- 9.1%* | *11.8%* | *9.6%* | *- 2.3%* | | | |
| 1998 | 12.1% | 20.0% | 7.9% | *12.2%* | *9.4%* | *- 2.8%* | | | |

Continued

Appendix 3. Recovery rates of Fraser River sockeye salmon in high and low stress categories, and the fraction of tagged and untagged sockeye salmon that spawned fully, in mark recapture studies from 1994 to 1998. Italics indicate cases with N>10 in the high stress category.

| | Recovery rates | | | | | | Fraction completely spawned | | |
|---|---|---|---|---|---|---|---|---|---|
| | Required ventilation upon release? | | | Recaptured? | | | Tagged? | | |
| Year | No | Yes | Difference | No | Yes | Difference | Yes | No | Difference |
| *Pitt River, upper: females* | | | | | | | | | |
| 1994 | - | - | - | - | - | - | - | - | - |
| 1995 | - | - | - | - | - | - | - | - | - |
| 1996 | 43.2% | - | - | 43.2% | - | - | *89.2%* | *94.9%* | *5.6%* |
| 1997 | *13.0%* | *21.4%* | *8.4%* | *13.7%* | *5.3%* | *- 8.4%* | *89.3%* | *90.7%* | *1.4%* |
| 1998 | 8.2% | - | - | *8.4%* | *6.7%* | *- 1.7%* | *87.5%* | *96.3%* | *8.8%* |
| *Pitt River, upper: males* | | | | | | | | | |
| 1994 | - | - | - | - | - | - | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | 27.7% | 33.3% | 5.6% | 27.4% | 50.0% | 22.6% | | | |
| 1997 | *9.4%* | *7.7%* | *- 1.7%* | *9.5%* | *6.9%* | *- 2.6%* | | | |
| 1998 | 9.8% | 0.0% | - 9.8% | *9.9%* | *8.0%* | *- 1.9%* | | | |
| *Pitt River, upper: pooled* | | | | | | | | | |
| 1994 | - | - | - | - | - | - | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | 35.5% | 33.3% | - 2.2% | 35.4% | 50.0% | 14.6% | | | |
| 1997 | *11.2%* | *14.8%* | *3.7%* | *11.5%* | *6.3%* | *- 5.3%* | | | |
| 1998 | 8.9% | 0.0% | - 8.9% | *9.0%* | *7.1%* | *- 1.8%* | | | |
| *Seymour River: females* | | | | | | | | | |
| 1994 | 16.7% | 0.0% | -16.7% | *16.3%* | *33.3%* | *17.1%* | *98.4%* | *99.3%* | *0.9%* |
| 1995 | 18.6% | - | - | *19.7%* | *7.4%* | *-12.3%* | *100.0%* | *98.2%* | *- 1.8%* |
| 1996 | - | - | - | - | - | - | - | - | - |
| 1997 | - | - | - | - | - | - | - | - | - |
| 1998 | 16.7% | 25.0% | 8.3% | *16.6%* | *17.3%* | *0.7%* | *94.4%* | *96.3%* | *2.0%* |
| *Seymour River: males* | | | | | | | | | |
| 1994 | 8.7% | 20.0% | 11.3% | *8.7%* | *5.7%* | *- 2.9%* | | | |
| 1995 | 19.5% | 0.0% | -19.5% | *19.2%* | *25.0%* | *5.8%* | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | 11.7% | 0.0% | -11.7% | *11.0%* | *13.6%* | *2.6%* | | | |
| *Seymour River: pooled* | | | | | | | | | |
| 1994 | 11.8% | 14.3% | 2.5% | *11.5%* | *14.0%* | *2.5%* | | | |
| 1995 | 19.1% | 0.0% | -19.1% | *19.4%* | *17.9%* | *- 1.5%* | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | 14.1% | 12.5% | - 1.6% | *13.8%* | *15.2%* | *1.4%* | | | |

Continued

Appendix 3. Recovery rates of Fraser River sockeye salmon in high and low stress categories, and the fraction of tagged and untagged sockeye salmon that spawned fully, in mark recapture studies from 1994 to 1998. Italics indicate cases with N>10 in the high stress category.

| | Recovery rates | | | | | | Fraction completely spawned | | |
|---|---|---|---|---|---|---|---|---|---|
| | Required ventilation upon release? | | | Recaptured? | | | Tagged? | | |
| Year | No | Yes | Difference | No | Yes | Difference | Yes | No | Difference |
| *Shuswap System: females* | | | | | | | | | |
| 1994 | 26.3% | 20.0% | - 6.3% | 0.0% | 0.0% | 0.0% | *98.4%* | *99.5%* | *1.1%* |
| 1995 | - | - | - | - | - | - | - | - | - |
| 1996 | - | - | - | - | - | - | - | - | - |
| 1997 | - | - | - | - | - | - | - | - | - |
| 1998 | 20.0% | 0.0% | -20.0% | *19.8%* | *27.5%* | *7.7%* | *96.7%* | *92.6%* | *- 4.1%* |
| *Shuswap System: males* | | | | | | | | | |
| 1994 | *33.2%* | *31.6%* | *- 1.7%* | *0.0%* | *0.0%* | *0.0%* | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | 21.8% | 33.3% | 11.6% | *21.8%* | *20.0%* | *- 1.8%* | | | |
| *Shuswap System: pooled* | | | | | | | | | |
| 1994 | *30.0%* | *29.2%* | *- 0.8%* | *0.0%* | *0.0%* | *0.0%* | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | 21.0% | 28.6% | 7.6% | *20.9%* | *23.5%* | *2.6%* | | | |
| *Stellako River: females* | | | | | | | | | |
| 1994 | *33.6%* | *30.8%* | *- 2.8%* | 0.0% | - | - | *91.7%* | *89.0%* | *- 2.6%* |
| 1995 | *30.0%* | *20.8%* | *- 9.2%* | 0.0% | - | - | *65.7%* | *74.9%* | *9.2%* |
| 1996 | *32.1%* | *56.0%* | *23.9%* | 0.0% | - | - | *93.2%* | *93.4%* | *0.3%* |
| 1997 | - | - | - | - | - | - | - | - | - |
| 1998 | 35.5% | 0.0% | -35.5% | 0.0% | - | - | *95.4%* | *98.4%* | *3.0%* |
| *Stellako River: males* | | | | | | | | | |
| 1994 | *24.7%* | *16.7%* | *- 8.0%* | 0.0% | - | - | | | |
| 1995 | *42.2%* | *22.7%* | *-19.5%* | 0.0% | - | - | | | |
| 1996 | *30.3%* | *35.5%* | *5.2%* | 0.0% | - | - | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | 52.4% | 0.0% | -52.4% | 0.0% | - | - | | | |
| *Stellako River: pooled* | | | | | | | | | |
| 1994 | *31.0%* | *26.3%* | *- 4.7%* | 0.0% | - | - | | | |
| 1995 | *37.3%* | *21.7%* | *-15.5%* | 0.0% | - | - | | | |
| 1996 | *31.4%* | *44.6%* | *13.3%* | 0.0% | - | - | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | 42.3% | 0.0% | -42.3% | 0.0% | - | - | | | |

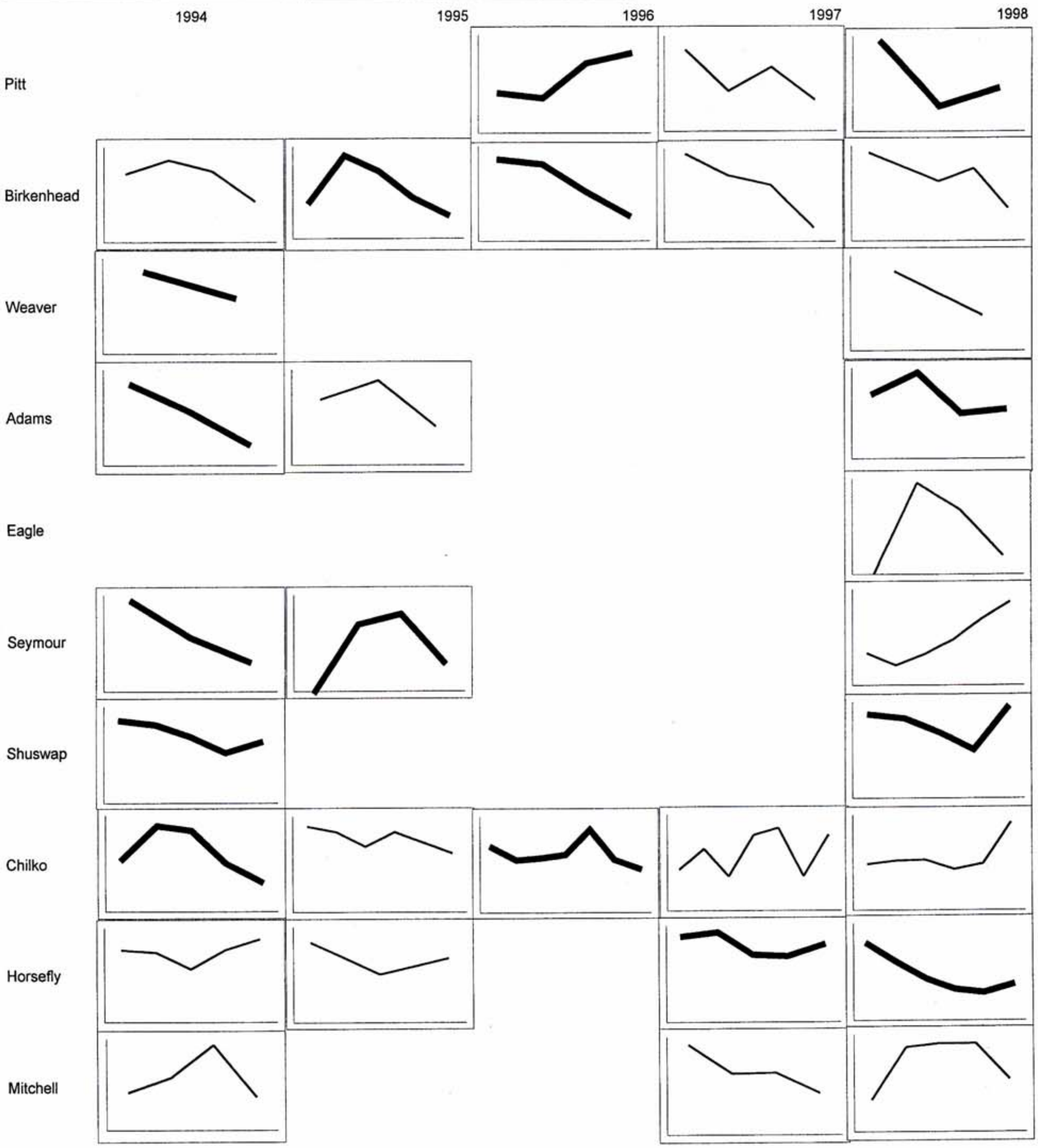
Continued

Appendix 3. Recovery rates of sockeye salmon in high and low stress categories, and fraction of tagged and untagged sockeye salmon which spawned fully, in mark recapture studies, from 1994 to 1998. Italics indicate cases with N>10 in the high stress category.

| | Recovery rates | | | | | | Fraction completely spawned | | |
|---|---|---|---|---|---|---|---|---|---|
| | Required ventilation upon release? | | | Recaptured? | | | Tagged? | | |
| Year | No | Yes | □ | No | Yes | □ | Yes | No | □ |
| *Tachie River: females* | | | | | | | | | |
| 1994 | 18.3% | 27.3% | 9.0% | 17.7% | 20.7% | 3.0% | - | - | - |
| 1995 | - | - | - | - | - | - | - | - | - |
| 1996 | - | - | - | - | - | - | - | - | - |
| 1997 | 20.3% | 14.3% | - 6.0% | 17.2% | 20.7% | 3.5% | 85.9% | 87.2% | 1.3% |
| 1998 | 15.4% | 40.0% | 24.6% | 16.4% | 11.4% | - 4.9% | 98.2% | 98.3% | 0.1% |
| *Tachie River: males* | | | | | | | | | |
| 1994 | 19.4% | 17.9% | - 1.6% | 19.1% | 21.7% | 2.6% | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | 18.0% | 15.8% | - 2.2% | 13.9% | 23.6% | 9.7% | | | |
| 1998 | 12.7% | 0.0% | -12.7% | 11.8% | 18.2% | 6.3% | | | |
| *Tachie River: pooled* | | | | | | | | | |
| 1994 | 18.8% | 22.0% | 3.2% | 18.3% | 21.3% | 2.9% | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | - | - | - | - | - | - | | | |
| 1997 | 19.4% | 15.0% | - 4.4% | 15.9% | 22.2% | 6.3% | | | |
| 1998 | 14.2% | 22.2% | 8.0% | 14.3% | 14.0% | - 0.3% | | | |
| *Weaver Creek: females* | | | | | | | | | |
| 1994 | 21.2% | - | - | - | - | - | - | - | - |
| 1995 | - | - | - | - | - | - | - | - | - |
| 1996 | 38.1% | 50.0% | 11.9% | 38.2% | 37.5% | - 0.7% | 50.8% | - | - |
| 1997 | - | - | - | - | - | - | - | - | - |
| 1998 | 43.4% | 50.0% | 6.6% | 43.7% | 100.0% | 56.3% | 79.1% | 89.4% | 10.3% |
| *Weaver Creek: males* | | | | | | | | | |
| 1994 | 26.6% | - | - | - | - | - | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | 50.1% | 75.0% | 24.9% | 50.7% | 26.3% | -24.4% | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | 55.3% | 66.7% | 11.4% | 56.1% | 100.0% | 43.9% | | | |
| *Weaver Creek: pooled* | | | | | | | | | |
| 1994 | 24.0% | - | - | - | - | - | | | |
| 1995 | - | - | - | - | - | - | | | |
| 1996 | 45.0% | 66.7% | 21.6% | 45.4% | 29.6% | -15.8% | | | |
| 1997 | - | - | - | - | - | - | | | |
| 1998 | 49.2% | 57.7% | 8.5% | 49.7% | 100.0% | 50.3% | | | |

Appendix 4. Spatial patterns of tag incidence in Fraser River sockeye mark-recapture programs, between 1994 and 1998. Figures with a thick line represent cases in which a chi-square test of the effect of recovery area on tag incidence (spatial application bias test) was significant. The x-axis represents recovery areas moving upstream from left to right.

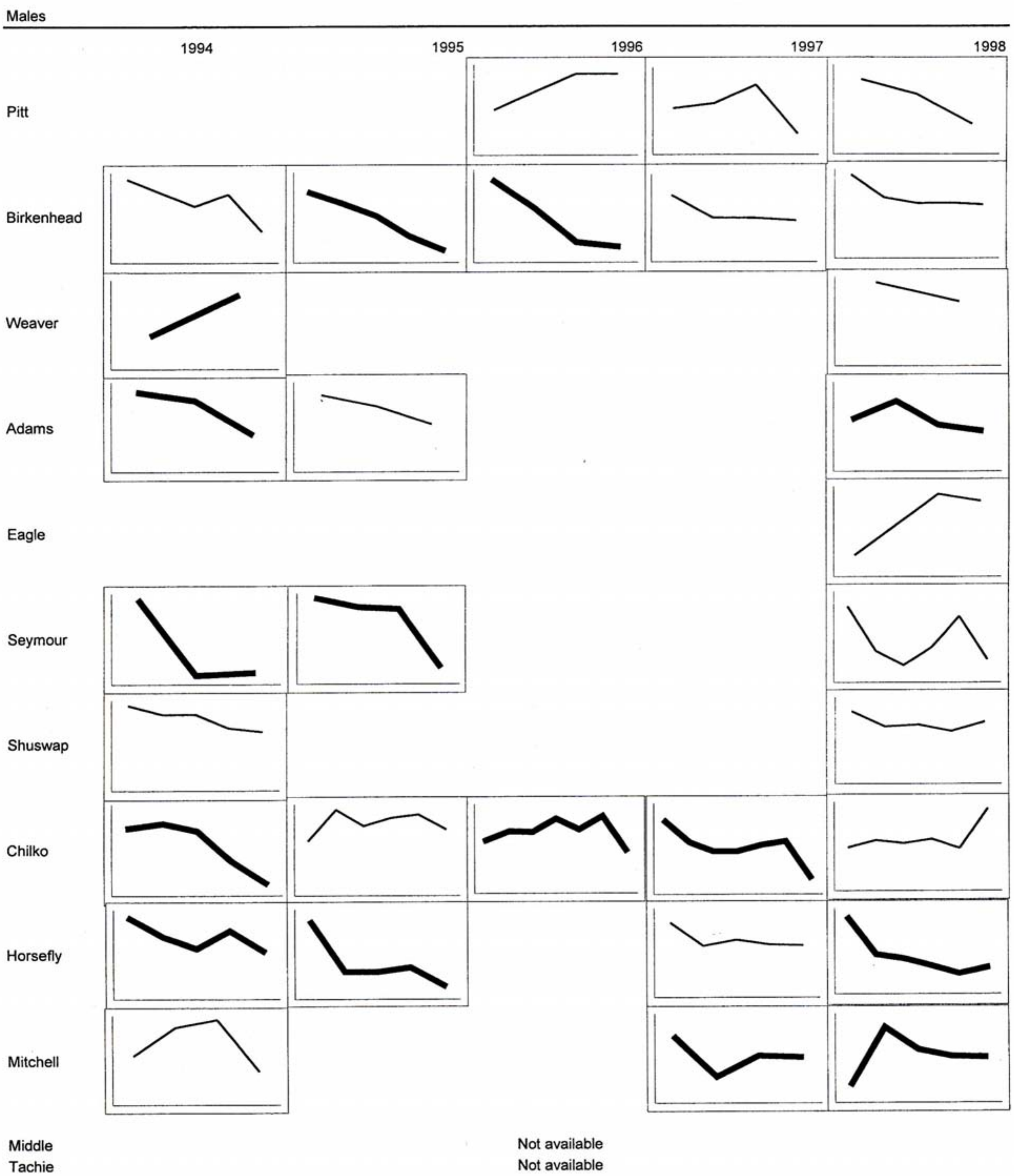
Females




| | |
|---|---|
| Middle | Not available |
| Tachie | Not available |

Continued

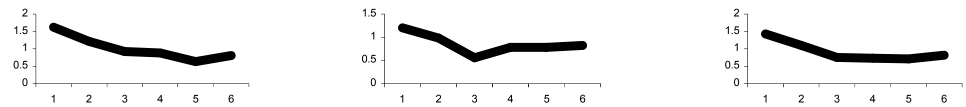
Appendix 4. Spatial patterns of tag incidence in Fraser River sockeye mark-recapture programs, between 1994 and 1998. Figures with a thick line represent cases in which a chi-square test of the effect of recovery area on tag incidence (spatial application bias test) was significant. X-axis represents recovery areas moving upstream from left to right.



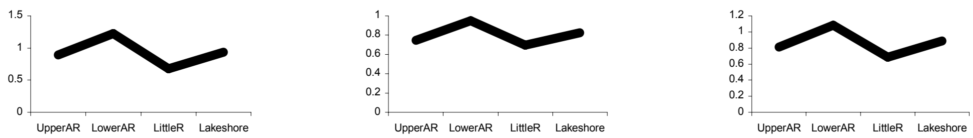
Appendix 5. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results ($p<0.05$, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

*Adams*

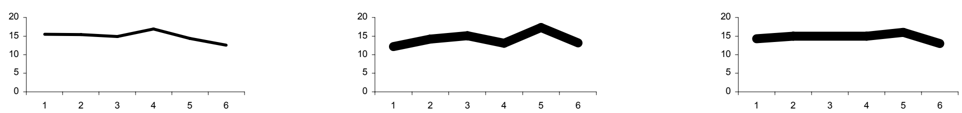
MALE FEMALE POOLED



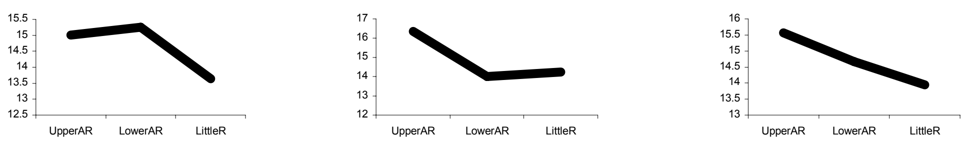

Tag Incidence vs Recovery Period




Tag Incidence vs Recovery Area




Recovery rate vs Application Period

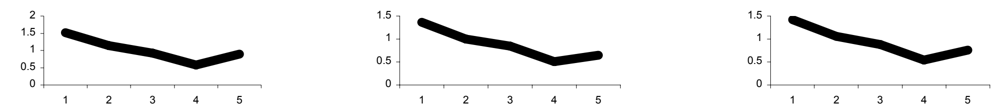



Recovery rate vs tagging area

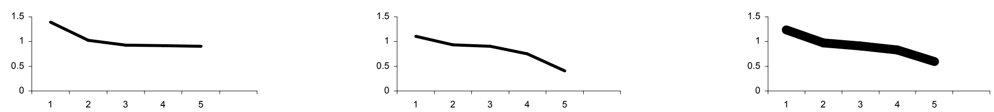
Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results (p<0.05, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

*Birkenhead*

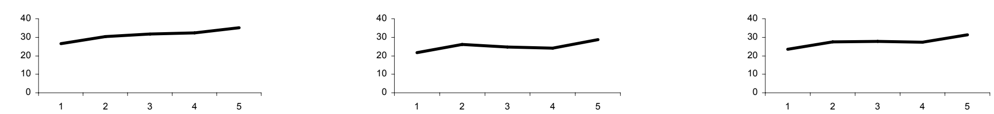
MALE FEMALE POOLED



Tag Incidence vs Recovery Period

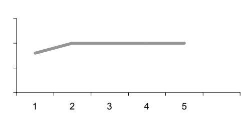


Tag Incidence vs Recovery Area



Recovery rate vs Application Period

MALE & FEMALE



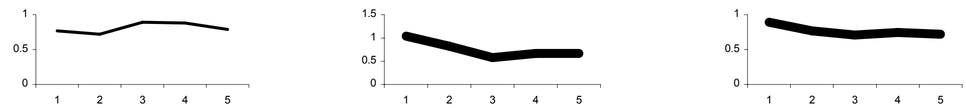
Recovery rate vs spawning area (best guess)*

* The guess was based on the following logic: i) Except for the bottom reaches, the river morphology is quite consistent over the extent of spawning, with carcasses relatively likely to become available to recovery- in the bottom reach, the river deepens and slows, with riprap banks, probably resulting in lower recoverability of carcasses (approximately 10-20% of the population spawned low enough to have experienced this lower recovery rate), and ii) Recovery effort was quite evenly applied spatially.

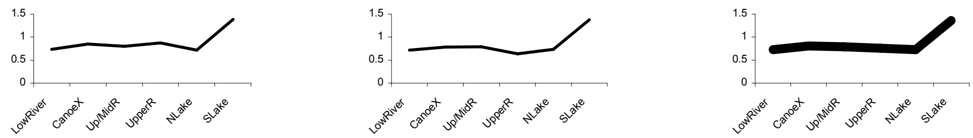
Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results (p<0.05, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

*Chilko*

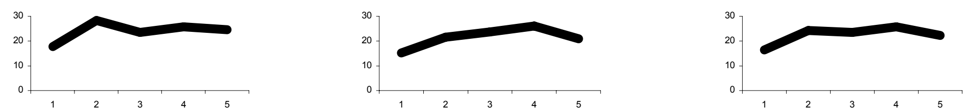
MALE | FEMALE | POOLED




Tag Incidence vs Recovery Period

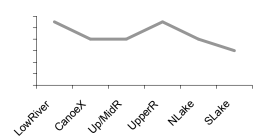



Tag Incidence vs Recovery Area




Recovery rate vs Application Period

MALE & FEMALE



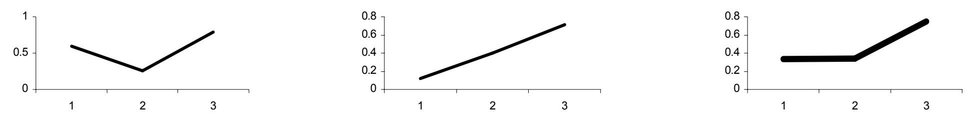

Recovery rate vs spawning area (best guess) *

* The guess was based on the following logic: the lower and upper river morphology lends itself best to recovery. In canoe crossing, the river is slow and broad, with probable low recoverability of fish spawning there and the larger number of fish spawning in the area just above ('upper/mid'). In the lake, carcasses are relatively unlikely to come to shore. Recovery rates for south lake spawners are probably lower than north lake because the shores of the south lake are mostly steeply sloped unlike the north lake (gravel shoreline common).

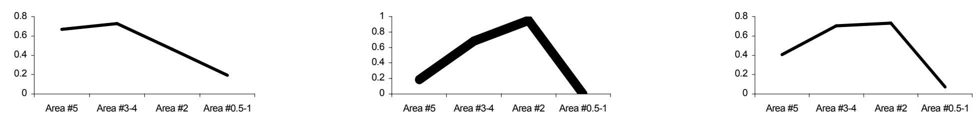
Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results (p<0.05, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

*Eagle*

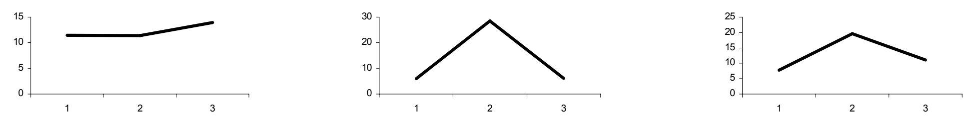
MALE FEMALE POOLED




Tag Incidence vs Recovery Period

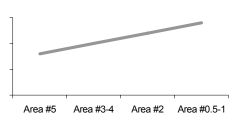



Tag Incidence vs Recovery Area




Recovery rate vs Application Period

MALE & FEMALE



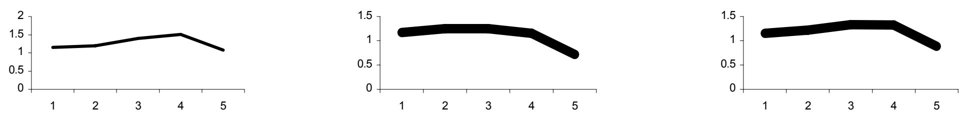

Recovery rate vs spawning area (best guess) *

* The guess was based on the following logic: The upper river had lower volume and lower turbidity, and was shallower, and thus had a higher recovery probability than the lower river.

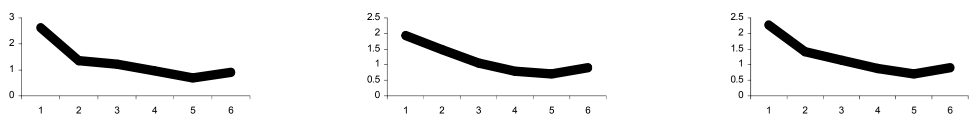
Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results ($p<0.05$, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

*Horsefly*

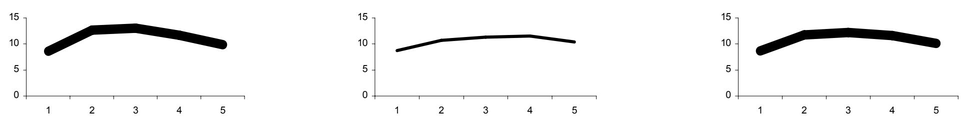
MALE FEMALE POOLED




Tag Incidence vs Recovery Period

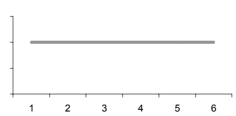



Tag Incidence vs Recovery Area




Recovery rate vs Application Period

MALE & FEMALE



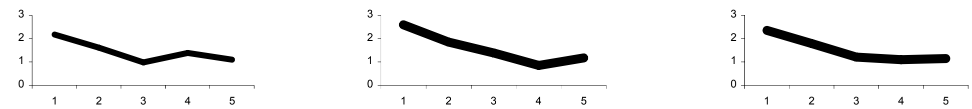

Recovery rate vs spawning area (best guess) *

* The guess was based on the following logic: i) a small (<10%) of spawning occurs within 1 km upstream of the two major unrecoverable carcass sinks (Quesnel Lake and the meandering reach in the mid-river), ii) the river volume is similar throughout the length of spawning, iii) recovery effort was very consistently applied spatially.

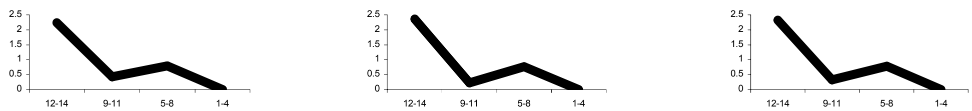
Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results (p<0.05, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

Middle

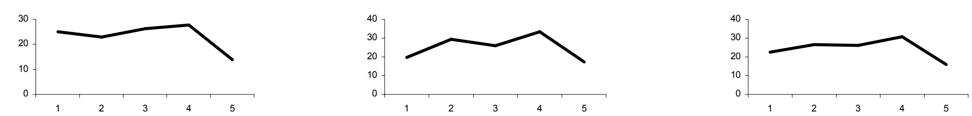
MALE FEMALE POOLED



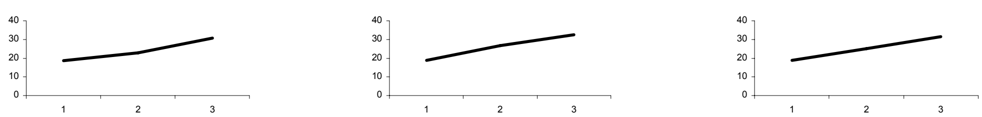

Tag Incidence vs Recovery Period




Tag Incidence vs Recovery Area




Recovery rate vs Application Period

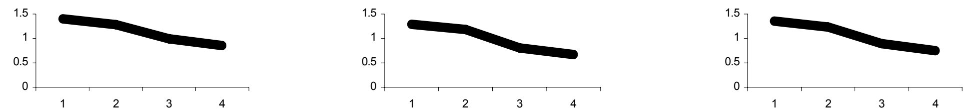



Recovery rate vs spawning area

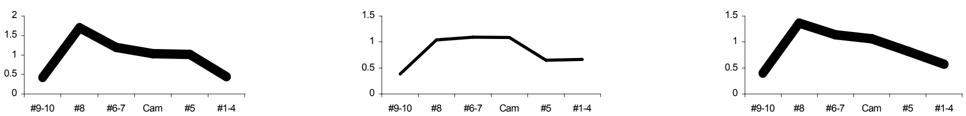
Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results ($p<0.05$, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

Mitchell

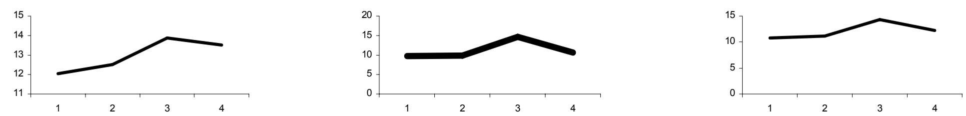
MALE FEMALE POOLED



Tag Incidence vs Recovery Period

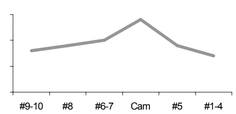



Tag Incidence vs Recovery Area



Recovery rate vs Application Period

MALE & FEMALE



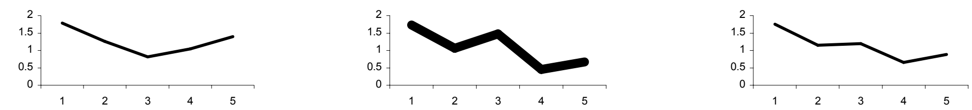

Recovery rate vs spawning area (best guess) *

* The guess was based on the following logic: i) The bottom end of the river is slow and deeper than the rest of river. Cameron creek had high recovery rate due to its small volume. Near the bottom of area 5, a canyon probably acted as a carcass sink for area five spawners. Access to reaches 1-4 was difficult, resulting in less frequent and extensive surveys than in the rest of the river. Approximately 75% of spawning occurred in the Mitchell River itself from reach 5 to 7.

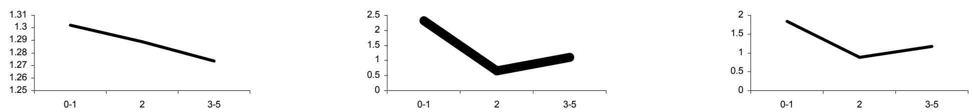
Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results (p<0.05, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

Pitt

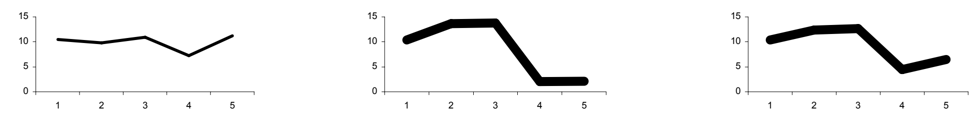
MALE FEMALE POOLED




Tag Incidence vs Recovery Period

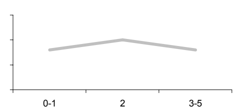



Tag Incidence vs Recovery Area




Recovery rate vs Application Period

MALE & FEMALE




Recovery rate vs spawning area (best guess) *

* The guess was based on the following logic: The majority of area 2 spawners spawn in Corbold Creek where recovery rates should be relatively high due to the lower volume of the creek.

Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results ($p<0.05$, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

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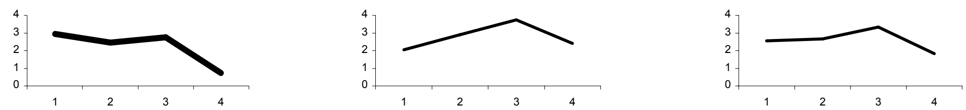
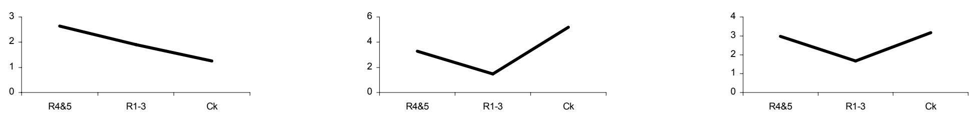
Seymour

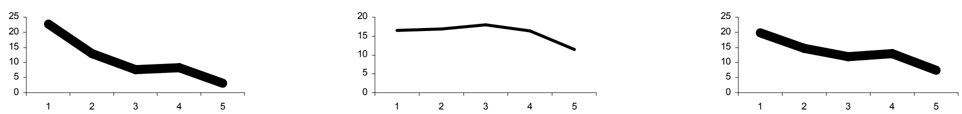
MALE FEMALE POOLED




Tag Incidence vs Recovery Period

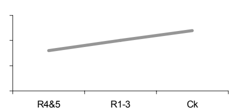



Tag Incidence vs Recovery Area




Recovery rate vs Application Period

MALE & FEMALE




Recovery rate vs spawning area (best guess) *

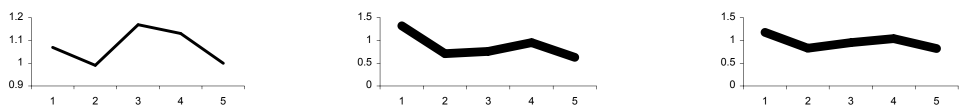
---

* The guess was based on the following logic: i) Reach 4 and 5 are slower and deeper than reaches 1-3, and carcasses dying there have less distance to become recoverable. ii) This difference in recovery probability between lower (R5&4) and upper (R1-3) river spawners is known to have existed in 1995 when fish were tagged in both areas. iii) McNomee Creek is low volume and therefore, a high fraction of carcasses probably become available to recovery.

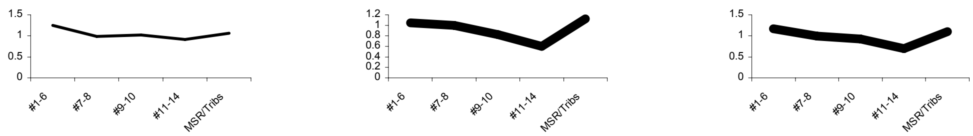
Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results ($p<0.05$, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

Shuswap

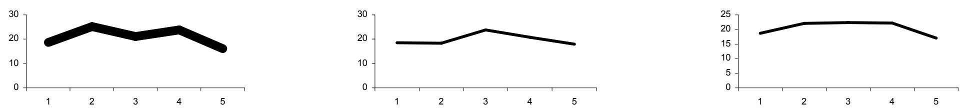
MALE FEMALE POOLED




Tag Incidence vs Recovery Period

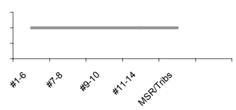



Tag Incidence vs Recovery Area




Recovery rate vs Application Period

MALE & FEMALE




Recovery rate vs spawning area (best guess) *

* The guess was based on the following logic: i) The morphology and volume of the lower and middle Shuswap are quite consistent through most of the study area. ii) Spawners upstream of two areas with probable low recovery probabilities (reach 4 & 5, canyon in reach 11) are seperated from these areas by several hundred meters with high recoverability. iii) Recovery effort was evenly applied throughout the study area.

Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results ($p<0.05$, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

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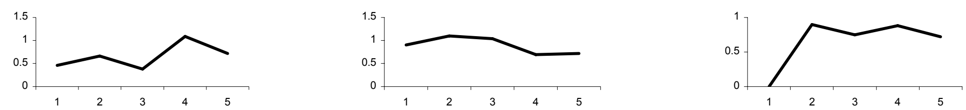
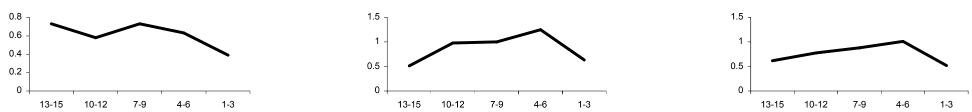
Tachie

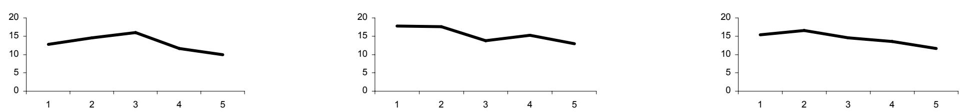
MALE FEMALE POOLED




Tag Incidence vs Recovery Period

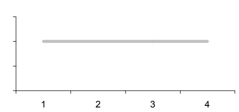



Tag Incidence vs Recovery Area




Recovery rate vs Application Period

MALE & FEMALE




Recovery rate vs spawning area (best guess) *

---

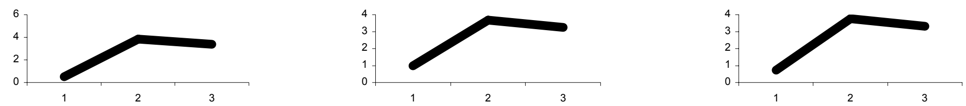
* The guess was based on the following logic: i) the river morphology was quite constant throughout the study area, and ii) recovery effort was quite evenly applied.

NOTE: All tests had low power; thus, significant sampling biases could be present

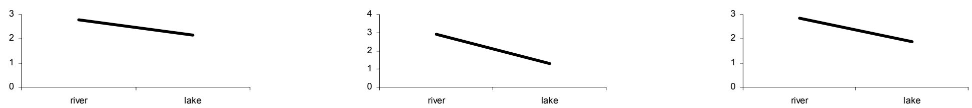
Appendix 5, continued. Application and recovery sampling profiles in the 1998 mark recapture studies of sockeye salmon. Thick lines represent significant test results (p<0.05, chi-square test). The x-axis represents time periods (temporal patterns) or areas (spatial patterns); from left to right, recovery periods are ordered from the start to the end of the program, while areas are ordered from downstream up (unless area names are given).

*Weaver*

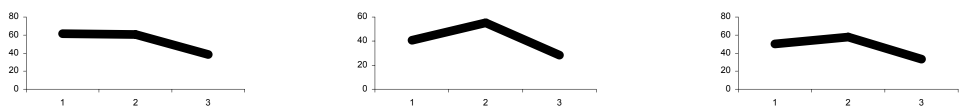
MALE FEMALE POOLED



Tag Incidence vs Recovery Period

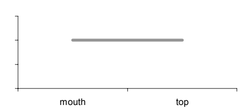



Tag Incidence vs Recovery Area



Recovery rate vs Application Period

MALE & FEMALE




Recovery rate vs spawning area (best guess) *

* The guess was based on the following logic: The mark-recapture study area is so small, with spawning extending for approx. 800m upstream of Morris Lake, that recovery rates probably had little opportunity to vary spatially.

Appendix 6. Mean daily sockeye counts during 15-minute index periods at towers or bridge crossings in the Adams, Lower Shuswap, Chilko and Quesnel rivers, 1998.

| | Lower Adams River West Channel Tower | | Lower Adams River East Channel Tower | | Lower Shuswap River Enderby Bridge | | Chilko River Henry's Bridge | | Quesnel River Likely Bridge | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Number of counts per day [A] | Mean sockeye count | Number of counts per day [A] | Mean sockeye count | Number of counts per day [A] | Mean sockeye count | Number of counts per day [A] | Mean sockeye count | Number of counts per day [A] | Mean sockeye count |
| 1-Aug | - | - | - | - | - | - | 8 | 1 | 8 | 0 |
| 2-Aug | - | - | - | - | - | - | 8 | 0 | 8 | 0 |
| 3-Aug | - | - | - | - | - | - | 8 | 0 | 8 | 0 |
| 4-Aug | - | - | - | - | - | - | 8 | 0 | 8 | 0 |
| 5-Aug | - | - | - | - | - | - | 8 | 1 | 8 | 3 |
| 6-Aug | - | - | - | - | - | - | 9 | 0 | 8 | 5 |
| 7-Aug | - | - | - | - | - | - | 9 | 0 | 8 | 6 |
| 8-Aug | - | - | - | - | - | - | 14 | 0 | 8 | 3 |
| 9-Aug | - | - | - | - | - | - | 14 | 0 | 8 | 8 |
| 10-Aug | - | - | - | - | - | - | 14 | 1 | 8 | 4 |
| 11-Aug | - | - | - | - | - | - | 14 | 10 | 8 | 3 |
| 12-Aug | - | - | - | - | - | - | 14 | 5 | 8 | 6 |
| 13-Aug | - | - | - | - | - | - | 14 | 13 | 8 | 5 |
| 14-Aug | - | - | - | - | - | - | 14 | 9 | 8 | 15 |
| 15-Aug | - | - | - | - | - | - | 14 | 6 | 8 | 13 |
| 16-Aug | - | - | - | - | - | - | 14 | 10 | 8 | 65 |
| 17-Aug | - | - | - | - | - | - | 14 | 29 | 8 | 154 |
| 18-Aug | - | - | - | - | - | - | 14 | 95 | 8 | 107 |
| 19-Aug | - | - | - | - | - | - | 14 | 165 | 8 | 84 |
| 20-Aug | - | - | - | - | - | - | 14 | 152 | 8 | 52 |
| 21-Aug | - | - | - | - | - | - | 14 | 238 | 8 | 38 |
| 22-Aug | - | - | - | - | - | - | 14 | 61 | 8 | 107 |
| 23-Aug | - | - | - | - | - | - | 14 | 316 | 8 | 151 |
| 24-Aug | - | - | - | - | - | - | 14 | 247 | 8 | 399 |
| 25-Aug | - | - | - | - | - | - | 14 | 137 | 8 | 550 |
| 26-Aug | - | - | - | - | - | - | 14 | 249 | 8 | 372 |
| 27-Aug | - | - | - | - | - | - | 14 | 306 | 8 | 251 |
| 28-Aug | - | - | - | - | - | - | 14 | 479 | 8 | 122 |
| 29-Aug | - | - | - | - | - | - | 14 | 287 | 8 | 148 |
| 30-Aug | - | - | - | - | - | - | 14 | 196 | 8 | 184 |
| 31-Aug | 1 [B] | 0 | - | - | - | - | 14 | 213 | 8 | 263 |
| 1-Sep | 1 [B] | 0 | - | - | - | - | 14 | 167 | 8 | 239 |
| 2-Sep | 1 [B] | 9 | - | - | - | - | 14 | 283 | 8 | 146 |
| 3-Sep | 1 [B] | 1 | - | - | - | - | 14 | 220 | 8 | 137 |
| 4-Sep | 1 [B] | 1 | - | - | - | - | 14 | 309 | 8 | 160 |
| 5-Sep | 1 [B] | 0 | - | - | - | - | 14 | 265 | 8 | 224 |
| 6-Sep | 1 [B] | 2 | - | - | - | - | 14 | 170 | 8 | 309 |
| 7-Sep | 1 [B] | 15 | - | - | - | - | 14 | 235 | 8 | 206 |
| 8-Sep | - | - | - | - | - | - | 14 | 296 | 8 | 230 |
| 9-Sep | - | - | - | - | - | - | 14 | 424 | 8 | 201 |
| 10-Sep | 1 [B] | 5 | - | - | - | - | 14 | 413 | 8 | 171 |
| 11-Sep | 2 [B] | 417 | - | - | - | - | 14 | 500 | 8 | 109 |
| 12-Sep | 3 [B] | 353 | - | - | - | - | 14 | 197 | 8 | 75 |
| 13-Sep | 8 [B] | 557 | - | - | - | - | 14 | 160 | 8 | 74 |
| 14-Sep | - | | - | - | - | - | 14 | 114 | 8 | 42 |
| 15-Sep | - | | - | - | - | - | 14 | 76 | 8 | 57 |
| 16-Sep | - | | - | - | - | - | 14 | 65 | 8 | 34 |
| 17-Sep | 6 [B] | 303 | - | - | - | - | 14 | 46 | 8 | 18 |
| 18-Sep | 8 [B] | 1,084 | - | - | - | - | 14 | 40 | 8 | 16 |

Continued

Appendix 6. Mean daily sockeye counts during 15-minute index periods at towers or bridge crossings in the Adams, Lower Shuswap, Quesnel and Chilko rivers, 1998 continued.

| | Lower Adams River West Channel Tower | | Lower Adams River East Channel Tower | | Lower Shuswap River Enderby Bridge | | Chilko River Henry's Bridge | | Quesnel River Likely Bridge | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Number of counts per day [A] | Mean sockeye count | Number of counts per day [A] | Mean sockeye count | Number of counts per day [A] | Mean sockeye count | Number of counts per day [A] | Mean sockeye count | Number of counts per day [A] | Mean sockeye count |
| 19-Sep | - | - | - | - | - | - | 14 | 23 | 8 | 12 |
| 20-Sep | - | - | - | - | - | - | 14 | 29 | 8 | 7 |
| 21-Sep | - | - | - | - | - | - | 14 | 18 | 8 | 6 |
| 22-Sep | 10 | 0 | 20 | 1 | - | - | 14 | 19 | 8 | 6 |
| 23-Sep | 11 | 2 | 25 | 5 | - | - | 14 | 19 | 8 | 10 |
| 24-Sep | 6 | 1 | 11 | 5 | - | - | 14 | 12 | 8 | 8 |
| 25-Sep | 7 | 0 | 15 | 32 | - | - | 14 | 9 | 8 | 7 |
| 26-Sep | 6 | 83 | 16 | 169 | - | - | 14 | 5 | 8 | 3 |
| 27-Sep | 11 | 109 [C] | 23 | 64 | - | - | 14 | 11 | 8 | 2 |
| 28-Sep | 5 | 133 | 14 | 249 | 16 | 2 | 14 | 8 | 8 | 1 |
| 29-Sep | 7 | 62 | 16 | 515 | 16 | 28 | 14 | 3 | 8 | 1 |
| 30-Sep | 6 | 163 | 15 | 779 | 16 | 62 | 14 | 2 | 8 | 1 |
| 1-Oct | 8 | 246 | 16 | 1,126 | 16 | 225 | 14 | 7 | - | - |
| 2-Oct | 8 | 61 | 15 | 132 | 16 | 304 | 14 | 3 | - | - |
| 3-Oct | 8 | 351 | 15 | 623 | 16 | 554 | 14 | 2 | - | - |
| 4-Oct | 8 | 475 | 16 | 880 | 16 | 609 | - | - | - | - |
| 5-Oct | 8 | 249 | 16 | 209 | 16 | 594 | - | - | - | - |
| 6-Oct | 8 | 205 | 16 | 455 | 16 | 254 | - | - | - | - |
| 7-Oct | 8 | 33 | 16 | 24 | 20 | 311 | - | - | - | - |
| 8-Oct | 8 | 53 | 16 | 21 | 17 | 120 | - | - | - | - |
| 9-Oct | 7 | 58 | 16 | 16 | 16 | 55 | - | - | - | - |
| 10-Oct | 8 | 43 | 15 | 48 | 16 | 56 | - | - | - | - |
| 11-Oct | 8 | 46 | 16 | 128 | 16 | 73 | - | - | - | - |
| 12-Oct | 8 | 110 | 16 | 382 | 16 | 32 | - | - | - | - |
| 13-Oct | 7 | 156 | 16 | 865 | 16 | 32 | - | - | - | - |
| 14-Oct | 8 | 67 | 16 | 239 | 15 | 26 | - | - | - | - |
| 15-Oct | 8 | 78 | 16 | 157 | 16 | 18 | - | - | - | - |
| 16-Oct | 8 | 109 | 16 | 93 | 16 | 12 | - | - | - | - |
| 17-Oct | 8 | 101 | 15 | 249 | 16 | 6 | - | - | - | - |
| 18-Oct | 8 | 72 | 15 | 95 | 16 | 4 | - | - | - | - |
| 19-Oct | 8 | 80 | 16 | 102 | 16 | 0 | - | - | - | - |
| 20-Oct | 7 | 59 | 16 | 239 | 16 | 1 | - | - | - | - |
| 21-Oct | 8 | 56 | 16 | 80 | 16 | 1 | - | - | - | - |
| 22-Oct | 8 | 30 | 15 | 77 | 16 | 0 | - | - | - | - |
| 23-Oct | 7 | 30 | 15 | 111 | 16 | 1 | - | - | - | - |
| 24-Oct | 8 | 16 | 16 | 21 | 16 | 0 | - | - | - | - |
| 25-Oct | 7 | 15 | 16 | 71 | - | - | - | - | - | - |
| 26-Oct | 7 | 23 | 16 | 163 | - | - | - | - | - | - |
| 27-Oct | 8 | 22 | 16 | 126 | - | - | - | - | - | - |
| 28-Oct | 7 | 18 | 16 | 25 | - | - | - | - | - | - |
| 29-Oct | 8 | 16 | 16 | 24 | - | - | - | - | - | - |
| 30-Oct | 8 | 20 | 16 | 24 | - | - | - | - | - | - |
| 31-Oct | 7 | 3 | 15 | 4 | - | - | - | - | - | - |

A. Fifteen minute counts every half hour.

B. Initial counts were at the Squalax Bridge across Little River.

C. Jet boats and scuba divers disrupted migration

Appendix 7. Daily sockeye counts at enumeration fences constructed in the Fraser River system, 1998.

| | | | | | | | Early Stuart Group | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Eagle River [A] | Kuzkwa Creek | McKinley Creek | Scotch Creek [B] | Salmon River [B] | Stellako River | Forfar Creek | Gluske Creek | Kynoch Creek | Sweltzer Creek |
| 14-Jul | - | - | - | - | - | | - | - | - | - |
| 15-Jul | - | - | - | - | - | | - | - | - | - |
| 16-Jul | - | - | - | - | - | | - | 0 | - | - |
| 17-Jul | - | - | - | - | - | | 0 | 0 | - | - |
| 18-Jul | - | - | - | - | - | - | 0 | 0 | 0 | - |
| 19-Jul | - | - | - | - | - | - | 0 | 0 | 0 | - |
| 20-Jul | - | - | - | - | - | - | 0 | 0 | 0 | - |
| 21-Jul | - | - | - | - | - | - | 0 | 0 | 2 | - |
| 22-Jul | - | - | - | - | - | - | 0 | 0 | 88 [C] | - |
| 23-Jul | - | - | - | - | - | - | 0 | 9 | 399 | - |
| 24-Jul | - | - | - | - | - | - | 16 | 19 | 244 | - |
| 25-Jul | - | - | - | - | - | - | 3 | 184 | 18 | - |
| 26-Jul | - | - | - | - | - | - | 0 | 43 | 183 | - |
| 27-Jul | - | - | - | - | - | - | 97 | 44 | 219 | - |
| 28-Jul | - | - | - | - | - | - | 49 | 52 | 128 | - |
| 29-Jul | - | - | - | - | - | - | 2 | 40 | 213 | - |
| 30-Jul | - | - | - | - | - | - | 101 | 33 | 63 | - |
| 31-Jul | - | - | - | - | - | - | 55 | 75 | 58 | - |
| 1-Aug | - | - | - | - | - | - | 33 | 37 | 37 | - |
| 2-Aug | - | - | - | - | - | - | 86 | 42 | 44 | - |
| 3-Aug | - | - | - | - | - | - | 47 | 21 | 100 | - |
| 4-Aug | - | - | - | - | - | - | 105 | 21 | 98 | - |
| 5-Aug | - | - | - | - | - | - | 29 | 85 | 19 | - |
| 6-Aug | - | - | - | - | - | - | 70 | 18 | 38 | - |
| 7-Aug | - | - | - | - | - | - | 75 | 7 | 39 | - |
| 8-Aug | - | - | - | - | - | - | 2 | 19 | 30 | - |
| 9-Aug | - | - | - | - | - | - | 33 | 12 | 69 | - |
| 10-Aug | - | - | - | - | - | - | 8 | 25 | 56 | - |
| 11-Aug | - | - | - | - | - | - | 14 | 5 | 1 | - |
| 12-Aug | - | - | - | - | - | - | 64 | 11 | 57 | - |
| 13-Aug | - | - | - | - | - | - | 52 | 4 | 35 | - |
| 14-Aug | - | - | - | 0 | - | - | 12 | 3 | 13 | - |
| 15-Aug | - | - | - | 2 | - | - | -1 | 2 | 14 | - |
| 16-Aug | - | - | - | 61 | - | - | 4 | 1 | 3 | - |
| 17-Aug | - | - | - | 2,174 | - | - | -2 | 0 | 0 | - |
| 18-Aug | - | - | - | 1,713 | - | 13 | 2 | 0 | 2 | - |
| 19-Aug | - | - | - | 856 | - | 17 | - | 0 | - | - |
| 20-Aug | - | - | - | 1,023 | - | 20 | - | 0 | - | - |
| 21-Aug | - | - | - | 889 | - | 169 | - | 0 | - | - |
| 22-Aug | - | - | - | 3,623 | - | 349 | - | 0 | - | - |
| 23-Aug | - | - | - | 3,782 | - | 197 | - | - | - | - |
| 24-Aug | - | - | 3,214 | 2,999 | - | 205 | - | - | - | - |
| 25-Aug | - | - | 3,859 | 2,966 | - | 38 | - | - | - | - |
| 26-Aug | - | - | 2,216 | 3,654 | - | 56 | - | - | - | - |
| 27-Aug | - | - | 5,756 | 3,334 | - | 38 | - | - | - | - |
| 28-Aug | - | - | 5,746 | 833 | - | 118 | - | - | - | - |
| 29-Aug | - | - | 6,399 | 1,187 | - | 732 | - | - | - | - |
| 30-Aug | - | - | 4,419 | 1,227 | - | 84 | - | - | - | - |
| 31-Aug | - | - | 2,322 | 655 | - | 1,650 | - | - | - | - |
| 1-Sep | - | - | 8,355 | 1,184 | - | 24 | - | - | - | - |
| 2-Sep | - | - | 4,621 | 861 | - | 393 | - | - | - | - |
| 3-Sep | - | - | 2,309 | 599 | - | 355 | - | - | - | - |
| 4-Sep | - | - | 2,778 | 607 | - | 23 | - | - | - | - |
| 5-Sep | - | 0 | 2,637 | 1,082 | - | 46 | - | - | - | - |
| 6-Sep | - | 8 | 3,724 | 337 | - | 1,373 | - | - | - | - |
| 7-Sep | - | 14 | 2,578 | 19 | - | 5,511 | - | - | - | - |
| 8-Sep | - | 0 | 1,868 | 158 | - | 17,402 | - | - | - | - |

Continued

Appendix 7. Daily sockeye counts at enumeration fences constructed in the Fraser River system, 1998 continued.

| | | | | | | | Early Stuart Group | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Eagle River [A] | Kuzkwa Creek | McKinley Creek | Scotch Creek | Salmon River [B] | Stellako River | Forfar Creek | Gluske Creek | Kynoch Creek | Sweltzer Creek |
| 9-Sep | - | 0 | 1,504 | 16 | - | 17,642 | - | - | - | - |
| 10-Sep | - | 28 | 1,789 | 55 | - | 21,166 | - | - | - | - |
| 11-Sep | - | 0 | 2,677 | 30 | - | 12,294 | - | - | - | - |
| 12-Sep | - | 0 | 1,935 | 31 | - | 8,624 | - | - | - | - |
| 13-Sep | - | 1297 | 1,813 | 11 | - | 10,620 | - | - | - | - |
| 14-Sep | - | 1 | 1,087 | 0 | - | 8,939 | - | - | - | 6 |
| 15-Sep | - | 0 | 602 | - | - | 3,068 | - | - | - | 2 |
| 16-Sep | - | 2 | 418 | - | - | 5,854 | - | - | - | 3 |
| 17-Sep | - | 154 | 406 | - | - | 14,620 | - | - | - | 3 |
| 18-Sep | - | 489 | 238 | - | - | 8,822 | - | - | - | 2 |
| 19-Sep | - | 193 | 108 | - | - | 9,561 | - | - | - | 3 |
| 20-Sep | - | 164 | 100 | - | - | 10,720 | - | - | - | 7 |
| 21-Sep | - | 60 | 74 | - | - | 5,130 | - | - | - | 19 |
| 22-Sep | - | 401 | 88 | - | - | 3,184 | - | - | - | 7 |
| 23-Sep | - | 11 | 58 | - | - | 1,756 | - | - | - | 9 |
| 24-Sep | - | 11 | 71 | - | - | 986 | - | - | - | 7 |
| 25-Sep | - | 0 | 56 | - | - | 2,670 | - | - | - | 11 |
| 26-Sep | - | 24 | 1 | - | - | 1,439 | - | - | - | 21 |
| 27-Sep | - | 7 | 0 | - | - | 1,364 | - | - | - | 62 |
| 28-Sep | - | 3 | 3 | - | - | 772 | - | - | - | 13 |
| 29-Sep | - | 0 | 0 | - | - | 1,092 | - | - | - | 6 |
| 30-Sep | - | 0 | 0 | - | - | 935 | - | - | - | 6 |
| 1-Oct | 206 | 0 | - | - | - | 622 | - | - | - | 22 |
| 2-Oct | 501 | 0 | - | - | - | 650 | - | - | - | 10 |
| 3-Oct | 844 | 0 | - | - | - | 626 | - | - | - | 7 |
| 4-Oct | 1,707 | 0 | - | - | - | 1687 | - | - | - | 6 |
| 5-Oct | 2,297 | - | - | - | 1 | 1239 | - | - | - | 7 |
| 6-Oct | 836 | - | - | - | - | 1298 | - | - | - | 6 |
| 7-Oct | 711 | - | - | - | 1 | 715 | - | - | - | 18 |
| 8-Oct | 813 | - | - | - | 1 | 271 | - | - | - | 6 |
| 9-Oct | 713 | - | - | - | - | 220 | - | - | - | 7 |
| 10-Oct | 681 | - | - | - | - | 78 | - | - | - | 16 |
| 11-Oct | 341 | - | - | - | 1 | 123 | - | - | - | 3 |
| 12-Oct | 118 | - | - | - | - | 128 | - | - | - | 9 |
| 13-Oct | 115 | - | - | - | 17 | 84 | - | - | - | 11 |
| 14-Oct | 192 | - | - | - | 4 | 37 | - | - | - | 129 |
| 15-Oct | 128 | - | - | - | 5 | 20 | - | - | - | 279 |
| 16-Oct | 61 | - | - | - | 4 | 47 | - | - | - | 160 |
| 17-Oct | 60 | - | - | - | 17 | 28 | - | - | - | 14 |
| 18-Oct | 31 | - | - | - | 2 | 0 | - | - | - | 167 |
| 19-Oct | 32 | - | - | - | - | - | - | - | - | 134 |
| 20-Oct | 19 | - | - | - | - | - | - | - | - | 63 |
| 21-Oct | 0 | - | - | - | 6 | - | - | - | - | 116 |
| 22-Oct | 0 | - | - | - | 6 | - | - | - | - | 62 |
| 23-Oct | 0 | - | - | - | 7 | - | - | - | - | 84 |
| 24-Oct | 0 | - | - | - | - | - | - | - | - | 25 |
| 25-Oct | 0 | - | - | - | 1 | - | - | - | - | 15 |
| 26-Oct | 0 | - | - | - | 1 | - | - | - | - | 22 |
| 27-Oct | 0 | - | - | - | 2 | - | - | - | - | 24 |
| 28-Oct | 0 | - | - | - | - | - | - | - | - | 33 |
| 29-Oct | 0 | - | - | - | 1 | - | - | - | - | 50 |
| 30-Oct | 0 | - | - | - | 1 | - | - | - | - | 27 |
| 31-Oct | 0 | - | - | - | - | - | - | - | - | 35 |
| 1-Nov | 0 | - | - | - | 1 | - | - | - | - | 17 |
| 2-Nov | 0 | - | - | - | 1 | - | - | - | - | 30 |
| 3-Nov | 0 | - | - | - | - | - | - | - | - | 21 |
| 4-Nov | 0 | - | - | - | - | - | - | - | - | 23 |

Continued

Appendix 7. Daily sockeye counts at enumeration fences constructed in the Fraser River system, 1998 continued.

| | | | | | | | Early Stuart Group | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Eagle River [A] | Kuzkwa Creek | McKinley Creek | Scotch Creek | Salmon River [B] | Stellako River | Forfar Creek | Gluske Creek | Kynoch Creek | Sweltzer Creek |
| 5-Nov | 0 | - | - | - | 1 | - | - | - | - | 19 |
| 6-Nov | 0 | - | - | - | - | - | - | - | - | 20 |
| 7-Nov | 0 | - | - | - | - | - | - | - | - | 58 |
| 8-Nov | 0 | - | - | - | - | - | - | - | - | 11 |
| 9-Nov | 0 | - | - | - | - | - | - | - | - | 8 |
| 10-Nov | 92 | - | - | - | - | - | - | - | - | 8 |
| 11-Nov | 0 | - | - | - | - | - | - | - | - | 10 |
| 12-Nov | 0 | - | - | - | - | - | - | - | - | 33 |
| 13-Nov | 0 | - | - | - | - | - | - | - | - | 38 |
| 14-Nov | - | - | - | - | - | - | - | - | - | 25 |
| 15-Nov | - | - | - | - | - | - | - | - | - | 22 |
| 16-Nov | - | - | - | - | - | - | - | - | - | 10 |
| 17-Nov | - | - | - | - | - | - | - | - | - | 11 |
| 18-Nov | - | - | - | - | - | - | - | - | - | 7 |
| 19-Nov | - | - | - | - | - | - | - | - | - | 5 |
| 20-Nov | - | - | - | - | - | - | - | - | - | 3 |
| 21-Nov | - | - | - | - | - | - | - | - | - | 1 |
| 22-Nov | - | - | - | - | - | - | - | - | - | 0 |
| 23-Nov | - | - | - | - | - | - | - | - | - | 0 |
| 24-Nov | - | - | - | - | - | - | - | - | - | - |
| 25-Nov | - | - | - | - | - | - | - | - | - | - |
| 26-Nov | - | - | - | - | - | - | - | - | - | - |
| 27-Nov | - | - | - | - | - | - | - | - | - | - |
| 28-Nov | - | - | - | - | - | - | - | - | - | - |
| 29-Nov | - | - | - | - | - | - | - | - | - | - |
| 30-Nov | - | - | - | - | - | - | - | - | - | - |
| Male | 5,445 [E] | 1,393 | 37,892 [D] | 17,962 [D] | 51 | 88,353 [F] | 546 [D] | 453 [D] | 1,059 [D] | 928 [D] |
| Female | 5,053 [E] | 1,471 | 37,937 [D] | 17,994 [D] | 27 | 99,535 [F] | 407 [D] | 358 [D] | 1,207 [D] | 1,031 [D] |
| Jack | 0 [E] | 3 | 0 [D] | 12 [D] | 0 | 56 | 3 [D] | 1 [D] | 4 [D] | 175 [D] |
| Total | 10,498 | 2,867 | 75,829 | 35,968 | 78 | 187,944 | 956 | 812 | 2,270 | 2,134 |

A. Data provided by Habitat and Enhancement Branch.

B. Data provided by Shuswap Nation Fisheries Commission.

C. Fence breached, live count of 90 fish above fence.

D. Sex ratio and jack composition estimated from carcass surveys upstream from the fence.

E. From observations at the fence.

F. Sex ratio was from the total carcass sample. Includes Nadina spawners; excludes pre-fence installation immigrants and below-fence spawners.

Appendix 8. Daily live counts, male, female and jack carcass recoveries, and female spawning success from the Gates, Nadina and Weaver spawning channels, 1998.

| | Gates Creek Channel | | | | | | | Nadina River Channel | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Carcasses recovered | | | % spawned | | | | Carcasses recovered | | | % spawned | | |
| Date | Live count | Male | Female | Jack | 0% | 50% | 100% | Live count | Male | Female | Jack | 0% | 50% | 100% |
| 8-Aug | 1 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 9-Aug | 1 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 10-Aug | 1 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 11-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 12-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 13-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 14-Aug | 2 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 15-Aug | 5 | 0 | 1 | 0 | 1 | 0 | 0 | - | - | - | - | - | - | - |
| 16-Aug | 72 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 17-Aug | 154 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | - | - | - | - | - | - |
| 18-Aug | 264 | 0 | 0 | 0 | 0 | 0 | 0 | 96 | - | - | - | - | - | - |
| 19-Aug | 739 | 1 | 0 | 0 | 0 | 0 | 0 | 63 | - | - | - | - | - | - |
| 20-Aug | 394 | 2 | 0 | 2 | 0 | 0 | 0 | 43 | - | - | - | - | - | - |
| 21-Aug | 303 | 6 | 5 | 0 | 5 | 0 | 0 | 53 | - | - | - | - | - | - |
| 22-Aug | 443 | 6 | 7 | 1 | 7 | 0 | 0 | 100 | - | - | - | - | - | - |
| 23-Aug | 386 | 13 | 9 | 2 | 9 | 0 | 0 | 82 | - | - | - | - | - | - |
| 24-Aug | 359 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | - | - | - | - | - | - |
| 25-Aug | 609 | 2 | 21 | 0 | 21 | 0 | 0 | 79 | 1 | 2 | 0 | 2 | 0 | 0 |
| 26-Aug | 500 | 14 | 22 | 2 | 22 | 0 | 0 | 25 | 2 | 2 | 0 | 2 | 0 | 0 |
| 27-Aug | 503 | 35 | 43 | 9 | 41 | 2 | 0 | 10 | 1 | 1 | 0 | 1 | 0 | 0 |
| 28-Aug | 528 | 50 | 71 | 2 | 58 | 8 | 5 | 76 | 1 | 1 | 0 | 1 | 0 | 0 |
| 29-Aug | 151 | 62 | 87 | 3 | 70 | 9 | 8 | 152 | 0 | 6 | 0 | 6 | 0 | 0 |
| 30-Aug | 284 | 92 | 100 | 4 | 76 | 7 | 17 | 140 | 1 | 2 | 0 | 2 | 0 | 0 |
| 31-Aug | 286 | 81 | 83 | 1 | 63 | 15 | 5 | 139 | 1 | 2 | 0 | 2 | 0 | 0 |
| 1-Sep | 305 | 82 | 143 | 17 | 72 | 16 | 55 | 75 | 2 | 3 | 0 | 3 | 0 | 0 |
| 2-Sep | 182 | 147 | 234 | 22 | 84 | 36 | 114 | 32 | 2 | 1 | 0 | 1 | 0 | 0 |
| 3-Sep | 301 | 197 | 189 | 31 | 60 | 32 | 97 | 123 | 1 | 1 | 0 | 1 | 0 | 0 |
| 4-Sep | 200 | 175 | 234 | 34 | 79 | 28 | 127 | 66 | 0 | 2 | 0 | 2 | 0 | 0 |
| 5-Sep | 54 | 170 | 200 | 39 | 67 | 25 | 108 | 210 | 1 | 1 | 0 | 1 | 0 | 0 |
| 6-Sep | 41 | 171 | 232 | 49 | 67 | 33 | 132 | 230 | 2 | 1 | 0 | 1 | 0 | 0 |
| 7-Sep | 40 | 188 | 257 | 73 | 83 | 36 | 138 | 173 | 0 | 2 | 0 | 2 | 0 | 0 |
| 8-Sep | - | 194 | 228 | 56 | 69 | 30 | 129 | 142 | 3 | 0 | 1 | 0 | 0 | 0 |
| 9-Sep | - | 125 | 169 | 73 | 38 | 23 | 108 | 117 | 0 | 4 | 0 | 4 | 0 | 0 |
| 10-Sep | - | 103 | 194 | 103 | 39 | 25 | 130 | 47 | 1 | 2 | 0 | 2 | 0 | 0 |
| 11-Sep | - | 89 | 175 | 109 | 28 | 24 | 123 | 28 | 0 | 1 | 1 | 1 | 0 | 0 |
| 12-Sep | - | 63 | 175 | 125 | 32 | 16 | 127 | 121 | 2 | 4 | 0 | 3 | 0 | 1 |
| 13-Sep | - | 80 | 185 | 159 | 24 | 16 | 145 | 33 | 1 | 1 | 0 | 1 | 0 | 0 |
| 14-Sep | - | 54 | 207 | 164 | 36 | 21 | 150 | 51 | 3 | 1 | 0 | 1 | 0 | 0 |
| 15-Sep | - | 40 | 118 | 102 | 18 | 16 | 84 | 317 | 3 | 2 | 0 | 1 | 0 | 1 |
| 16-Sep | - | 39 | 103 | 74 | 6 | 6 | 91 | 35 | 2 | 3 | 0 | 2 | 0 | 1 |
| 17-Sep | - | 27 | 85 | 88 | 13 | 6 | 66 | 66 | 1 | 3 | 0 | 2 | 0 | 1 |
| 18-Sep | - | 18 | 60 | 76 | 3 | 2 | 55 | - | 9 | 9 | 2 | 2 | 0 | 7 |
| 19-Sep | - | 15 | 79 | 71 | 16 | 0 | 63 | - | 7 | 13 | 0 | 4 | 0 | 9 |
| 20-Sep | - | 2 | 6 | 7 | 0 | 0 | 6 | - | 15 | 19 | 1 | 2 | 0 | 17 |
| 21-Sep | - | 1 | 7 | 19 | 1 | 2 | 4 | - | 22 | 21 | 2 | 1 | 0 | 20 |
| 22-Sep | - | 3 | 9 | 15 | 2 | 0 | 7 | - | 41 | 31 | 1 | 0 | 0 | 31 |
| 23-Sep | - | 0 | 1 | 10 | 1 | 0 | 0 | - | 42 | 55 | 1 | 0 | 0 | 55 |
| 24-Sep | - | - | - | - | - | - | - | - | 54 | 55 | 0 | 0 | 0 | 55 |
| 25-Sep | - | - | - | - | - | - | - | - | 48 | 57 | 2 | 0 | 0 | 57 |
| 26-Sep | - | - | - | - | - | - | - | - | 99 | 106 | 0 | 0 | 0 | 106 |
| 27-Sep | - | - | - | - | - | - | - | - | 105 | 102 | 0 | 0 | 0 | 102 |
| 28-Sep | - | - | - | - | - | - | - | - | 92 | 119 | 0 | 0 | 0 | 119 |
| 29-Sep | - | - | - | - | - | - | - | - | 55 | 69 | 0 | 0 | 0 | 69 |
| 30-Sep | - | - | - | - | - | - | - | - | 68 | 101 | 0 | 0 | 0 | 101 |

Continued

Appendix 8. Daily live counts, male, female and jack carcass recoveries, and female spawning success from the Gates, Nadina and Weaver spawning channels, 1998, continued.

| | Gates Creek Channel | | | | | | | Nadina River Channel | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Carcasses recovered | | | % spawned | | | | Carcasses recovered | | | % spawned | | |
| Date | Live count | Male | Female | Jack | 0% | 50% | 100% | Live count | Male | Female | Jack | 0% | 50% | 100% |
| 1-Oct | - | - | - | - | - | - | - | - | 93 | 111 | 0 | 0 | 0 | 111 |
| 2-Oct | - | - | - | - | - | - | - | - | 48 | 82 | 0 | 0 | 0 | 82 |
| 3-Oct | - | - | - | - | - | - | - | - | 22 | 42 | 0 | 0 | 0 | 42 |
| 4-Oct | - | - | - | - | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 0 |
| 5-Oct | - | - | - | - | - | - | - | - | 40 | 81 | 0 | 0 | 0 | 81 |
| 6-Oct | - | - | - | - | - | - | - | - | 13 | 27 | 0 | 0 | 0 | 27 |
| 7-Oct | - | - | - | - | - | - | - | - | 9 | 21 | 0 | 0 | 0 | 21 |
| 8-Oct | - | - | - | - | - | - | - | - | 18 | 17 | 0 | 0 | 0 | 17 |
| 9-Oct | - | - | - | - | - | - | - | - | 14 | 15 | 0 | 0 | 0 | 15 |
| 10-Oct | - | - | - | - | - | - | - | - | 0 | 0 | 0 | 0 | 0 | 0 |
| 11-Oct | - | - | - | - | - | - | - | - | 9 | 11 | 0 | 0 | 0 | 11 |
| 12-Oct | - | - | - | - | - | - | - | - | 3 | 4 | 0 | 0 | 0 | 4 |
| Total | - | 2,347 | 3,739 | 1,542 [A] | 1,211 | 434 | 2,094 | 2,964 [B] | 957 | 1,216 | 11 | 53 | 0 | 1,554 |

[A] Carcasses recoveries not adjusted for age misidentification.
[B] Dead recovery terminated before die-off was complete; total live count was used as the escapement estimate.

Appendix 8. Daily live counts, male, female and jack carcass recoveries and female spawning success from the Gates, Nadina, and Weaver spawning channels, 1998, continued.

| | Weaver Creek Channel | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Carcasses recovered | | | % spawned | | |
| Date | Live count | Male | Female | Jack | 0% | 50% | 100% |
| 3-Oct | 1,991 | - | - | - | - | - | - |
| 4-Oct | 2,920 | - | - | - | - | - | - |
| 5-Oct | 3,891 | - | - | - | - | - | - |
| 6-Oct | 507 | - | - | - | - | - | - |
| 7-Oct | 500 | - | - | - | - | - | - |
| 8-Oct | 500 | - | - | - | - | - | - |
| 9-Oct | 1,003 | 103 | 134 | 3 | 52 | 14 | 68 |
| 10-Oct | 74 | 238 | 357 | 4 | 87 | 11 | 259 |
| 11-Oct | 1,008 | 208 | 402 | 3 | 39 | 3 | 360 |
| 12-Oct | 1,111 | 488 | 930 | 2 | 39 | 3 | 888 |
| 13-Oct | 2,002 | 792 | 1,640 | | 39 | 5 | 1,596 |
| 14-Oct | 2,087 | 724 | 1,257 | 1 | 22 | 2 | 1,233 |
| 15-Oct | 5,372 | 913 | 1,374 | 1 | 38 | 6 | 1,330 |
| 16-Oct | 3,720 | 695 | 828 | 3 | 9 | 2 | 817 |
| 17-Oct | 3,206 | 563 | 445 | 2 | 27 | 7 | 411 |
| 18-Oct | - | 218 | 385 | 1 | 37 | 7 | 341 |
| 19-Oct | - | 463 | 571 | 4 | 61 | 6 | 504 |
| 20-Oct | - | 327 | 555 | 4 | 62 | 8 | 485 |
| 21-Oct | - | 733 | 1,642 | 4 | 133 | 16 | 1,493 |
| 22-Oct | - | 995 | 2,123 | 3 | 104 | 21 | 1,998 |
| 23-Oct | - | 1,335 | 2,170 | 2 | 63 | 16 | 2,091 |
| 24-Oct | - | 1,398 | 1,463 | 3 | 39 | 12 | 1,412 |
| 25-Oct | - | 1,101 | 713 | 5 | 9 | 0 | 704 |
| 27-Oct | - | 402 | 344 | 3 | 0 | 0 | 344 |
| 1-Nov | - | 34 | 5 | 1 | - | - | 5 |
| Total | 29,892 | 11,730 | 17,338 | 49 [A] | 860 | 139 | 16,339 |

[A] Carcasses recoveries not adjusted for age misidentification.

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998.

| | | | | Carcasses recovered | | | | | % spawned | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stock group | Stock | Date | Live count | Male | Female | Jack | Total | Cum. | 0% | 50% | 100% |
| **Lower Fraser** | Chilliwack Lake | 18-Aug | - | 5 | 1 | 0 | 6 | 6 | 1 | 0 | 3 |
| | | 25-Aug | - | 2 | 17 | 0 | 19 | 25 | 10 | 2 | 5 |
| | | 31-Aug | - | 31 | 33 | 0 | 64 | 89 | 17 | 1 | 11 |
| | | 4-Sep | - | 32 | 45 | 0 | 77 | 166 | 9 | 3 | 25 |
| | | 11-Sep | - | 39 | 62 | 1 | 102 | 268 | 5 | 2 | 39 |
| | Nahatlatch Lake | 26-Aug | 1 | 16 | 18 | 0 | 34 | 34 | 15 | 2 | 1 |
| | | 2-Sep | - | 54 | 59 | 0 | 113 | 147 | 27 | 2 | 12 |
| | | 8-Sep | 1 | 47 | 41 | 0 | 88 | 235 | 9 | 4 | 20 |
| | Nahatlatch River | 27-Aug | 2,875 | 7 | 10 | 0 | 17 | 17 | 10 | 0 | 0 |
| | | 2-Sep | 2,712 | 31 | 29 | 0 | 60 | 77 | 12 | 3 | 24 |
| | | 9-Sep | 3,437 | 23 | 33 | 0 | 56 | 133 | 2 | 4 | 21 |
| | | 16-Sep | - | 61 | 72 | 0 | 133 | 266 | 0 | 1 | 71 |
| | Widgeon Slough | 12-Nov | - | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| | | 18-Nov | 34 | 3 | 1 | 0 | 4 | 5 | 0 | 0 | 1 |
| | | 24-Nov | 19 | 4 | 2 | 0 | 6 | 11 | 0 | 0 | 2 |
| | | 1-Dec | 4 | 4 | 1 | 0 | 5 | 16 | 0 | 0 | 1 |
| **Harrison-Lillooet** | Big Silver Creek | 15-Sep | 2,414 | 15 | 12 | 0 | 27 | 27 | 7 | 1 | 3 |
| | | 21-Sep | 2,908 | 78 | 61 | 0 | 139 | 166 | 4 | 1 | 48 |
| | | 23-Sep | 3,018 | 70 | 68 | 0 | 138 | 304 | 6 | 2 | 48 |
| | | 1-Oct | 1,377 | 293 | 360 | 1 | 654 | 958 | 3 | 1 | 310 |
| | Green River | 25-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Harrison River | 2-Nov | 638 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 9-Nov | 2,482 | 10 | 6 | 0 | 16 | 16 | 0 | 0 | 5 |
| | | 13-Nov | - | 3 | 7 | 0 | 10 | 26 | 0 | 1 | 5 |
| | | 16-Nov | 627 | 7 | 9 | 0 | 16 | 42 | 1 | 0 | 8 |
| | | 18-Nov | - | 13 | 24 | 0 | 37 | 79 | 0 | 0 | 23 |
| | | 23-Nov | - | 39 | 61 | 0 | 100 | 179 | 0 | 1 | 53 |
| | | 24-Nov | - | 30 | 75 | 0 | 105 | 284 | 0 | 1 | 74 |
| | | 30-Nov | - | 24 | 82 | 0 | 106 | 390 | 0 | 0 | 82 |
| | Poole Creek | 21-Sep | 117 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 5-Oct | 81 | 20 | 20 | 0 | 40 | 40 | 1 | 0 | 19 |
| | Samson Creek | 16-Sep | 335 | 6 | 5 | 0 | 11 | 11 | 0 | 0 | 5 |
| | | 24-Sep | 318 | 12 | 21 | 0 | 33 | 44 | 1 | 2 | 18 |
| | | 29-Sep | 127 | 14 | 20 | 0 | 34 | 78 | 0 | 0 | 10 |
| **Seton-Anderson** | Gates Creek [A] | 17-Aug | 8 [B] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 20-Aug | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 22-Aug | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| | | 24-Aug | 200 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | | 27-Aug | 99 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | | 30-Aug | 0 | 6 | 5 | 0 | 11 | 12 | 5 | 0 | 0 |
| | | 1-Sep | 47 | 2 | 1 | 0 | 3 | 15 | 0 | 0 | 1 |
| | | 2-Sep | 40 | 2 | 1 | 1 | 4 | 19 | 1 | 0 | 0 |
| | | 3-Sep | 87 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 |
| | | 4-Sep | 77 | 0 | 8 | 0 | 8 | 27 | 4 | 1 | 3 |
| | | 7-Sep | 0 | 20 | 0 | 0 | 20 | 47 | 0 | 0 | 0 |
| | | 9-Sep | 0 | 5 | 5 | 7 | 17 | 64 | 3 | 0 | 2 |
| | | 10-Sep | 0 | 4 | 0 | 0 | 4 | 68 | 0 | 0 | 0 |
| | | 11-Sep | 0 | 11 | 0 | 0 | 11 | 79 | 0 | 0 | 0 |
| | | 14-Sep | 0 | 33 | 9 | 9 | 51 | 130 | 1 | 0 | 8 |
| | | 16-Sep | 0 | 17 | 6 | 5 | 28 | 158 | 1 | 0 | 5 |
| | | 19-Sep | 500 | 0 | 0 | 0 | 0 | 158 | 0 | 0 | 0 |
| | Portage Creek | 28-Oct | 13,491 | 0 | 0 | 0 | 512 [C] | 512 | 0 | 0 | 0 |
| | | 2-Nov | 3,858 | 1,008 | 1,105 | 2 | 2,115 | 2,627 | 82 | 11 | 1,003 |
| | | 6-Nov | - | 777 | 812 | 1 | 1,590 | 4,217 | 60 | 19 | 648 |
| | | 10-Nov | - | 60 | 90 | 0 | 150 | 4,367 | 12 | 9 | 39 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered Male | Female | Jack | Total | Cum. | % spawned 0% | 50% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **South Thompson *Early Summer Runs*** | Adams Channel | 24-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 3-Sep | 167 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 5-Sep | 219 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 10-Sep | 173 | 3 | 7 | 0 | 10 | 10 | 3 | 0 | 4 |
| | | 14-Sep | 62 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 |
| | | 17-Sep | 21 | 2 | 5 | 0 | 7 | 17 | 0 | 0 | 5 |
| | Adams River, lower | 26-Aug | 76 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 31-Aug | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Sep | 98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 4-Sep | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 5-Sep | 843 | 7 | 5 | 0 | 12 | 12 | 0 | 0 | 5 |
| | | 7-Sep | 32 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| | | 9-Sep | 9 | 0 | 3 | 0 | 3 | 15 | 0 | 0 | 3 |
| | | 10-Sep | 431 | 6 | 12 | 0 | 18 | 33 | 1 | 0 | 11 |
| | | 14-Sep | 39 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 |
| | | 15-Sep | 3 | 1 | 0 | 0 | 1 | 34 | 0 | 0 | 0 |
| **South Thompson *Early Summer Runs*** Continued | Adams River, upper | 25-Aug | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| | | 2-Sep | 86 | 1 | 2 | 0 | 3 | 4 | 0 | 0 | 2 |
| | | 7-Sep | 46 | 18 | 15 | 0 | 33 | 37 | 0 | 0 | 15 |
| | | 12-Sep | 123 | 17 | 14 | 0 | 31 | 68 | 0 | 1 | 13 |
| | | 15-Sep | 44 | 7 | 7 | 0 | 14 | 82 | 0 | 0 | 7 |
| | Anstey River | 23-Aug | 242 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 29-Aug | 2,082 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 1 |
| | | 3-Sep | 2,571 | 30 | 31 | 0 | 61 | 63 | 4 | 1 | 26 |
| | | 8-Sep | 1,782 | 115 | 83 | 0 | 198 | 261 | 6 | 0 | 77 |
| | | 14-Sep | 344 | 16 | 33 | 0 | 49 | 310 | 1 | 1 | 31 |
| | | 16-Sep | 0 | 39 | 51 | 0 | 90 | 400 | 1 | 0 | 50 |
| | Cayenne Creek | 18-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 25-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Sep | 86 | 2 | 2 | 0 | 4 | 4 | 0 | 0 | 2 |
| | | 7-Sep | 43 | 6 | 10 | 0 | 16 | 20 | 1 | 1 | 5 |
| | | 12-Sep | 2 | 0 | 2 | 0 | 2 | 22 | 0 | 0 | 2 |
| | Celista Creek | 31-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 8-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Hiuihill Creek | 26-Aug | 185 | 11 | 3 | 0 | 14 | 14 | 2 | 1 | 0 |
| | | 31-Aug | 425 | 14 | 16 | 1 | 31 | 45 | 6 | 0 | 10 |
| | | 5-Sep | 405 | 97 | 55 | 0 | 152 | 197 | 4 | 1 | 50 |
| | | 10-Sep | 113 | 85 | 107 | 0 | 192 | 389 | 4 | 1 | 102 |
| | Hunakwa Creek | 29-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 8-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Malakwa Creek | 30-Aug | 41 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 2-Sep | 31 | 4 | 4 | 0 | 8 | 9 | 1 | 0 | 3 |
| | | 5-Sep | 32 | 1 | 10 | 0 | 11 | 20 | 2 | 0 | 8 |
| | | 8-Sep | 10 | 1 | 9 | 0 | 10 | 30 | 0 | 0 | 8 |
| | | 11-Sep | 2 | 3 | 7 | 0 | 10 | 40 | 0 | 0 | 7 |
| | McNomee Creek | 24-Aug | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Aug | 203 | 3 | 1 | 0 | 4 | 4 | 1 | 0 | 0 |
| | | 30-Aug | 358 | 8 | 2 | 0 | 10 | 14 | 0 | 0 | 0 |
| | | 2-Sep | 348 | 9 | 14 | 0 | 23 | 37 | 0 | 0 | 11 |
| | | 5-Sep | 327 | 17 | 13 | 0 | 30 | 67 | 3 | 0 | 9 |
| | | 8-Sep | 150 | 25 | 28 | 0 | 53 | 120 | 0 | 0 | 26 |
| | | 11-Sep | 50 | 8 | 12 | 0 | 20 | 140 | 0 | 1 | 8 |
| | | 14-Sep | 14 | 1 | 4 | 0 | 5 | 145 | 0 | 0 | 4 |
| | Momich River | 18-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered | | | | | % spawned | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Male | Female | Jack | Total | Cum. | 0% | 50% | 100% |
| | Nikwikwaia Creek | 21-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 26-Aug | 52 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 31-Aug | 78 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 0 |
| | | 5-Sep | 126 | 1 | 3 | 0 | 4 | 6 | 0 | 0 | 3 |
| | | 10-Sep | 57 | 0 | 2 | 0 | 2 | 8 | 0 | 0 | 2 |
| | Onyx Creek [b] | 21-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Perry River | 28-Aug | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 31-Aug | 134 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 0 |
| | | 3-Sep | 296 | 0 | 4 | 0 | 4 | 6 | 0 | 0 | 4 |
| | | 6-Sep | 319 | 2 | 1 | 0 | 3 | 9 | 0 | 0 | 1 |
| | | 9-Sep | - | 13 | 21 | 0 | 34 | 43 | 0 | 0 | 21 |
| | | 12-Sep | 93 | 11 | 20 | 0 | 31 | 74 | 0 | 0 | 20 |
| | | 15-Sep | - | 6 | 16 | 0 | 22 | 96 | 0 | 0 | 16 |
| | | 18-Sep | 0 | 0 | 0 | 0 | 0 | 96 | 0 | 0 | 0 |
| | Ross Creek [b] | 21-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Salmon River | 15-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Scotch Creek | 4-Sep | 7,822 | 2,750 | 2,046 | 0 | 4,796 | 4,796 | 302 | 198 | 1,545 |
| | (above fence) | 7-Sep | - | 5,490 | 5,093 | 0 | 10,583 | 15,379 | 207 | 10 | 4,874 |
| | | 10-Sep | - | 1,545 | 1,738 | 0 | 3,283 | 18,662 | 24 | 0 | 1,714 |
| | | 11-Sep | - | 249 | 547 | 0 | 796 | 19,458 | 8 | 0 | 539 |
| | | 15-Sep | - | 1,719 | 2,106 | 0 | 3,825 | 23,283 | 16 | 1 | 2,089 |
| | | 18-Sep | - | 222 | 462 | 0 | 684 | 23,967 | 0 | 0 | 462 |
| | Yard Creek | 25-Aug | 91 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| | | 30-Aug | 526 | 5 | 4 | 0 | 9 | 10 | 0 | 0 | 4 |
| | | 2-Sep | 554 | 31 | 39 | 0 | 70 | 80 | 2 | 0 | 37 |
| | | 5-Sep | 235 | 80 | 98 | 0 | 178 | 258 | 10 | 0 | 88 |
| | | 8-Sep | 163 | 108 | 158 | 0 | 266 | 524 | 3 | 0 | 138 |
| | | 11-Sep | 62 | 46 | 74 | 0 | 120 | 644 | 2 | 0 | 72 |
| | | 14-Sep | 14 | 12 | 18 | 0 | 30 | 674 | 0 | 0 | 18 |
| | | 17-Sep | 1 | 2 | 14 | 0 | 16 | 690 | 0 | 0 | 12 |
| **South** | Adams Lake | 14-Oct | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Thompson** | | 15-Oct | 439 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Late Run*** | | 23-Oct | 525 | 85 | 41 | 0 | 126 | 126 | 2 | 0 | 37 |
| | | 27-Oct | - | 76 | 47 | 0 | 123 | 249 | 0 | 0 | 32 |
| | | 30-Oct | 26 | 107 | 101 | 0 | 208 | 457 | 2 | 0 | 85 |
| | | 9-Nov | - | 71 | 98 | 0 | 169 | 626 | 0 | 0 | 96 |
| | Anstey River | 9-Oct | 153 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 17-Oct | 401 | 5 | 1 | 0 | 6 | 6 | 0 | 0 | 1 |
| | | 26-Oct | 224 | 4 | 2 | 0 | 6 | 12 | 0 | 0 | 2 |
| | | 1-Nov | 33 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| | | 8-Nov | 1 | 0 | 1 | 0 | 1 | 13 | 0 | 0 | 1 |
| | Bush Creek | 8-Oct | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 15-Oct | 160 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 23-Oct | 208 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Canoe Creek | 13-Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 22-Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Celista Creek | 12-Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 19-Oct | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 29-Oct | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 5-Nov | 11 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| | Eagle River | 13-Oct | 235 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (below fence) | 20-Oct | - | 60 | 47 | 0 | 107 | 107 | 0 | 0 | 47 |
| | | 21-Oct | 393 | 0 | 0 | 0 | 0 | 107 | 0 | 0 | 0 |
| | | 31-Oct | 80 | 107 | 196 | 0 | 303 | 410 | 0 | 0 | 196 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| | | | | Carcasses recovered | | | | | % spawned | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stock group | Stock | Date | Live count | Male | Female | Jack | Total | Cum. | 0% | 50% | 100% |
| **South** | Hiuihill Creek | 8-Oct | 491 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Thompson** | | 16-Oct | 28 | 9 | 1 | 0 | 10 | 10 | 0 | 0 | 1 |
| ***Late Run*** | | 22-Oct | 19 | 5 | 0 | 0 | 5 | 15 | 0 | 0 | 0 |
| Continued | | 27-Oct | - | 5 | 4 | 0 | 9 | 24 | 0 | 0 | 4 |
| | | 2-Nov | 0 | 9 | 7 | 0 | 16 | 40 | 0 | 0 | 7 |
| | Hunakwa Creek | 9-Oct | 73 | 1 | 1 | 0 | 2 | 2 | 1 | 0 | 0 |
| | | 17-Oct | 149 | 19 | 9 | 0 | 28 | 30 | 1 | 0 | 8 |
| | | 26-Oct | 11 | 15 | 22 | 0 | 37 | 67 | 0 | 0 | 22 |
| | | 1-Nov | 1 | 9 | 15 | 0 | 24 | 91 | 0 | 0 | 14 |
| | McNomee Creek | 12-Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 21-Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 29-Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 5-Nov | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Momich River | 14-Oct | 46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 21-Oct | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Nikwikwaia Creek | 8-Oct | 239 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 0 |
| | | 16-Oct | 382 | 15 | 6 | 0 | 26 [c] | 28 | 0 | 0 | 6 |
| | | 22-Oct | 220 | 19 | 12 | 0 | 31 | 59 | 0 | 0 | 12 |
| | | 27-Oct | 105 | 8 | 18 | 0 | 26 | 85 | 0 | 0 | 18 |
| | | 2-Nov | 20 | 0 | 15 | 0 | 15 | 100 | 0 | 0 | 15 |
| | Pass Creek | 8-Oct | 73 | 17 | 6 | 0 | 23 | 23 | 6 | 0 | 0 |
| | | 15-Oct | 357 | 7 | 1 | 0 | 8 | 31 | 0 | 0 | 1 |
| | | 23-Oct | 459 | 22 | 4 | 0 | 26 | 57 | 2 | 0 | 2 |
| | | 27-Oct | 339 | 17 | 9 | 0 | 26 | 83 | 0 | 0 | 9 |
| | | 2-Nov | 120 | 13 | 67 | 0 | 80 | 163 | 0 | 0 | 67 |
| | | 9-Nov | 4 | 2 | 49 | 0 | 51 | 214 | 0 | 0 | 49 |
| | Perry River | 13-Oct | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 1-Nov | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Salmon River | 13-Oct | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (below fence) | 22-Oct | 133 | 1 | 2 | 0 | 3 | 3 | 1 | 0 | 1 |
| | | 30-Oct | 16 | 10 | 10 | 0 | 20 | 23 | 1 | 0 | 9 |
| | Scotch Creek | 8-Oct | 290 | 17 | 12 | 0 | 29 | 29 | 0 | 0 | 8 |
| | | 16-Oct | 1,265 | 21 | 25 | 0 | 46 | 75 | 6 | 1 | 17 |
| | | 22-Oct | 1,434 | 187 | 151 | 0 | 338 | 413 | 3 | 0 | 57 |
| | | 27-Oct | 1,234 | 270 | 210 | 0 | 480 | 893 | 16 | 0 | 192 |
| | | 2-Nov | 637 | 103 | 101 | 0 | 204 | 1,097 | 11 | 0 | 63 |
| | | 7-Nov | 363 | 112 | 203 | 0 | 315 | 1,412 | 15 | 0 | 188 |
| | | 10-Nov | - | 101 | 20 | 0 | 121 | 1,533 | 4 | 0 | 16 |
| | | 13-Nov | 115 | 23 | 99 | 0 | 122 | 1,655 | 5 | 1 | 82 |
| | Seymour River | 12-Oct | 58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 21-Oct | 64 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 29-Oct | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 5-Nov | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | S. Thompson R. | 10-Oct | 1,276 | 3 | 3 | 0 | 6 | 6 | 3 | 0 | 0 |
| | | 17-Oct | - | 120 | 74 | 0 | 194 | 200 | 11 | 4 | 59 |
| | | 25-Oct | 208 | 536 | 589 | 0 | 1,125 | 1,325 | 3 | 2 | 145 |
| | | 5-Nov | - | 258 | 187 | 0 | 445 | 1,770 | 0 | 0 | 183 |
| | Tappen Creek | 11-Oct | 54 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 22-Oct | 92 | 4 | 2 | 0 | 6 | 7 | 0 | 0 | 2 |
| | | 30-Oct | 78 | 31 | 20 | 0 | 51 | 58 | 0 | 1 | 19 |
| | | 10-Nov | - | 10 | 19 | 0 | 29 | 87 | 0 | 0 | 19 |
| | Yard Creek | 13-Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 21-Oct | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 7-Nov | - | 601 | 820 | 0 | 1,421 | 1,421 | 1 | 0 | 818 |
| | | 9-Nov | - | 589 | 612 | 0 | 1,201 | 2,622 | 0 | 0 | 611 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered: Male | Female | Jack | Total | Cum. | % spawned: 0% | 50% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **South** | **Shuswap Lake** | | | | | | | | | | |
| **Thompson** | Anstey Arm | 9-Oct | 185 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Late Run*** | | 18-Oct | 395 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Continued | | 26-Oct | 946 | 36 | 32 | 0 | 68 | 68 | 1 | 0 | 31 |
| | | 1-Nov | 83 | 71 | 81 | 0 | 152 | 220 | 1 | 0 | 80 |
| | | 6-Nov | 0 | 0 | 0 | 0 | 0 | 220 | 0 | 0 | 0 |
| | | 8-Nov | - | 38 | 41 | 0 | 79 | 299 | 0 | 0 | 41 |
| | Main Arm | 8-Oct | 382 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 16-Oct | 3,067 | 3 | 6 | 0 | 9 | 9 | 6 | 0 | 0 |
| | | 19-Oct | - | 4 | 3 | 0 | 7 | 16 | 0 | 0 | 3 |
| | | 22-Oct | - | 86 | 52 | 0 | 138 | 154 | 6 | 1 | 45 |
| | | 23-Oct | - | 70 | 85 | 0 | 155 | 309 | 4 | 0 | 81 |
| | | 24-Oct | 1,865 | 45 | 33 | 0 | 78 | 387 | 0 | 1 | 32 |
| | | 25-Oct | 1,179 | 0 | 0 | 0 | 0 | 387 | 0 | 0 | 0 |
| | | 26-Oct | - | 422 | 289 | 0 | 711 | 1,098 | 19 | 0 | 152 |
| | | 2-Nov | 398 | 175 | 150 | 0 | 325 | 1,423 | 7 | 0 | 89 |
| | | 9-Nov | 2 | 81 | 72 | 0 | 153 | 1,576 | 0 | 0 | 72 |
| | Salmon Arm | 11-Oct | 960 | 0 | 1 | 0 | 4 [c] | 4 | 1 | 0 | 0 |
| | | 18-Oct | 1,697 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| | | 24-Oct | - | 33 | 33 | 0 | 66 | 70 | 0 | 0 | 33 |
| | | 27-Oct | - | 96 | 95 | 0 | 191 | 261 | 1 | 0 | 94 |
| | | 28-Oct | 870 | 0 | 0 | 0 | 0 | 261 | 0 | 0 | 0 |
| | | 6-Nov | 35 | 49 | 60 | 0 | 109 | 370 | 0 | 0 | 90 |
| | | 10-Nov | - | 43 | 47 | 0 | 90 | 460 | 0 | 0 | 47 |
| | Seymour Arm | 12-Oct | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 19-Oct | 85 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | | 5-Nov | 0 | 3 | 2 | 0 | 5 | 6 | 0 | 0 | 2 |
| | **Shuswap River** | | | | | | | | | | |
| | Shuswap R., middle | 13-Oct | 8,372 | 50 | 57 | 0 | 107 | 107 | 0 | 1 | 56 |
| | | 14-Oct | - | 146 | 65 | 0 | 211 | 318 | 0 | 0 | 62 |
| | | 15-Oct | - | 155 | 44 | 0 | 199 | 517 | 2 | 2 | 37 |
| | | 17-Oct | - | 229 | 281 | 0 | 510 | 1,027 | 0 | 1 | 277 |
| | | 18-Oct | - | 281 | 236 | 0 | 517 | 1,544 | 1 | 0 | 144 |
| | | 20-Oct | - | 299 | 154 | 0 | 453 | 1,997 | 0 | 4 | 150 |
| | | 21-Oct | - | 122 | 280 | 0 | 402 | 2,399 | 0 | 0 | 227 |
| | | 22-Oct | - | 286 | 480 | 0 | 766 | 3,165 | 0 | 0 | 45 |
| | | 23-Oct | - | 155 | 167 | 0 | 322 | 3,487 | 0 | 0 | 131 |
| | | 25-Oct | - | 56 | 422 | 0 | 478 | 3,965 | 0 | 0 | 30 |
| | | 26-Oct | - | 78 | 230 | 0 | 308 | 4,273 | 1 | 0 | 155 |
| | | 27-Oct | 15 | 49 | 86 | 0 | 135 | 4,408 | 0 | 0 | 64 |
| | Tsuius Creek | 16-Oct | 351 | 4 | 4 | 0 | 8 | 8 | 0 | 1 | 3 |
| | | 20-Oct | 260 | 2 | 5 | 0 | 7 | 15 | 0 | 0 | 5 |
| | | 24-Oct | 169 | 3 | 12 | 0 | 15 | 30 | 0 | 0 | 12 |
| | | 28-Oct | 31 | 0 | 7 | 0 | 7 | 37 | 0 | 0 | 7 |
| | Wap Creek | 17-Oct | 584 | 7 | 8 | 0 | 15 | 15 | 0 | 0 | 8 |
| | | 21-Oct | 498 | 22 | 12 | 0 | 34 | 49 | 2 | 0 | 8 |
| | | 25-Oct | 286 | 18 | 21 | 0 | 39 | 88 | 0 | 0 | 20 |
| | | 29-Oct | 113 | 6 | 18 | 0 | 24 | 112 | 0 | 0 | 18 |
| **North** | Fennell Creek | 17-Aug | 134 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Thompson** | | 22-Aug | 2,299 | 3 | 3 | 0 | 6 | 6 | 2 | 0 | 1 |
| | | 27-Aug | 4,778 | 33 | 39 | 0 | 72 | 78 | 12 | 0 | 20 |
| | | 1-Sep | 3,786 | 234 | 332 | 0 | 566 | 644 | 7 | 14 | 205 |
| | | 6-Sep | 150 | 167 | 305 | 0 | 472 | 1,116 | 9 | 3 | 293 |
| | | 13-Sep | 134 | 29 | 49 | 0 | 78 | 1,194 | 2 | 0 | 47 |
| | Harper Creek | 30-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 13-Sep | 2 | 1 | 2 | 0 | 3 | 3 | 0 | 0 | 2 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered: Male | Female | Jack | Total | Cum. | % spawned: 0% | 50% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **North Thompson Continued** | Raft River | 20-Aug | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 24-Aug | 307 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Aug | 2,063 | 46 | 39 | 0 | 85 | 85 | 10 | 1 | 28 |
| | | 4-Sep | 3,297 | 322 | 310 | 2 | 634 | 719 | 33 | 4 | 273 |
| | | 9-Sep | 1,567 | 834 | 973 | 6 | 1,813 | 2,532 | 23 | 7 | 683 |
| | | 14-Sep | 581 | 319 | 403 | 3 | 725 | 3,257 | 25 | 3 | 375 |
| **Chilcotin** | Elkin Creek | 8-Sep | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Taseko Lake | 10-Sep | 8 | 6 | 14 | 0 | 20 | 20 | 0 | 2 | 10 |
| **Quesnel** | **Horsefly River** | | | | | | | | | | |
| | Little Horsefly River | 1-Sep | 221 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 8-Sep | 914 | 3 | 10 | 0 | 13 | 14 | 4 | 0 | 6 |
| | | 16-Sep | 2,018 | 126 | 161 | 0 | 287 | 301 | 24 | 12 | 120 |
| | | 24-Sep | 683 | 352 | 571 | 0 | 923 | 1,224 | 13 | 7 | 507 |
| | | 2-Oct | 63 | 44 | 68 | 0 | 112 | 1,336 | 0 | 0 | 68 |
| | Moffat Creek | 28-Aug | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 4-Sep | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | | 13-Sep | 412 | 70 | 38 | 0 | 108 | 109 | 5 | 4 | 26 |
| | | 20-Sep | 113 | 198 | 172 | 0 | 370 | 479 | 3 | 2 | 164 |
| | | 28-Sep | 44 | 64 | 67 | 0 | 131 | 610 | 2 | 2 | 62 |
| | **Mitchell River** | | | | | | | | | | |
| | Cameron Creek | 8-Sep | 2,003 | 42 | 27 | 0 | 69 | 69 | 3 | 2 | 22 |
| | | 19-Sep | 4,050 | 749 | 615 | 0 | 1,364 | 1,433 | 4 | 3 | 143 |
| | | 26-Sep | 734 | 1,271 | 1,206 | 0 | 2,477 | 3,910 | 4 | 1 | 85 |
| | | 2-Oct | 46 | 540 | 632 | 0 | 1,172 | 5,082 | 1 | 1 | 88 |
| | Penfold Creek | 6-Sep | 300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | **Quesnel Lake, E. Arm** | | | | | | | | | | |
| | Big Slide, lakeshore | 6-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bill Miner Creek | 6-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 23-Sep | 100 | 39 | 57 | 0 | 96 | 96 | 0 | 0 | 57 |
| | | 30-Sep | 17 | 33 | 32 | 0 | 65 | 161 | 0 | 0 | 32 |
| | Bill Miner Creek, lakeshore | 6-Sep | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 23-Sep | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 29-Sep | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bill Miner Creek, lakeshore 3 km W | 6-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Blue Lead Creek | 31-Aug | 470 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 7-Sep | 1,253 | 8 | 5 | 0 | 13 | 14 | 0 | 0 | 5 |
| | | 17-Sep | 1,422 | 131 | 168 | 0 | 299 | 313 | 3 | 1 | 161 |
| | | 22-Sep | 1,332 | 165 | 154 | 0 | 319 | 632 | 0 | 1 | 152 |
| | | 29-Sep | 246 | 131 | 254 | 0 | 385 | 1,017 | 0 | 0 | 251 |
| | Blue Lead Creek, lakeshore | 31-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 6-Sep | 219 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 17-Sep | 690 | 39 | 34 | 0 | 73 | 73 | 1 | 1 | 28 |
| | | 23-Sep | 390 | 52 | 61 | 0 | 113 | 186 | 2 | 0 | 49 |
| | | 29-Sep | 172 | 34 | 55 | 0 | 89 | 275 | 0 | 0 | 54 |
| | Bouldery Creek | 31-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 6-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 23-Sep | 20 | 5 | 5 | 0 | 10 | 10 | 0 | 0 | 5 |
| | | 30-Sep | 0 | 1 | 2 | 0 | 3 | 13 | 0 | 0 | 2 |
| | Bouldery Creek, lakeshore | 31-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 6-Sep | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Sep | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bouldery Creek, lakeshore 2 km E | 6-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 23-Sep | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Killdog Creek | 31-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 6-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered Male | Female | Jack | Total | Cum. | % spawned 0% | 50% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Quesnel** | Killdog Cr, cont'd | 23-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Continued | Lynx Creek | 31-Aug | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 7-Sep | 194 | 4 | 3 | 0 | 7 | 7 | 1 | 0 | 1 |
| | | 16-Sep | 264 | 18 | 33 | 0 | 51 | 58 | 1 | 0 | 25 |
| | | 22-Sep | 185 | 24 | 19 | 0 | 43 | 101 | 0 | 0 | 19 |
| | | 30-Sep | 30 | 3 | 10 | 0 | 13 | 114 | 0 | 0 | 9 |
| | Lynx Creek, | 31-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | lakeshore | 6-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 22-Sep | 47 | 2 | 2 | 0 | 4 | 4 | 0 | 0 | 2 |
| | | 30-Sep | 7 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| | Niagara Creek | 31-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Slate Bay | 6-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Summit Creek | 31-Aug | 578 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 6-Sep | 1,835 | 38 | 8 | 0 | 46 | 47 | 3 | 1 | 4 |
| | | 17-Sep | 520 | 699 | 792 | 0 | 1,491 | 1,538 | 32 | 11 | 741 |
| | | 23-Sep | 99 | 157 | 216 | 0 | 373 | 1,911 | 2 | 0 | 214 |
| | | 29-Sep | 74 | 28 | 47 | 0 | 75 | 1,986 | 0 | 0 | 47 |
| | Taku Creek | 31-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | **Quesnel Lake, N. Arm** | | | | | | | | | | |
| | Bear Beach, | 3-Sep | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | lakehsore | 20-Sep | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Betty Frank's Shore | 3-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Bowling Point | 27-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | lakehsore | 3-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 10-Sep | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 20-Sep | 122 | 2 | 5 | 0 | 7 | 7 | 0 | 1 | 4 |
| | | 26-Sep | 30 | 6 | 9 | 0 | 15 | 22 | 0 | 0 | 9 |
| | Deception Point | 27-Aug | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | lakehsore | 3-Sep | 329 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 10-Sep | 2,320 | 8 | 7 | 0 | 15 | 15 | 0 | 0 | 6 |
| | | 20-Sep | 1,732 | 66 | 139 | 0 | 205 | 220 | 2 | 4 | 132 |
| | | 27-Sep | 390 | 59 | 144 | 0 | 203 | 423 | 0 | 0 | 114 |
| | Devoe Creek | 27-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Devoe Creek, | 4-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | lakeshore | 20-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Goose Point | 27-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | lakeshore | 3-Sep | 242 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 10-Sep | 620 | 16 | 18 | 0 | 34 | 34 | 1 | 0 | 11 |
| | | 20-Sep | 227 | 18 | 40 | 0 | 58 | 92 | 0 | 0 | 34 |
| | | 26-Sep | 130 | 61 | 131 | 0 | 192 | 284 | 0 | 0 | 108 |
| | Grain Creek | 27-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 3-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 16-Sep | 105 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 20-Sep | 242 | 3 | 4 | 0 | 7 | 8 | 0 | 2 | 2 |
| | | 27-Sep | 201 | 17 | 13 | 0 | 30 | 38 | 0 | 0 | 10 |
| | | 3-Oct | 52 | 10 | 21 | 0 | 31 | 69 | 0 | 0 | 20 |
| | Grain Creek, | 4-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | lakeshore | 20-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Isaiah Creek [b] | 27-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Limestone Point | 4-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | lakeshore | 20-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Long Creek [b] | 27-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Long Creek, | 4-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | lakeshore | 20-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Marten Creek | 4-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered | | | | | % spawned | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Male | Female | Jack | Total | Cum. | 0% | 50% | 100% |
| **Quesnel** | Marten Creek, | 4-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Continued | lakeshore | 20-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Roaring River | 27-Aug | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 3-Sep | 248 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 10-Sep | 486 | 20 | 19 | 0 | 39 | 39 | 4 | 2 | 9 |
| | | 19-Sep | 330 | 57 | 51 | 0 | 108 | 147 | 0 | 1 | 46 |
| | | 26-Sep | 152 | 44 | 75 | 0 | 119 | 266 | 0 | 0 | 73 |
| | Roaring River, | 3-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | lakeshore | 10-Sep | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 19-Sep | 92 | 9 | 10 | 0 | 19 | 19 | 0 | 2 | 8 |
| | | 27-Sep | 30 | 10 | 21 | 0 | 31 | 50 | 0 | 0 | 14 |
| | Sue Creek [E] | 3-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Trickle Creek [E] | 3-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Wasko Creek | 27-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 3-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 10-Sep | 642 | 3 | 1 | 0 | 4 | 4 | 0 | 0 | 1 |
| | | 19-Sep | 670 | 445 | 454 | 0 | 899 | 903 | 18 | 2 | 434 |
| | | 27-Sep | 142 | 262 | 383 | 0 | 645 | 1,548 | 3 | 7 | 308 |
| | Watt Creek | 27-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 3-Sep | 169 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| | | 10-Sep | 420 | 4 | 6 | 0 | 10 | 11 | 2 | 1 | 2 |
| | | 19-Sep | 212 | 91 | 95 | 0 | 186 | 197 | 4 | 0 | 91 |
| | | 26-Sep | 27 | 51 | 103 | 0 | 154 | 351 | 0 | 0 | 66 |
| | **Quesnel Lake, W. Arm** | | | | | | | | | | |
| | Hazeltine Creek | 4-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Raft Creek | 4-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Spusks Creek, lakeshore | 4-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Stuart** | **Driftwood River** | | | | | | | | | | |
| ***Early Runs*** | Blackwater Creek | 1-Aug | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 7-Aug | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 18-Aug | 12 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| | Driftwood River | 1-Aug | 3,317 | 0 | 0 | 0 | 1,077 [C] | 1,077 | 0 | 0 | 0 |
| | Kastberg Creek | 1-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Kotsine River | 1-Aug | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Lion Creek | 1-Aug | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Porter Creek | 1-Aug | 879 | 52 | 59 | 0 | 111 | 111 | 46 | 5 | 8 |
| | | 7-Aug | 402 | 303 | 299 | 0 | 602 | 713 | 132 | 6 | 161 |
| | | 18-Aug | 173 | 90 | 83 | 0 | 173 | 886 | 11 | 0 | 72 |
| | **Takla Lake, N.E. Arm** | | | | | | | | | | |
| | Ankwill Creek | 24-Jul | 170 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 818 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 833 | 1 | 5 | 0 | 7 [C] | 7 | 3 | 0 | 2 |
| | | 1-Aug | 686 | 38 | 41 | 0 | 79 | 86 | 34 | 0 | 7 |
| | | 5-Aug | 686 | 65 | 80 | 0 | 145 | 231 | 48 | 8 | 24 |
| | | 8-Aug | 620 | 28 | 17 | 0 | 45 | 276 | 13 | 0 | 4 |
| | | 11-Aug | 574 | 26 | 32 | 0 | 58 | 334 | 13 | 0 | 13 |
| | | 14-Aug | 437 | 35 | 36 | 0 | 71 | 405 | 2 | 4 | 30 |
| | | 17-Aug | 197 | 6 | 12 | 0 | 18 | 423 | 7 | 1 | 4 |
| | | 19-Aug | 169 | 6 | 7 | 0 | 13 | 436 | 0 | 0 | 7 |
| | Bates Creek | 30-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 8-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Blanchette Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered: Male | Female | Jack | Total | Cum. | % spawned: 0% | 50% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stuart** | Blanchette Creek | 5-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Early Runs*** | cont'd | 9-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Continued | | 11-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 15-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Forsythe Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 134 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 0 |
| | | 30-Jul | 246 | 9 | 6 | 0 | 16 [C] | 18 | 4 | 1 | 1 |
| | | 1-Aug | 173 | 20 | 23 | 0 | 44 [C] | 62 | 16 | 3 | 4 |
| | | 5-Aug | 173 | 28 | 23 | 0 | 51 | 113 | 12 | 1 | 10 |
| | | 8-Aug | 207 | 18 | 27 | 0 | 45 | 158 | 16 | 1 | 10 |
| | | 11-Aug | 169 | 16 | 23 | 0 | 39 | 197 | 7 | 1 | 15 |
| | | 14-Aug | 101 | 14 | 19 | 0 | 33 | 230 | 6 | 0 | 12 |
| | | 17-Aug | 62 | 3 | 6 | 0 | 9 | 239 | 1 | 0 | 4 |
| | | 19-Aug | 38 | 2 | 2 | 0 | 4 | 243 | 1 | 0 | 1 |
| | French Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 1-Aug | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 5-Aug | 1 | 0 | 2 | 0 | 2 | 2 | 1 | 0 | 1 |
| | | 8-Aug | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | | 14-Aug | 27 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 0 |
| | | 17-Aug | 38 | 3 | 5 | 0 | 8 | 11 | 4 | 1 | 0 |
| | | 19-Aug | 17 | 3 | 1 | 0 | 4 | 15 | 0 | 0 | 1 |
| | Frypan Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 179 | 0 | 2 | 0 | 4 [C] | 4 | 2 | 0 | 0 |
| | | 30-Jul | 273 | 8 | 12 | 0 | 22 [C] | 26 | 12 | 0 | 0 |
| | | 1-Aug | 152 | 18 | 20 | 0 | 38 | 64 | 15 | 1 | 3 |
| | | 5-Aug | 284 | 37 | 41 | 0 | 79 [C] | 143 | 30 | 0 | 8 |
| | | 8-Aug | 371 | 24 | 11 | 0 | 35 | 178 | 4 | 0 | 6 |
| | | 11-Aug | 394 | 4 | 12 | 0 | 17 [C] | 195 | 1 | 0 | 7 |
| | | 14-Aug | 291 | 43 | 46 | 0 | 89 | 284 | 27 | 0 | 18 |
| | | 17-Aug | 131 | 24 | 51 | 0 | 75 | 359 | 17 | 0 | 26 |
| | | 19-Aug | 82 | 6 | 13 | 0 | 25 [C] | 384 | 3 | 0 | 9 |
| | Hudson's Bay Cr. | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 1-Aug | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 5-Aug | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | | 8-Aug | 13 | 2 | 2 | 0 | 4 | 5 | 1 | 0 | 1 |
| | | 11-Aug | 4 | 0 | 2 | 0 | 2 | 7 | 2 | 0 | 0 |
| | | 14-Aug | 12 | 2 | 1 | 0 | 3 | 10 | 0 | 0 | 1 |
| | | 17-Aug | 18 | 11 | 4 | 0 | 15 | 25 | 2 | 1 | 0 |
| | | 19-Aug | 25 | 0 | 1 | 0 | 1 | 26 | 0 | 0 | 1 |
| | Shale Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 1-Aug | 45 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 0 |
| | | 5-Aug | 66 | 3 | 2 | 0 | 5 | 7 | 1 | 0 | 1 |
| | | 9-Aug | 164 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| | | 11-Aug | 160 | 2 | 0 | 0 | 2 | 9 | 0 | 0 | 0 |
| | | 15-Aug | 163 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 |
| | | 17-Aug | 92 | 2 | 2 | 0 | 4 | 13 | 1 | 0 | 1 |
| | | 19-Aug | 59 | 1 | 3 | 0 | 4 | 17 | 0 | 1 | 2 |
| | Five Mile Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered Male | Female | Jack | Total | Cum. | % spawned 0% | 50% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stuart** | Five Mile Creek | 5-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Early Runs*** | cont'd | 8-Aug | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Continued | | 11-Aug | 41 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 1 |
| | | 14-Aug | 51 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 0 |
| | | 17-Aug | 43 | 2 | 1 | 0 | 3 | 6 | 0 | 0 | 1 |
| | | 19-Aug | 2 | 1 | 0 | 0 | 1 | 7 | 0 | 0 | 0 |
| | Fifteen Mile Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 1 | 0 | 0 | 0 | 1 [C] | 1 | 0 | 0 | 0 |
| | | 30-Jul | 8 | 0 | 0 | 0 | 2 [C] | 3 | 0 | 0 | 0 |
| | | 2-Aug | 30 | 2 | 1 | 0 | 3 | 6 | 0 | 0 | 1 |
| | | 5-Aug | 28 | 2 | 0 | 0 | 4 [C] | 10 | 0 | 0 | 0 |
| | | 8-Aug | 82 | 2 | 0 | 0 | 2 | 12 | 0 | 0 | 0 |
| | | 11-Aug | 106 | 1 | 0 | 0 | 1 | 13 | 0 | 0 | 0 |
| | | 15-Aug | 39 | 2 | 3 | 0 | 5 | 18 | 0 | 0 | 3 |
| | | 17-Aug | 26 | 1 | 1 | 0 | 2 | 20 | 0 | 0 | 1 |
| | | 19-Aug | 24 | 0 | 1 | 0 | 1 | 21 | 0 | 0 | 1 |
| | Ten Mile Creek [E] | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Twenty-five Mile Cr. | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 34 | 0 | 0 | 0 | 1 [C] | 1 | 0 | 0 | 0 |
| | | 30-Jul | 160 | 3 | 1 | 0 | 5 [C] | 6 | 1 | 0 | 0 |
| | | 2-Aug | 67 | 8 | 4 | 0 | 12 | 18 | 3 | 0 | 1 |
| | | 5-Aug | 97 | 7 | 7 | 0 | 14 | 32 | 4 | 0 | 2 |
| | | 9-Aug | 88 | 5 | 8 | 0 | 13 | 45 | 5 | 0 | 2 |
| | | 11-Aug | 86 | 2 | 2 | 0 | 4 | 49 | 1 | 0 | 1 |
| | | 15-Aug | 42 | 5 | 10 | 0 | 15 | 64 | 1 | 0 | 9 |
| | | 17-Aug | 29 | 1 | 4 | 0 | 5 | 69 | 0 | 0 | 4 |
| | | 19-Aug | 31 | 0 | 0 | 0 | 0 | 69 | 0 | 0 | 0 |
| | **Takla Lake, NW** | | | | | | | | | | |
| | Crow Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 65 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 35 | 5 | 4 | 0 | 9 | 9 | 1 | 0 | 0 |
| | | 2-Aug | 27 | 5 | 8 | 0 | 13 | 22 | 1 | 0 | 7 |
| | | 5-Aug | 38 | 7 | 11 | 0 | 18 | 40 | 5 | 0 | 6 |
| | | 8-Aug | 75 | 2 | 12 | 0 | 14 | 54 | 3 | 1 | 8 |
| | | 11-Aug | 57 | 4 | 9 | 0 | 13 | 67 | 1 | 0 | 8 |
| | | 14-Aug | 55 | 9 | 23 | 0 | 32 | 99 | 5 | 0 | 18 |
| | | 17-Aug | 26 | 7 | 18 | 0 | 26 [C] | 125 | 5 | 0 | 13 |
| | | 20-Aug | 0 | 2 | 10 | 0 | 13 [C] | 138 | 0 | 0 | 10 |
| | Dust Creek | 27-Jul | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Aug | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 4-Aug | 1,155 | 0 | 0 | 0 | 314 [C] | 314 | 0 | 0 | 0 |
| | | 5-Aug | 1 | 0 | 0 | 0 | 0 | 314 | 0 | 0 | 0 |
| | | 8-Aug | - | 0 | 0 | 0 | 0 | 314 | 0 | 0 | 0 |
| | | 11-Aug | - | 0 | 0 | 0 | 0 | 314 | 0 | 0 | 0 |
| | Hooker Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 5-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 8-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 11-Aug | 12 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 1 |
| | | 14-Aug | 21 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | | 17-Aug | 21 | 5 | 3 | 0 | 8 | 10 | 1 | 0 | 2 |
| | | 20-Aug | 4 | 4 | 7 | 0 | 11 | 21 | 0 | 0 | 7 |
| | McDougall Creek [E] | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered Male | Female | Jack | Total | Cum. | % spawned 0% | 50% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stuart** | McDougall Creek | 2-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Early Runs*** | cont'd | 5-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Continued | | 8-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 11-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 14-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Point Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 87 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 120 | 3 | 3 | 0 | 6 | 6 | 3 | 0 | 0 |
| | | 2-Aug | 128 | 10 | 14 | 0 | 24 | 30 | 9 | 2 | 3 |
| | | 5-Aug | 108 | 24 | 21 | 0 | 46 [c] | 76 | 12 | 0 | 8 |
| | | 8-Aug | 167 | 23 | 18 | 0 | 41 | 117 | 8 | 0 | 10 |
| | | 11-Aug | 93 | 12 | 15 | 0 | 27 | 144 | 4 | 0 | 11 |
| | | 14-Aug | 64 | 8 | 32 | 0 | 41 [c] | 185 | 4 | 0 | 28 |
| | | 17-Aug | 55 | 15 | 20 | 0 | 35 | 220 | 2 | 0 | 18 |
| | | 20-Aug | 9 | 5 | 7 | 0 | 12 | 232 | 1 | 0 | 2 |
| | Sinta Creek [E] | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 5-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 8-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 11-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 14-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | **Takla Lake, S** | | | | | | | | | | |
| | Bivouac Creek | 23-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 26-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Aug | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 3-Aug | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | | 5-Aug | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | | 9-Aug | 0 | 2 | 0 | 0 | 2 | 3 | 0 | 0 | 0 |
| | | 13-Aug | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| | Gluske Creek | 25-Jul | 205 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (above fence) | 28-Jul | 264 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 31-Jul | 276 | 28 | 23 | 0 | 63 [c] | 64 | 8 | 2 | 13 |
| | | 3-Aug | 322 | 37 | 35 | 0 | 73 [c] | 137 | 11 | 2 | 22 |
| | | 6-Aug | 277 | 46 | 31 | 0 | 77 | 214 | 13 | 0 | 17 |
| | | 9-Aug | 200 | 32 | 24 | 0 | 56 | 270 | 4 | 1 | 19 |
| | | 12-Aug | 130 | 33 | 21 | 0 | 54 | 324 | 1 | 0 | 20 |
| | | 15-Aug | 61 | 13 | 14 | 0 | 27 | 351 | 1 | 0 | 13 |
| | | 18-Aug | 10 | 6 | 6 | 0 | 12 | 12 | 1 | 0 | 4 |
| | Gluske Creek | 25-Jul | 179 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (below fence) | 28-Jul | 330 | 1 | 11 | 0 | 12 | 12 | 6 | 2 | 3 |
| | | 29-Jul | - | 0 | 2 | 0 | 2 | 14 | 1 | 0 | 1 |
| | | 30-Jul | - | 14 | 11 | 0 | 25 | 39 | 9 | 1 | 1 |
| | | 31-Jul | 355 | 2 | 1 | 0 | 3 | 42 | 0 | 0 | 1 |
| | | 2-Aug | - | 1 | 1 | 0 | 2 | 44 | 1 | 0 | 0 |
| | | 3-Aug | 256 | 21 | 29 | 0 | 50 | 94 | 11 | 5 | 13 |
| | | 6-Aug | 179 | 43 | 31 | 0 | 74 | 168 | 15 | 0 | 15 |
| | | 9-Aug | 193 | 22 | 21 | 0 | 43 | 211 | 3 | 1 | 17 |
| | | 12-Aug | 118 | 27 | 27 | 0 | 54 | 265 | 3 | 0 | 22 |
| | | 15-Aug | 68 | 8 | 11 | 0 | 19 | 284 | 0 | 0 | 11 |
| | | 18-Aug | 19 | 9 | 10 | 0 | 19 | 303 | 3 | 0 | 6 |
| | Leo Creek [F] | 23-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 26-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 30-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 2-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered | | | | | % spawned | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Male | Female | Jack | Total | Cum. | 0% | 50% | 100% |
| **Stuart** | Leo Creek cont'd | 4-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Early Runs*** | Narrows Creek | 23-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Continued | | 26-Jul | 209 | 3 | 3 | 0 | 6 | 6 | 1 | 0 | 0 |
| | | 29-Jul | 289 | 12 | 20 | 0 | 33 [C] | 39 | 13 | 1 | 6 |
| | | 1-Aug | 137 | 31 | 22 | 0 | 71 [C] | 110 | 14 | 4 | 4 |
| | | 4-Aug | 127 | 9 | 46 | 0 | 55 | 165 | 4 | 0 | 3 |
| | | 7-Aug | 320 | 23 | 11 | 0 | 37 [C] | 202 | 4 | 1 | 6 |
| | | 10-Aug | 257 | 48 | 34 | 0 | 82 | 284 | 12 | 2 | 20 |
| | | 13-Aug | 363 | 55 | 56 | 0 | 111 | 395 | 10 | 4 | 42 |
| | | 16-Aug | 154 | 28 | 28 | 0 | 56 | 451 | 7 | 1 | 20 |
| | | 20-Aug | 66 | 27 | 24 | 0 | 51 | 502 | 2 | 0 | 20 |
| | | 23-Aug | 16 | 14 | 13 | 0 | 27 | 529 | 1 | 0 | 12 |
| | Sakeniche Creek | 24-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 27-Jul | 2 | 2 | 15 | 0 | 17 | 17 | 11 | 0 | 1 |
| | | 30-Jul | 0 | 2 | 19 | 0 | 21 | 38 | 1 | 0 | 0 |
| | | 2-Aug | 0 | 0 | 0 | 0 | 0 | 38 | 0 | 0 | 0 |
| | | 5-Aug | 1 | 0 | 0 | 0 | 1 [C] | 39 | 0 | 0 | 0 |
| | | 9-Aug | 0 | 0 | 0 | 0 | 0 | 39 | 0 | 0 | 0 |
| | | 10-Aug | 30 | 1 | 0 | 0 | 1 | 40 | 0 | 0 | 0 |
| | | 13-Aug | 96 | 13 | 5 | 0 | 18 | 58 | 4 | 1 | 0 |
| | | 16-Aug | 51 | 22 | 15 | 0 | 37 | 95 | 5 | 0 | 8 |
| | | 20-Aug | 5 | 6 | 4 | 0 | 10 | 105 | 0 | 0 | 4 |
| | Sandpoint Creek | 23-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 26-Jul | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 29-Jul | 15 | 4 | 2 | 0 | 6 | 6 | 1 | 0 | 0 |
| | | 1-Aug | 16 | 1 | 3 | 0 | 4 | 10 | 1 | 0 | 2 |
| | | 4-Aug | 6 | 1 | 3 | 0 | 4 | 14 | 1 | 1 | 0 |
| | | 7-Aug | 13 | 5 | 1 | 0 | 6 | 20 | 1 | 0 | 0 |
| | | 10-Aug | 17 | 5 | 2 | 0 | 7 | 27 | 0 | 0 | 2 |
| | | 13-Aug | 17 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 |
| | | 16-Aug | 28 | 0 | 0 | 0 | 1 [C] | 28 | 0 | 0 | 0 |
| | | 20-Aug | 18 | 3 | 1 | 0 | 4 | 32 | 0 | 0 | 1 |
| | **Middle River** | | | | | | | | | | |
| | Forfar Creek | 25-Jul | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | (above fence) | 28-Jul | 69 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 31-Jul | 194 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | | 3-Aug | 221 | 0 | 17 | 0 | 28 [C] | 29 | 5 | 0 | 3 |
| | | 6-Aug | 372 | 8 | 11 | 0 | 19 | 48 | 5 | 2 | 4 |
| | | 9-Aug | 299 | 15 | 20 | 0 | 35 | 83 | 9 | 0 | 11 |
| | | 12-Aug | 246 | 60 | 25 | 0 | 85 | 168 | 10 | 0 | 15 |
| | | 15-Aug | 199 | 42 | 29 | 0 | 71 | 239 | 5 | 0 | 23 |
| | | 18-Aug | 39 | 11 | 21 | 0 | 32 | 271 | 2 | 0 | 19 |
| | Forfar Creek | 25-Jul | 283 | 2 | 3 | 0 | 5 | 5 | 2 | 0 | 1 |
| | (below fence) | 28-Jul | 303 | 1 | 5 | 0 | 6 | 11 | 4 | 0 | 1 |
| | | 30-Jul | - | 9 | 12 | 0 | 21 | 32 | 10 | 1 | 1 |
| | | 31-Jul | 381 | 4 | 6 | 0 | 10 | 42 | 6 | 0 | 0 |
| | | 2-Aug | - | 0 | 0 | 1 | 1 | 43 | 0 | 0 | 0 |
| | | 3-Aug | 301 | 15 | 11 | 0 | 26 | 69 | 7 | 1 | 3 |
| | | 6-Aug | 359 | 12 | 16 | 0 | 28 | 97 | 8 | 3 | 5 |
| | | 9-Aug | 249 | 11 | 10 | 0 | 21 | 118 | 4 | 0 | 6 |
| | | 12-Aug | 198 | 24 | 29 | 0 | 53 | 171 | 14 | 0 | 15 |
| | | 15-Aug | 94 | 24 | 21 | 0 | 45 | 216 | 3 | 0 | 18 |
| | | 18-Aug | 45 | 13 | 10 | 0 | 23 | 239 | 2 | 0 | 7 |
| | Kazchek Creek | 3-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 10-Aug | 5 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 1 |
| | | 12-Aug | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered | | | | | % spawned | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Male | Female | Jack | Total | Cum. | 0% | 50% | 100% |
| **Stuart** | Kynoch Creek | 22-Jul | 80 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| ***Early Runs*** | (above fence) | 25-Jul | 383 | 1 | 1 | 0 | 2 | 3 | 0 | 0 | 0 |
| Continued | | 28-Jul | 645 | 9 | 11 | 0 | 23 [C] | 26 | 11 | 0 | 0 |
| | | 31-Jul | 618 | 66 | 73 | 0 | 139 | 165 | 46 | 1 | 24 |
| | | 3-Aug | 631 | 89 | 129 | 0 | 218 | 383 | 88 | 0 | 37 |
| | | 6-Aug | 481 | 104 | 105 | 0 | 209 | 592 | 55 | 0 | 50 |
| | | 9-Aug | 397 | 95 | 51 | 0 | 165 [C] | 757 | 27 | 0 | 24 |
| | | 12-Aug | 210 | 95 | 82 | 0 | 205 [C] | 962 | 9 | 0 | 50 |
| | | 15-Aug | 158 | 33 | 26 | 0 | 70 [C] | 1,032 | 7 | 2 | 15 |
| | | 18-Aug | 75 | 17 | 17 | 0 | 34 | 1,066 | 3 | 0 | 12 |
| | Kynoch Creek | 21-Jul | 94 | 3 | 1 | 0 | 4 | 4 | 1 | 0 | 0 |
| | (below fence) | 22-Jul | 18 | 0 | 2 | 0 | 2 | 6 | 2 | 0 | 0 |
| | | 23-Jul | - | 6 | 4 | 0 | 10 | 16 | 4 | 0 | 0 |
| | | 25-Jul | 328 | 4 | 4 | 0 | 8 | 24 | 4 | 0 | 0 |
| | | 28-Jul | 334 | 8 | 16 | 0 | 24 | 48 | 13 | 0 | 3 |
| | | 30-Jul | - | 3 | 4 | 0 | 7 | 55 | 4 | 0 | 0 |
| | | 31-Jul | 234 | 5 | 8 | 0 | 13 | 68 | 8 | 0 | 0 |
| | | 2-Aug | - | 18 | 16 | 1 | 35 | 103 | 15 | 0 | 1 |
| | | 3-Aug | 182 | 18 | 22 | 0 | 40 | 143 | 15 | 1 | 4 |
| | | 6-Aug | 145 | 22 | 11 | 1 | 34 | 177 | 9 | 0 | 2 |
| | | 9-Aug | 147 | 15 | 16 | 0 | 31 | 208 | 7 | 0 | 6 |
| | | 12-Aug | 135 | 6 | 11 | 0 | 17 | 225 | 1 | 0 | 10 |
| | | 15-Aug | 129 | 3 | 1 | 0 | 4 | 229 | 0 | 0 | 1 |
| | | 18-Aug | 71 | 8 | 14 | 0 | 22 | 251 | 3 | 1 | 10 |
| | Middle River | 3-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 4-Aug | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 12-Aug | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Rossette Creek | 22-Jul | 29 | 3 | 0 | 0 | 12 [C] | 12 | 0 | 0 | 0 |
| | | 25-Jul | 182 | 1 | 2 | 0 | 3 | 15 | 1 | 0 | 0 |
| | | 28-Jul | 379 | 7 | 6 | 0 | 13 | 28 | 6 | 0 | 0 |
| | | 31-Jul | 401 | 36 | 32 | 0 | 70 [C] | 98 | 16 | 4 | 4 |
| | | 3-Aug | 267 | 58 | 36 | 0 | 94 | 192 | 16 | 3 | 15 |
| | | 4-Aug | - | 6 | 14 | 0 | 20 | 212 | 6 | 0 | 8 |
| | | 6-Aug | 200 | 26 | 48 | 0 | 104 [C] | 316 | 9 | 1 | 34 |
| | | 9-Aug | 112 | 54 | 46 | 0 | 137 [C] | 453 | 4 | 0 | 23 |
| | | 12-Aug | 88 | 37 | 31 | 0 | 68 | 521 | 3 | 1 | 22 |
| | | 15-Aug | 66 | 11 | 2 | 0 | 33 [C] | 554 | 0 | 0 | 1 |
| | | 18-Aug | 47 | 11 | 13 | 0 | 28 [C] | 582 | 3 | 0 | 9 |
| | **Trembleur Lake** | | | | | | | | | | |
| | Felix Creek | 19-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 23-Jul | 143 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 26-Jul | 400 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 29-Jul | 689 | 26 | 20 | 0 | 46 | 47 | 14 | 1 | 5 |
| | | 1-Aug | 721 | 82 | 95 | 0 | 178 [C] | 225 | 36 | 3 | 53 |
| | | 4-Aug | 579 | 121 | 140 | 0 | 262 [C] | 487 | 45 | 2 | 93 |
| | | 7-Aug | 517 | 117 | 131 | 0 | 248 | 735 | 45 | 0 | 86 |
| | | 10-Aug | 398 | 88 | 90 | 0 | 178 | 913 | 32 | 0 | 56 |
| | | 13-Aug | 175 | 84 | 125 | 0 | 210 [C] | 1,123 | 24 | 0 | 93 |
| | | 16-Aug | 109 | 55 | 78 | 0 | 133 | 1,256 | 14 | 0 | 59 |
| | Fleming Creek | 4-Aug | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Paula Creek | 19-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 23-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 26-Jul | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 29-Jul | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 1-Aug | 189 | 1 | 2 | 0 | 9 [C] | 9 | 2 | 0 | 0 |
| | | 4-Aug | 256 | 7 | 7 | 0 | 16 [C] | 25 | 5 | 0 | 2 |
| | | 7-Aug | 361 | 18 | 16 | 0 | 34 | 59 | 6 | 1 | 9 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered Male | Female | Jack | Total | Cum. | % spawned 0% | 50% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stuart** | Paula Creek | 10-Aug | 252 | 26 | 24 | 0 | 50 | 109 | 4 | 3 | 16 |
| ***Early Runs*** | cont'd | 13-Aug | 161 | 67 | 59 | 0 | 126 | 235 | 13 | 0 | 46 |
| Continued | | 16-Aug | 62 | 57 | 44 | 0 | 101 | 336 | 5 | 0 | 35 |
| **Stuart** | Kazchek Creek | 28-Aug | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Summer Runs*** | | 2-Sep | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 3-Sep | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 6-Sep | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 17-Sep | 450 | 2 | 5 | 0 | 7 | 7 | 2 | 0 | 3 |
| | | 22-Sep | 1,196 | 13 | 22 | 0 | 35 | 42 | 0 | 0 | 16 |
| | | 28/98 | 310 | 24 | 25 | 0 | 49 | 91 | 1 | 0 | 19 |
| | | 1-Oct | 165 | 37 | 49 | 0 | 86 | 177 | 0 | 0 | 47 |
| | Pinchi Creek | 2-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 8-Sep | 20 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | | 16-Sep | 487 | 2 | 3 | 0 | 5 | 6 | 0 | 0 | 3 |
| | | 24-Sep | 587 | 55 | 95 | 0 | 150 | 156 | 14 | 0 | 81 |
| | | 30-Sep | 255 | 79 | 114 | 0 | 193 | 349 | 4 | 0 | 110 |
| | | 3-Oct | 149 | 29 | 41 | 0 | 70 | 419 | 0 | 0 | 41 |
| | Sakeniche River | 17-Sep | 54 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| | | 25-Sep | 14 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 |
| | | 29-Sep | 0 | 0 | 3 | 0 | 3 | 5 | 0 | 0 | 0 |
| | Sowchea Creek | 8-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 16-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 24-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Nechako** | Nadina River | 12-Sep | 161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 19-Sep | 422 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Stellako River [G] | 31-Aug | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 4-Sep | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 7-Sep | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 11-Sep | - | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| | | 14-Sep | - | 2 | 2 | 0 | 4 | 5 | 2 | 0 | 0 |
| | | 18-Sep | - | 2 | 1 | 0 | 3 | 8 | 1 | 0 | 0 |
| | | 19-Sep | - | 3 | 7 | 0 | 10 | 18 | 6 | 0 | 1 |
| | | 20-Sep | - | 6 | 14 | 0 | 20 | 38 | 9 | 0 | 4 |
| | | 22-Sep | - | 8 | 12 | 0 | 20 | 58 | 4 | 0 | 8 |
| | | 23-Sep | - | 61 | 58 | 0 | 119 | 177 | 29 | 0 | 26 |
| | | 25-Sep | - | 68 | 130 | 0 | 198 | 375 | 19 | 0 | 107 |
| | | 26-Sep | - | 85 | 137 | 0 | 222 | 597 | 18 | 0 | 114 |
| | | 28-Sep | - | 513 | 458 | 2 | 973 | 1,570 | 25 | 0 | 425 |
| | | 29-Sep | - | 653 | 1,009 | 1 | 1,663 | 3,233 | 51 | 4 | 941 |
| | | 1-Oct | - | 2,091 | 2,165 | 1 | 4,257 | 7,490 | 32 | 4 | 2,108 |
| | | 2-Oct | - | 1,074 | 1,521 | 0 | 2,595 | 10,085 | 23 | 14 | 1,464 |
| | | 3-Oct | - | 1,196 | 1,443 | 3 | 2,642 | 12,727 | 32 | 0 | 1,396 |
| | | 4-Oct | - | 3,311 | 2,994 | 0 | 6,305 | 19,032 | 27 | 4 | 2,916 |
| | | 5-Oct | - | 2,318 | 2,554 | 2 | 4,874 | 23,906 | 48 | 18 | 2,466 |
| | | 6-Oct | - | 1,710 | 1,853 | 1 | 3,564 | 27,470 | 34 | 8 | 1,788 |
| | | 7-Oct | - | 4,617 | 4,551 | 4 | 9,172 | 36,642 | 33 | 17 | 4,463 |
| | | 8-Oct | - | 2,307 | 2,555 | 0 | 4,862 | 41,504 | 7 | 8 | 2,520 |
| | | 9-Oct | - | 2,751 | 3,403 | 4 | 6,158 | 47,662 | 21 | 16 | 3,338 |
| | | 10-Oct | - | 3,127 | 3,262 | 2 | 6,391 | 54,053 | 21 | 8 | 3,210 |
| | | 11-Oct | - | 2,340 | 2,926 | 0 | 5,266 | 59,319 | 19 | 16 | 2,875 |
| | | 12-Oct | - | 1,832 | 2,103 | 0 | 3,935 | 63,254 | 11 | 9 | 2,070 |
| | | 13-Oct | - | 2,569 | 3,089 | 1 | 5,659 | 68,913 | 3 | 7 | 3,046 |
| | | 14-Oct | - | 1,494 | 1,982 | 0 | 3,476 | 72,389 | 6 | 0 | 1,961 |
| | | 15-Oct | - | 937 | 1,247 | 0 | 2,184 | 74,573 | 0 | 0 | 1,244 |
| | | 16-Oct | - | 855 | 1,002 | 0 | 1,857 | 76,430 | 0 | 0 | 999 |

Continued

Appendix 9. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by stock group, stock and date, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock group | Stock | Date | Live count | Carcasses recovered: Male | Female | Jack | Total | Cum. | % spawned: 0% | 50% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Upper Fraser** | Bowron River | 28-Aug | 930 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 3-Sep | 2,527 | 0 | 0 | 0 | 127 [C] | 127 | 0 | 0 | 0 |
| | | 4-Sep | - | 74 | 109 | 1 | 184 | 311 | 0 | 0 | 109 |
| | Indianpoint Creek | 3-Sep | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[A.] Includes one recovery field identified as a jack which scale evaluation confirmed as an adult.

[B.] Live counts are fish let above the barrier.

[C.] Includes unsexed dead recorded but not sampled during a live enumeration survey.

[D.] Creek dry; no sockeye access.

[E.] Low water; no sockeye access.

[F.] Beaver dams blocked access.

[G.] Includes five recoveries field identified as a jack which scale evaluation confirmed as an adult.

Appendix 10. Number of surveys, peak live counts, cumulative dead counts, expansion factors, spawning success, and escapement of sockeye adults (by sex) and jacks, by stock group and stock, for Fraser River sockeye salmon assessed using visual surveys, 1998.

| Stock Group | Stock | Number of surveys | Peak live | Cumulative dead | Expansion factor | Weighted percent spawning success | Source of sex ratio[A] | Escapement estimate Male | Female | Jack |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lower** | Chilliwack Lake | 5 | 0 | 268 | 4.0 | 67.1% | - | 436 | 632 | 4 |
| **Fraser** | Nahatlatch Lake | 3 | 1 | 235 | 6.7 | 40.7% | - | 780 | 787 | 0 |
| | Nahatlatch River | 4 | 3,437 | 133 | 1.8 | 82.3% | - | 2,947 | 3,479 | 0 |
| | Widgeon Slough | 4 | 34 | 5 | 1.8 | 80.0% | - | 48 | 22 | 0 |
| **Harrison-** | Big Silver Creek | 4 | 3,018 | 304 | 1.8 | 94.8% | - | 2,846 | 3,128 | 6 |
| **Lillooet** | Green River | 1 | 0 | 0 | - | - | - | 0 | 0 | 0 |
| | Harrison River | 8 | 5,482 | 16 | 1.8 | 99.0% | - | 1,453 | 3,043 | 0 |
| | Poole Creek | 2 | 117 | 0 | 1.8 | 95.0% | - | 105 | 106 | 0 |
| | Samson Creek | 3 | 335 | 11 | 1.8 | 95.7% | - | 256 | 367 | 0 |
| **Seton-** | Gates Creek | 17 [B] | 1,097 | 0 | - | 54.2% | - | 694 | 242 | 161 |
| **Anderson** | Portage Creek | 4 | 13,491 | 512 | 1.8 | 90.5% | - | 12,060 | 13,119 | 26 |
| **South** | Adams Channel | 6 | 219 | 0 | 1.8 | 75.0% | - [C] | 210 | 184 | 0 |
| **Thompson** | Adams River, lower | 10 | 843 | 12 | 1.8 | 95.0% | - [C] | 821 | 718 | 0 |
| ***Early Sum-*** | Adams River, upper | 5 | 123 | 68 | 1.8 | 96.2% | - | 180 | 164 | 0 |
| ***mer Runs*** | Anstey River | 6 | 2,571 | 63 | 1.8 | 93.5% | - | 2,382 | 2,359 | 0 |
| | Cayenne Creek | 5 | 86 | 4 | 1.8 | 84.7% | - | 59 | 103 | 0 |
| | Celista Creek | 2 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Hiuihill Creek | 4 | 425 | 45 | 1.8 | 90.3% | - | 450 | 394 | 2 |
| | Hunakwa Creek | 2 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Malakwa Creek | 5 | 41 | 1 | 1.8 | 90.0% | - | 19 | 57 | 0 |
| | McNomee Creek | 8 | 358 | 14 | 1.8 | 90.7% | - | 328 | 342 | 0 |
| | Momich River | 2 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Nikwikwaia Creek | 3 | 126 | 6 | 1.8 | 83.3% | - [C] | 127 | 111 | 0 |
| | Onyx Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Perry River | 8 | 319 | 9 | 1.8 | 100.0% | - | 209 | 381 | 0 |
| | Ross Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Salmon River | 1 | 0 | 0 | - | - | - | 0 | 0 | 0 |
| | Scotch Cr., above | 6 | 7,822 | 4,796 | - | 94.5% | - | 17,962 | 18,019 | 12 |
| | Yard Creek | 8 | 554 | 80 | 1.8 | 95.7% | - | 470 | 671 | 0 |
| **South** | Adams Lake | 6 | 525 | 126 | 1.8 | 98.5% | - | 635 | 537 | 0 |
| **Thompson** | Adams River, upper | - [D] | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| ***Late Runs*** | Anstey River | 5 | 401 | 6 | 1.8 | 100.0% | - | 507 | 226 | 0 |
| | Bush Creek | 3 | 208 | 0 | 1.8 | 98.5% | - [E] | 203 | 171 | 0 |
| | Canoe Creek | 3 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Celista Creek | 4 | 30 | 0 | 1.8 | 100.0% | - [F] | 30 | 24 | 0 |
| | Eagle River [G] | 4 | 393 | 107 | 1.8 | 100.0% | - | 367 | 533 | 0 |
| | Hiuihill Creek | 5 | 491 | 0 | 1.8 | 100.0% | - | 619 | 265 | 0 |
| | Hunakwa Creek | 4 | 149 | 30 | 1.8 | 95.7% | - | 156 | 166 | 0 |
| | McNomee Creek | 4 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Momich River | 2 | 50 | 0 | 1.8 | 98.5% | - [E] | 49 | 41 | 0 |
| | Nikwikwaia Creek | 5 | 382 | 28 | 1.8 | 100.0% | - | 342 | 396 | 0 |
| | Pass Creek | 6 | 459 | 57 | 1.8 | 94.1% | - | 339 | 590 | 0 |
| | Perry River | 2 | 3 | 0 | 1.8 | 100.0% | - [H] | 2 | 3 | 0 |
| | Salmon River [I] | 3 | 133 | 3 | 1.8 | 83.3% | - | 102 | 143 | 0 |
| | Scotch Creek | 8 | 1,434 | 413 | 1.8 | 91.4% | - | 1,675 | 1,650 | 0 |
| | Seymour River | 4 | 64 | 0 | 1.8 | 91.3% | - [F] | 65 | 50 | 0 |
| | S. Thompson R. | 4 | 1,276 | 6 | 1.8 | 96.3% | - | 1,196 | 1,112 | 0 |
| | Tappen Creek | 4 | 92 | 7 | 1.8 | 98.8% | - | 94 | 84 | 0 |
| | Yard Creek | 2 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |

Continued

Appendix 10. Number of surveys, peak live counts, cumulative dead counts, expansion factors, spawning success, and escapement of sockeye adults (by sex) and jacks, by stock group and stock, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock Group | Stock | Number of surveys | Peak live | Cumula-tive dead | Expan-sion factor | Weighted percent spawn-ing success | Source of sex ratio[A] | Escapement estimate Male | Female | Jack |
|---|---|---|---|---|---|---|---|---|---|---|
| **South Thompson** | **Shuswap Lake** | | | | | | | | | |
| ***Late Runs*** | Anstey Arm | 6 | 946 | 68 | 1.8 | 98.7% | - | 885 | 940 | 0 |
| Continued | Main Arm | 10 | 3,067 | 9 | 1.8 | 91.3% | - | 3,113 | 2,424 | 0 |
| | Salmon Arm | 7 | 1,697 | 4 | 1.8 | 99.2% | - | 1,481 | 1,581 | 0 |
| | Seymour Arm | 3 | 85 | 1 | 1.8 | 100.0% | - [F] | 87 | 68 | 0 |
| | **Shuswap River** | | | | | | | | | |
| | Shuswap R., middle | 12 | 8,372 | 107 | 1.8 | 99.6% | - | 6,599 | 8,663 | 0 |
| | Tsuius Creek | 4 | 351 | 8 | 1.8 | 98.2% | - [I] | 318 | 328 | 0 |
| | Wap Creek | 4 | 584 | 15 | 1.8 | 95.9% | - | 510 | 568 | 0 |
| **North Thompson** | Fennell Creek | 6 | 4,778 | 78 | 1.8 | 93.2% | - | 3,411 | 5,330 | 0 |
| | Harper Creek | 2 | 2 | 3 | 1.8 | 100.0% | - | 3 | 6 | 0 |
| | Raft River | 6 | 3,297 | 719 | 1.8 | 93.7% | - | 3,373 | 3,825 | 31 |
| **Chilcotin** | Elkin Creek | 1 [J] | 47 | 0 | 1.8 | 91.7% [K] | - [K] | 25 | 60 | 0 |
| | Taseko Lake | 1 | 8 | 20 | 14.3 | 91.7% | - | 120 | 280 | 0 |
| **Quesnel** | **Horsefly River** | | | | | | | | | |
| | Little Horsefly River | 5 | 2,018 | 301 | 1.8 | 93.5% | - | 1,643 | 2,531 | 0 |
| | Moffat Creek | 5 | 412 | 109 | 1.8 | 94.7% | - | 512 | 426 | 0 |
| | **Mitchell River** | | | | | | | | | |
| | Cameron Creek | 4 | 4,050 | 1,433 | 1.8 | 96.1% | - | 5,053 | 4,816 | 0 |
| | Penfold Creek | 1 | 300 | 0 | 1.8 | 93.7% [L] | - [L] | 258 | 282 | 0 |
| | **Quesnel Lake, E. Arm** | | | | | | | | | |
| | Big Slide lakeshore | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Bill Miner Creek | 3 | 100 | 96 | 1.8 | 100.0% | - | 158 | 195 | 0 |
| | Bill Miner lakeshore | 3 | 43 | 0 | 1.8 | 100.0% [M] | - [M] | 34 | 43 | 0 |
| | Bill Miner, 3km W | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Blue Lead Creek | 5 | 1,422 | 313 | 1.8 | 99.1% | - | 1,336 | 1,787 | 0 |
| | Blue Lead lakeshore | 5 | 690 | 73 | 1.8 | 97.3% | - | 624 | 749 | 0 |
| | Bouldery Creek | 4 | 20 | 10 | 1.8 | 100.0% | - | 25 | 29 | 0 |
| | Bouldery lakeshore | 3 | 5 | 0 | 1.8 | 100.0% [N] | - [N] | 4 | 5 | 0 |
| | Bouldery, 2 km E | 2 | 10 | 0 | 1.8 | 100.0% [N] | - [N] | 8 | 10 | 0 |
| | Killdog Creek | 3 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Lynx Creek | 5 | 264 | 58 | 1.8 | 95.7% | - | 249 | 331 | 0 |
| | Lynx lakeshore | 4 | 47 | 4 | 1.8 | 100.0% | - | 40 | 52 | 0 |
| | Niagara Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Slate Bay | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Summit Creek | 5 | 1,835 | 47 | 1.8 | 95.9% | - | 1,575 | 1,813 | 0 |
| | Taku Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | **Quesnel Lake, N. Arm** | | | | | | | | | |
| | Bear Beach lakeshore | 2 | 25 | 0 | 1.8 | 99.2% [O] | - [O] | 15 | 30 | 0 |
| | Betty Frank's Shore | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Bowling Point | 5 | 122 | 7 | 1.8 | 96.4% | - | 84 | 148 | 0 |
| | Deception Point | 5 | 2,320 | 15 | 1.8 | 98.6% | - | 1,322 | 2,881 | 0 |
| | Devoe Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Devoe lakeshore | 2 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Goose Point | 5 | 620 | 34 | 1.8 | 99.2% | - | 394 | 783 | 0 |
| | Grain Creek | 6 | 242 | 8 | 1.8 | 97.4% | - | 202 | 248 | 0 |
| | Grain lakeshore | 2 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Isaiah Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Limestone Point | 2 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |

Continued

Appendix 10. Number of surveys, peak live counts, cumulative dead counts, expansion factors, spawning success, and escapement of sockeye adults (by sex) and jacks, by stock group and stock, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock Group | Stock | Number of surveys | Peak live | Cumula-tive dead | Expan-sion factor | Weighted percent spawn-ing success | Source of sex ratio[A] | Escapement estimate Male | Escapement estimate Female | Escapement estimate Jack |
|---|---|---|---|---|---|---|---|---|---|---|
| **Quesnel** | Long Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| Continued | Long lakeshore | 2 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Marten Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Marten lakeshore | 2 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Roaring River | 5 | 486 | 39 | 1.8 | 95.3% | - | 430 | 515 | 0 |
| | Roaring lakeshore | 4 | 92 | 19 | 1.8 | 96.8% | - | 76 | 124 | 0 |
| | Sue Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Trickle Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Wasko Creek | 5 | 670 | 903 | 1.8 | 96.8% | - | 1,298 | 1,533 | 0 |
| | Watt Creek | 5 | 420 | 11 | 1.8 | 96.1% | - | 323 | 453 | 0 |
| | **Quesnel Lake Tributaries - West Arm** | | | | | | | | | |
| | Hazeltine Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Raft Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| | Spusks Cr lakeshore | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| **Stuart** | **Driftwood River** | | | | | | | | | |
| ***Early Runs*** | Blackwater Creek | 3 | 12 | 1 | 2.1 | 100.0% | - [P] | 14 | 13 | 0 |
| | Driftwood River | 1 | 3,317 | 1,077 | 2.1 | 55.9% [P] | - [P] | 4,635 | 4,592 | 0 |
| | Kastberg Creek | 1 | 0 | 0 | 2.1 | - | - | 0 | 0 | 0 |
| | Kotsine River | 1 | 2 | 0 | 2.1 | 55.9% [P] | - [P] | 2 | 2 | 0 |
| | Lion Creek | 1 | 32 | 0 | 2.1 | 55.9% [P] | - [P] | 34 | 33 | 0 |
| | Porter Creek | 3 | 879 | 111 | 2.1 | 55.9% | - | 1,044 | 1,035 | 0 |
| | **Takla Lake, N.E. Arm** | | | | | | | | | |
| | Ankwill Creek | 10 | 833 | 7 | 2.1 | 43.7% | - | 831 | 933 | 0 |
| | Bates Creek | 3 | 0 | 0 | 2.1 | - | - | 0 | 0 | 0 |
| | Blanchette Creek | 8 | 0 | 0 | 2.1 | - | - | 0 | 0 | 0 |
| | Forsythe Creek | 10 | 246 | 18 | 2.1 | 48.0% | - | 257 | 297 | 0 |
| | French Creek | 9 | 38 | 11 | 2.1 | 31.3% | - | 48 | 55 | 0 |
| | Frypan Creek | 10 | 394 | 195 | 2.1 | 42.5% | - | 545 | 692 | 0 |
| | Hudson's Bay Cr. | 10 | 25 | 26 | 2.1 | 36.7% | - | 66 | 41 | 0 |
| | Shale Creek | 10 | 164 | 7 | 2.1 | 64.3% | - [Q] | 174 | 185 | 0 |
| | Five Mile Creek | 10 | 51 | 3 | 2.1 | 100.0% | - [Q] | 55 | 58 | 0 |
| | Fifteen Mile Creek | 10 | 106 | 13 | 2.1 | 100.0% | - [Q] | 121 | 129 | 0 |
| | Ten Mile Creek | 1 | 0 | 0 | 2.1 | - | - | 0 | 0 | 0 |
| | Twenty-five Mile Cr. | 10 | 160 | 6 | 2.1 | 54.5% | - | 161 | 188 | 0 |
| | **Takla Lake, N.W. Arm** | | | | | | | | | |
| | Crow Creek | 10 | 75 | 54 | 2.1 | 74.2% | - | 82 | 189 | 0 |
| | Dust Creek | 7 | 1,155 | 314 | 2.1 | 52.9% [Q] | - [Q] | 1,492 | 1,591 | 0 |
| | Hooker Creek | 10 | 21 | 10 | 2.1 | 90.9% | - | 31 | 34 | 0 |
| | McDougall Creek | 7 | 0 | 0 | 2.1 | - | - | 0 | 0 | 0 |
| | Point Creek | 10 | 167 | 117 | 2.1 | 64.7% | - | 259 | 337 | 0 |
| | Sinta Creek | 8 | 0 | 0 | 2.1 | - | - | 0 | 0 | 0 |
| | **Takla Lake, S. Arm** | | | | | | | | | |
| | Bivouac Creek | 8 | 0 | 3 | 2.1 | 0.0% | - | 4 | 2 | 0 |
| | Gluske Cr., above | 9 | 322 | 137 | - | 72.6% | - | 453 | 358 | 1 |
| | Gluske Cr., below | 12 | 108 | 265 | 1.8 | 62.9% | - | 328 | 343 | 0 |
| | Leo Creek | 5 | 0 | 0 | 2.1 | - | - | 0 | 0 | 0 |
| | Narrows Creek | 11 | 363 | 395 | 2.1 | 61.5% | - | 785 | 807 | 0 |
| | Sakeniche River | 10 | 96 | 58 | 2.1 | 38.4% | - | 102 | 221 | 0 |
| | Sandpoint Creek | 10 | 28 | 28 | 2.1 | 47.9% | - | 72 | 46 | 0 |

Continued

Appendix 10. Number of surveys, peak live counts, cumulative dead counts, expansion factors, spawning success, and escapement of sockeye adults (by sex) and jacks, by stock group and stock, for Fraser River sockeye salmon assessed using visual surveys, 1998 continued.

| Stock Group | Stock | Number of surveys | Peak live | Cumula- tive dead | Expan- sion factor | Weighted percent spawn- ing success | Source of sex ratio[A] | Escapement estimate Male | Female | Jack |
|---|---|---|---|---|---|---|---|---|---|---|
| **Stuart** | **Middle River** | | | | | | | | | |
| ***Early Runs*** | Forfar Cr., above | 9 | 372 | 48 | - | 65.2% | - | 546 | 407 | 3 |
| Continued | Forfar Cr., below | 12 | 131 | 171 | 2.3 | 49.0% | - | 333 | 357 | 3 |
| | Kazchek Creek | 3 | 5 | 2 | 2.1 | 100.0% | - | 7 | 8 | 0 |
| | Kynock Cr., above | 10 | 631 | 383 | - | 47.9% | - | 1,059 | 1,207 | 4 |
| | Kynoch Cr., below | 14 | 124 | 229 | 2.2 | 30.6% | - | 367 | 401 | 9 |
| | Middle River | 3 | 15 | 0 | 2.1 | 64.7% [R] | - [R] | 17 | 15 | 0 |
| | Rossette Creek | 11 | 401 | 98 | 2.1 | 64.7% | - | 546 | 502 | 0 |
| | **Trembleur Lake** | | | | | | | | | |
| | Felix Creek | 10 | 721 | 225 | 2.1 | 68.0% | - | 910 | 1,077 | 0 |
| | Fleming Creek | 1 | 33 | 0 | 2.1 | 68.0% [S] | - [S] | 36 | 42 | 0 |
| | Paula Creek | 10 | 361 | 59 | 2.1 | 75.2% | - | 473 | 409 | 0 |
| **Stuart** | Kazchek Creek | 8 | 1,196 | 42 | 1.8 | 96.8% | - | 957 | 1,271 | 0 |
| ***Summer Runs*** | Pinchi Creek | 6 | 587 | 156 | 1.8 | 92.9% | - | 530 | 807 | 0 |
| | Sakeniche River. | 3 | 54 | 1 | 1.8 | 98.6% [T] | - [T] | 49 | 50 | 0 |
| | Sowchea Creek | 3 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |
| **Nechako** | Nadina River | 2 | 422 | 0 | 1.8 | 95.6% [U] | - [U] | 333 | 423 | 4 |
| **Upper Fraser** | Bowron River | 3 | 2,527 | 127 | 1.8 | 100.0% | - | 1,921 | 2,830 | 26 |
| | Indianpoint Creek | 1 | 0 | 0 | 1.8 | - | - | 0 | 0 | 0 |

A. Noted only when insufficient survey data were available for that stock.
B. Total let above barrier
C. Hiuihill Creek estimate.
D. SNFC coho surveys; no sockeye were observed.
E. Adams Lake estimate.
F. Shuswap Lake Main Arm estimate.
G. Below fence estimate, see Appendix 3.
H. Eagle River estimate
I. Lower Shuswap River estimate.
J. Data provided by C&P
K. Taseko Lake estimate.
L. Mitchell River estimate.
M. Bill Miner Creek estimate.
N. Bouldery Creek estimate.
O. Goose Point Shore estimate.
P. Porter Creek estimates.
Q. Takla Lake stocks composite estimate.
R. Rossette Creek estimate.
S. Felix Creek estimate.
T. Middle River estimate.
U. Nadina Channel estimate.

Appendix 11. Period of peak spawning, adult and jack escapement, spawning success, and the number of females that spawned successfully, by stock group, stock and estimation method, for Fraser River sockeye salmon, 1998.

| Stock Group | Stock | Period of peak spawning | Escapement Total | Adults | Jacks | Males | Females | Percent spawning success | Effective females | Estimation method |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lower Fraser** | Chilliwack Lake | Early Sep | 1,072 | 1,068 | 4 | 436 | 632 | 67.1% | 424 | Visual |
| | Cultus Lake | Early Dec | 2,166 | 1,959 | 207 | 928 | 1,031 | 62.5% | 644 | Fence |
| | Nahatlatch Lake | 07-Sep to 12-Sep | 1,567 | 1,567 | 0 | 780 | 787 | 40.7% | 320 | Visual |
| | Nahatlatch River | 07-Sep to 12-Sep | 6,426 | 6,426 | 0 | 2,947 | 3,479 | 82.3% | 2,865 | Visual |
| | Pitt River, upper | 15-Sep to 20-Sep | 76,888 | 76,888 | 0 | 27,753 | 49,135 | 96.9% | 47,612 | M.R. |
| | Widgeon Slough | 18-Nov to 24-Nov | 70 | 70 | 0 | 48 | 22 | 80.0% | 18 | Visual |
| | **Total** | **-** | **88,189** | **87,978** | **211** | **32,892** | **55,086** | **94.2%** | **51,883** | **-** |
| **Harrison-Lillooet** | Big Silver Creek | Late Sep | 5,980 | 5,974 | 6 | 2,846 | 3,128 | 94.8% | 2,967 | Visual |
| | Birkenhead River | 22-Sep to 27-Sep | 296,038 | 295,669 | 369 | 114,299 | 181,370 | 95.4% | 172,997 | M.R. |
| | Green River | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Harrison River | 10-Nov to 15-Nov | 4,496 | 4,496 | 0 | 1,453 | 3,043 | 99.0% | 3,013 | Visual |
| | Poole Creek | 22-Sep to 27-Sep | 211 | 211 | 0 | 105 | 106 | 95.0% | 101 | Visual |
| | Samson Creek | 22-Sep to 27-Sep | 623 | 623 | 0 | 256 | 367 | 95.7% | 351 | Visual |
| | Weaver Channel | 11-Oct to 16-Oct | 29,117 | 29,071 | 46 | 11,733 | 17,338 | 94.6% | 16,409 | Census |
| | Weaver Creek | 11-Oct to 16-Oct | 28,042 | 28,020 | 22 | 13,188 | 14,832 | 90.4% | 13,402 | M.R. |
| | **Total** | **-** | **364,507** | **364,064** | **443** | **143,880** | **220,184** | **95.0%** | **209,240** | **-** |
| **Seton-Anderson** | Gates Channel | 29-Aug to 02-Sep | 7,628 | 6,312 | 1,316 | 2,573 | 3,739 | 61.8% | 2,311 | Census |
| | Gates Creek | 29-Aug to 02-Sep | 1,097 | 936 | 161 | 694 | 242 | 54.2% | 131 | Visual |
| | Portage Creek | 25-Oct to 30-Oct | 25,205 | 25,179 | 26 | 12,060 | 13,119 | 90.5% | 11,873 | Visual |
| | **Total** | **-** | **33,930** | **32,427** | **1,503** | **15,327** | **17,100** | **83.7%** | **14,315** | **-** |
| **South Thompson *Early Summer Runs*** | Adams Channel | 05-Sep to 10-Sep | 394 | 394 | 0 | 210 | 184 | 75.0% | 138 | Visual |
| | Adams R., lower | 05-Sep to 10-Sep | 1,539 | 1,539 | 0 | 821 | 718 | 95.0% | 682 | Visual |
| | Adams R., upper | 02-Sep to 07-Sep | 344 | 344 | 0 | 180 | 164 | 96.2% | 158 | Visual |
| | Anstey River | 03-Sep to 08-Sep | 4,741 | 4,741 | 0 | 2,382 | 2,359 | 93.5% | 2,205 | Visual |
| | Cayenne Creek | 02-Sep to 07-Sep | 162 | 162 | 0 | 59 | 103 | 84.7% | 87 | Visual |
| | Celista Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Eagle River | 05-Sep to 10-Sep | 28,478 | 28,478 | 0 | 12,321 | 16,157 | 97.1% | 15,661 | M.R. |
| | Hiuihill Creek | 31-Aug to 05-Sep | 846 | 844 | 2 | 450 | 394 | 90.3% | 356 | Visual |
| | Hunakwa Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Malakwa Creek | 30-Aug to 05-Sep | 76 | 76 | 0 | 19 | 57 | 90.0% | 51 | Visual |
| | McNomee Creek | 02-Sep to 06-Sep | 670 | 670 | 0 | 328 | 342 | 90.7% | 310 | Visual |
| | Momich River | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Nikwikwaia Creek | 02-Sep to 07-Sep | 238 | 238 | 0 | 127 | 111 | 83.3% | 92 | Visual |
| | Onyx Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Perry River | 05-Sep to 10-Sep | 590 | 590 | 0 | 209 | 381 | 100.0% | 381 | Visual |
| | Ross Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Salmon River | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Scotch Creek | 30-Aug to 03-Sep | 35,993 | 35,981 | 12 | 17,962 | 18,019 | 94.5% | 17,001 | Fence |
| | Seymour River | 06-Sep to 08-Sep | 33,389 | 33,378 | 11 | 18,604 | 14,774 | 96.7% | 14,238 | M.R. |
| | Yard Creek | 05-Sep to 10-Sep | 1,141 | 1,141 | 0 | 470 | 671 | 95.7% | 642 | Visual |
| | **Total** | **-** | **108,601** | **108,576** | **25** | **54,142** | **54,434** | **95.5%** | **52,002** | **-** |
| **South Thompson *Late Runs*** | Adams Lake | 18-Oct to 25-Oct | 1,172 | 1,172 | 0 | 635 | 537 | 98.5% | 529 | Visual |
| | Adams R., lower | 18-Oct to 25-Oct | 871,184 | 870,919 | 265 | 411,951 | 458,968 | 95.7% | 439,185 | M.R. |
| | Adams R., upper | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Anstey River | 15-Oct to 20-Oct | 733 | 733 | 0 | 507 | 226 | 100.0% | 226 | Visual |
| | Bush Creek | 21-Oct to 28-Oct | 374 | 374 | 0 | 203 | 171 | 98.5% | 168 | Visual |
| | Canoe Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Celista Creek | 18-Oct to 25-Oct | 54 | 54 | 0 | 30 | 24 | 100.0% | 24 | Visual |
| | Eagle River | Early Oct | 11,398 | 11,398 | 0 | 5,812 | 5,586 | 100.0% | 5,586 | Fence |
| | Hiuihill Creek | 15-Oct to 22-Oct | 884 | 884 | 0 | 619 | 265 | 100.0% | 265 | Visual |
| | Hunakwa Creek | 15-Oct to 20-Oct | 322 | 322 | 0 | 156 | 166 | 95.7% | 159 | Visual |
| | Little River | 18-Oct to 25-Oct | 176,252 | 176,205 | 47 | 95,371 | 80,834 | 91.9% | 74,278 | M.R. |
| | McNomee Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Momich River | - | 90 | 90 | 0 | 49 | 41 | 98.5% | 40 | Visual |
| | Nikwikwaia Creek | 15-Oct to 22-Oct | 738 | 738 | 0 | 342 | 396 | 100.0% | 396 | Visual |
| | Pass Creek | 21-Oct to 28-Oct | 929 | 929 | 0 | 339 | 590 | 94.1% | 555 | Visual |
| | Perry River | - | 5 | 5 | 0 | 2 | 3 | 100.0% | 3 | Visual |
| | Salmon River | Late Oct | 326 | 326 | 0 | 156 | 170 | 83.3% | 142 | Fence |
| | Scotch Creek | 20-Oct to 26-Oct | 3,325 | 3,325 | 0 | 1,675 | 1,650 | 91.4% | 1,508 | Visual |
| | Seymour River | 18-Oct to 24-Oct | 115 | 115 | 0 | 65 | 50 | 91.3% | 46 | Visual |

Continued

Appendix 11. Period of peak spawning, adult and jack escapement, spawning success, and the number of females that spawned successfully, by stock group, stock and estimation method, for Fraser River sockeye salmon, 1998 continued.

| | | | Escapement | | | | | Percent | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Stock Group | Stock | Period of peak spawning | Total | Adults | Jacks | Males | Females | spawning success | Effective females | Estimation method |
| **South** | S. Thompson R. | 15-Oct to 20-Oct | 2,308 | 2,308 | 0 | 1,196 | 1,112 | 96.3% | 1,071 | Visual |
| **Thompson** | Tappen Creek | 20-Oct to 26-Oct | 178 | 178 | 0 | 94 | 84 | 98.8% | 83 | Visual |
| ***Late Runs*** | Yard Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| ***continued*** | **Shuswap Lake** | | | | | | | | | |
| | Anstey Arm | 20-Oct to 27-Oct | 1,825 | 1,825 | 0 | 885 | 940 | 98.7% | 928 | Visual |
| | Main Arm | 20-Oct to 26-Oct | 5,537 | 5,537 | 0 | 3,113 | 2,424 | 91.3% | 2,213 | Visual |
| | Salmon Arm | 20-Oct to 27-Oct | 3,062 | 3,062 | 0 | 1,481 | 1,581 | 99.2% | 1,568 | Visual |
| | Seymour Arm | 20-Oct to 27-Oct | 155 | 155 | 0 | 87 | 68 | 100.0% | 68 | Visual |
| | **Shuswap River** | | | | | | | | | |
| | Shuswap R., lower | 12-Oct to 16-Oct | 291,631 | 291,631 | 0 | 142,094 | 149,537 | 95.0% | 142,013 | M.R. |
| | Shuswap R., middle | 09-Oct to 15-Oct | 15,262 | 15,262 | 0 | 6,599 | 8,663 | 99.6% | 8,631 | Visual |
| | Tsuius Creek | 15-Oct to 19-Oct | 646 | 646 | 0 | 318 | 328 | 98.2% | 322 | Visual |
| | Wap Creek | 15-Oct to 19-Oct | 1,078 | 1,078 | 0 | 510 | 568 | 95.9% | 545 | Visual |
| | **Total** | **-** | **1,389,583** | **1,389,271** | **312** | **674,289** | **714,982** | **95.2%** | **680,552** | **-** |
| **North** | Fennell Creek | 27-Aug to 01-Sep | 8,741 | 8,741 | 0 | 3,411 | 5,330 | 93.2% | 4,966 | Visual |
| **Thompson** | Harper Creek | - | 9 | 9 | 0 | 3 | 6 | 100.0% | 6 | Visual |
| | Raft River | 30-Aug to 09-Sep | 7,229 | 7,198 | 31 | 3,373 | 3,825 | 93.7% | 3,585 | Visual |
| | **Total** | **-** | **15,979** | **15,948** | **31** | **6,787** | **9,161** | **93.4%** | **8,557** | **-** |
| **Chilcotin** | Chilko River and Lake | 25-Sep to 05-Oct | 880,944 | 879,010 | 1,934 | 367,336 | 511,674 | 91.4% | 467,624 | M.R. |
| | Elkin Creek | - | 85 | 85 | 0 | 25 | 60 | 91.7% | 55 | Visual |
| | Taseko Lake | Early Sep | 400 | 400 | 0 | 120 | 280 | 91.7% | 257 | Visual |
| | **Total** | **-** | **881,429** | **879,495** | **1,934** | **367,481** | **512,014** | **91.4%** | **467,936** | **-** |
| **Quesnel** | **Horsefly River** | | | | | | | | | |
| | Horsefly Channel | - | 24,934 | 24,934 | 0 | 11,760 | 13,174 | 89.1% | 11,735 | Census |
| | Horsefly River | 07-Sep to 17-Sep | 743,122 | 743,122 | 0 | 373,601 | 369,521 | 87.1% | 321,883 | M.R. |
| | Little Horsefly River | 16-Sep to 25-Sep | 4,174 | 4,174 | 0 | 1,643 | 2,531 | 93.5% | 2,366 | Visual |
| | McKinley Creek | 07-Sep to 17-Sep | 75,829 | 75,829 | 0 | 37,892 | 37,937 | 74.9% | 28,430 | Fence |
| | Moffat Creek | 13-Sep to 20-Sep | 938 | 938 | 0 | 512 | 426 | 94.7% | 403 | Visual |
| | **Mitchell River** | | | | | | | | | |
| | Cameron Creek | 18-Sep to 25-Sep | 9,869 | 9,869 | 0 | 5,053 | 4,816 | 96.1% | 4,627 | Visual |
| | Mitchell River | 18-Sep to 25-Sep | 299,920 | 299,920 | 0 | 136,240 | 163,680 | 93.7% | 153,370 | M.R. |
| | Penfold Creek | - | 540 | 540 | 0 | 258 | 282 | 93.7% | 264 | Visual |
| | **Quesnel Lake, E. Arm** | | | | | | | | | |
| | Big Slide lakeshore | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Bill Miner Creek | 20-Sep to 30-Sep | 353 | 353 | 0 | 158 | 195 | 100.0% | 195 | Visual |
| | Bill Miner lakeshore | 20-Sep to 26-Sep | 77 | 77 | 0 | 34 | 43 | 100.0% | 43 | Visual |
| | Bill Miner, 3km W | | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Blue Lead Creek | 14-Sep to 22-Sep | 3,123 | 3,123 | 0 | 1,336 | 1,787 | 99.1% | 1,771 | Visual |
| | Blue Lead lakeshore | 14-Sep to 22-Sep | 1,373 | 1,373 | 0 | 624 | 749 | 97.3% | 729 | Visual |
| | Bouldery Creek | 20-Sep to 26-Sep | 54 | 54 | 0 | 25 | 29 | 100.0% | 29 | Visual |
| | Bouldery lakeshore | - | 9 | 9 | 0 | 4 | 5 | 100.0% | 5 | Visual |
| | Bouldery, 2 km E | | 18 | 18 | 0 | 8 | 10 | 100.0% | 10 | Visual |
| | Killdog Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Lynx Creek | 14-Sep to 22-Sep | 580 | 580 | 0 | 249 | 331 | 95.7% | 317 | Visual |
| | Lynx lakeshore | 20-Sep to 26-Sep | 92 | 92 | 0 | 40 | 52 | 100.0% | 52 | Visual |
| | Niagara Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Slate Bay | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Summit Creek | 02-Sep to 12-Sep | 3,388 | 3,388 | 0 | 1,575 | 1,813 | 95.9% | 1,739 | Visual |
| | Taku Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | **Quesnel Lake, N. Arm** | | | | | | | | | |
| | Bear Beach lakeshore | - | 45 | 45 | 0 | 15 | 30 | 99.2% | 30 | Visual |
| | Betty Frank's lakeshore | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Bowling Point | 16-Sep to 24-Sep | 232 | 232 | 0 | 84 | 148 | 96.4% | 143 | Visual |
| | Deception Point | 10-Sep to 20-Sep | 4,203 | 4,203 | 0 | 1,322 | 2,881 | 98.6% | 2,841 | Visual |
| | Devoe Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Devoe lakeshore | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Goose Point | 10-Sep to 20-Sep | 1,177 | 1,177 | 0 | 394 | 783 | 99.2% | 777 | Visual |
| | Grain Creek | 20-Sep to 30-Sep | 450 | 450 | 0 | 202 | 248 | 97.4% | 241 | Visual |
| | Grain lakeshore | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Isaiah Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Limestone Point | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |

Continued

Appendix 11. Period of peak spawning, adult and jack escapement, spawning success, and the number of females that spawned successfully, by stock group, stock and estimation method, for Fraser River sockeye salmon, 1998 continued.

| | | | Escapement | | | | | Percent | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Stock Group | Stock | Period of peak spawning | Total | Adults | Jacks | Males | Females | spawning success | Effective females | Estimation method |
| **Quesnel** | Long Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| ***continued*** | Long Creek lakeshore | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Marten Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Roaring River | 10-Sep to 20-Sep | 945 | 945 | 0 | 430 | 515 | 95.3% | 491 | Visual |
| | Roaring lakeshore | 15-Sep to 23-Sep | 200 | 200 | 0 | 76 | 124 | 96.8% | 120 | Visual |
| | Sue Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Trickle Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Wasko Creek | 10-Sep to 20-Sep | 2,831 | 2,831 | 0 | 1,298 | 1,533 | 96.8% | 1,484 | Visual |
| | Watt Creek | 10-Sep to 20-Sep | 776 | 776 | 0 | 323 | 453 | 96.1% | 435 | Visual |
| | Watt lakeshore | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | **Quesnel Lake, W. Arm** | | | | | | | | | |
| | Hazeltine Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Raft Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Spusks Cr. lakeshore | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | **Total** | **-** | **1,179,252** | **1,179,252** | **0** | **575,156** | **604,096** | **88.5%** | **534,530** | **-** |
| **Stuart** | **Driftwood River** | | | | | | | | | |
| ***Early Runs*** | Blackwater River | - | 27 | 27 | 0 | 14 | 13 | 100.0% | 13 | Visual |
| | Driftwood River | - | 9,227 | 9,227 | 0 | 4,635 | 4,592 | 55.9% | 2,567 | Visual |
| | Kastberg Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Kotsine River | - | 4 | 4 | 0 | 2 | 2 | 55.9% | 1 | Visual |
| | Lion Creek | - | 67 | 67 | 0 | 34 | 33 | 55.9% | 18 | Visual |
| | Porter Creek | 01-Aug to 07-Aug | 2,079 | 2,079 | 0 | 1,044 | 1,035 | 55.9% | 579 | Visual |
| | **Takla Lake, N.E. Arm** | | | | | | | | | |
| | Ankwill Creek | 30-Jul to 11-Aug | 1,764 | 1,764 | 0 | 831 | 933 | 43.7% | 408 | Visual |
| | Bates Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Blanchette Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Forsythe Creek | 30-Jul to 11-Aug | 554 | 554 | 0 | 257 | 297 | 48.0% | 143 | Visual |
| | French Creek | 14-Aug to 18-Aug | 103 | 103 | 0 | 48 | 55 | 31.3% | 17 | Visual |
| | Frypan Creek | 30-Jul to 14-Aug | 1,237 | 1,237 | 0 | 545 | 692 | 42.5% | 294 | Visual |
| | Hudson's Bay Cr. | 14-Aug to 19-Aug | 107 | 107 | 0 | 66 | 41 | 36.7% | 15 | Visual |
| | Shale Creek | 09-Aug to 15-Aug | 359 | 359 | 0 | 174 | 185 | 64.3% | 119 | Visual |
| | Five Mile Creek | 11-Aug to 17-Aug | 113 | 113 | 0 | 55 | 58 | 100.0% | 58 | Visual |
| | Fifteen Mile Creek | 08-Aug to 14-Aug | 250 | 250 | 0 | 121 | 129 | 100.0% | 129 | Visual |
| | Ten Mile Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Twenty-five Mile Cr. | 30-Jul to 11-Aug | 349 | 349 | 0 | 161 | 188 | 54.5% | 102 | Visual |
| | **Takla Lake, N.W. Arm** | | | | | | | | | |
| | Crow Creek | 08-Aug to 15-Aug | 271 | 271 | 0 | 82 | 189 | 74.2% | 140 | Visual |
| | Dust Creek | 08-Aug to 15-Aug | 3,083 | 3,083 | 0 | 1,492 | 1,591 | 52.9% | 842 | Visual |
| | Hooker Creek | 14-Aug to 17-Aug | 65 | 65 | 0 | 31 | 34 | 90.9% | 31 | Visual |
| | McDougall Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Point Creek | 01-Aug to 15-Aug | 596 | 596 | 0 | 259 | 337 | 64.7% | 218 | Visual |
| | Sinta Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | **Takla Lake, S. Arm** | | | | | | | | | |
| | Bivouac Creek | - | 6 | 6 | 0 | 4 | 2 | 0.0% | 0 | Visual |
| | Gluske Creek | 31-Jul to 09-Aug | 1,508 | 1,507 | 1 | 781 | 726 | 67.7% | 475 | Fence |
| | Leo Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Narrows Creek | 29-Jul to 15-Aug | 1,592 | 1,592 | 0 | 785 | 807 | 61.5% | 496 | Visual |
| | Sakeniche River | 12-Aug to 17-Aug | 323 | 323 | 0 | 102 | 221 | 38.4% | 85 | Visual |
| | Sandpoint Creek | 01-Aug to 17-Aug | 118 | 118 | 0 | 72 | 46 | 47.9% | 22 | Visual |
| | **Middle River** | | | | | | | | | |
| | Forfar Creek | 06-Aug to 15-Aug | 1,674 | 1,668 | 6 | 879 | 789 | 57.1% | 436 | Fence |
| | Kazchek Creek | 07-Aug to 11-Aug | 15 | 15 | 0 | 7 | 8 | 100.0% | 8 | Visual |
| | Kynock Creek | 28-Jul to 05-Aug | 3,072 | 3,059 | 13 | 1,426 | 1,633 | 44.4% | 713 | Fence |
| | Middle River | - | 32 | 32 | 0 | 17 | 15 | 64.7% | 10 | Visual |
| | Rossette Creek | 31-Jul to 06-Aug | 1,048 | 1,048 | 0 | 546 | 502 | 64.7% | 325 | Visual |
| | **Trembleur Lake** | | | | | | | | | |
| | Felix Creek | 29-Jul to 05-Aug | 1,987 | 1,987 | 0 | 910 | 1,077 | 68.0% | 732 | Visual |
| | Fleming Creek | - | 78 | 78 | 0 | 36 | 42 | 68.0% | 29 | Visual |
| | Paula Creek | 04-Aug to 11-Aug | 882 | 882 | 0 | 473 | 409 | 75.2% | 307 | Visual |
| | **Total** | **-** | **32,590** | **32,570** | **20** | **15,889** | **16,681** | **56.2%** | **9,332** | **-** |

Continued

Appendix 11. Period of peak spawning, adult and jack escapement, spawning success, and the number of females that spawned successfully, by stock group, stock and estimation method, for Fraser River sockeye salmon, 1998 continued.

| Stock Group | Stock | Period of peak spawning | Escapement Total | Adults | Jacks | Males | Females | Percent spawning success | Effective females | Estimation method |
|---|---|---|---|---|---|---|---|---|---|---|
| **Stuart *Summer Runs*** | Kazchek Creek | 18-Sep to 25-Sep | 2,228 | 2,228 | 0 | 957 | 1,271 | 96.8% | 1,230 | Visual |
| | Kuzkwa River | 20-Sep to 28-Sep | 2,867 | 2,864 | 3 | 1,393 | 1,471 | 98.3% | 1,446 | Fence |
| | Middle River | 18-Sep to 24-Sep | 38,917 | 38,906 | 11 | 19,400 | 19,506 | 98.6% | 19,236 | M.R. |
| | Pinchi Creek | 20-Sep to 28-Sep | 1,337 | 1,337 | 0 | 530 | 807 | 92.9% | 750 | Visual |
| | Sakeniche River. | 20-Sep to 28-Sep | 99 | 99 | 0 | 49 | 50 | 98.6% | 49 | Visual |
| | Sowchea Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | Tachie River | 26-Sep to 02-Oct | 93,973 | 92,963 | 1,010 | 47,066 | 45,897 | 98.4% | 45,122 | M.R. |
| | **Total** | **-** | **139,421** | **138,397** | **1,024** | **69,395** | **69,002** | **98.3%** | **67,833** | **-** |
| **Nechako** | Nadina Channel | 20-Sep to 25-Sep | 2,964 | 2,949 | 15 | 1,299 | 1,650 | 95.6% | 1,578 | Census |
| | Nadina River | 20-Sep to 25-Sep | 760 | 756 | 4 | 333 | 423 | 95.6% | 405 | Visual |
| | Stellako River | 26-Sep to 05-Oct | 185,697 | 185,641 | 56 | 87,273 | 98,368 | 98.6% | 96,961 | Fence |
| | **Total** | **-** | **189,421** | **189,346** | **75** | **88,905** | **100,441** | **98.5%** | **98,944** | **-** |
| **Upper Fraser** | Bowron River | Early Sep | 4,777 | 4,751 | 26 | 1,921 | 2,830 | 100.0% | 2,830 | Visual |
| | Indianpoint Creek | - | 0 | 0 | 0 | 0 | 0 | - | 0 | Visual |
| | **Total** | | **4,777** | **4,751** | **26** | **1,921** | **2,830** | **100.0%** | **2,830** | |
| **Total** | **Early Runs** | **-** | **32,590** | **32,570** | **20** | **15,889** | **16,681** | **55.9%** | **9,332** | **-** |
| | **Early Summer Runs** | **-** | **228,244** | **226,662** | **1,582** | **99,810** | **126,852** | **94.1%** | **119,347** | **-** |
| | **Summer Runs** | **-** | **2,385,314** | **2,382,300** | **3,014** | **1,099,160** | **1,283,140** | **90.9%** | **1,166,948** | **-** |
| | **Late Runs** | **-** | **1,781,531** | **1,780,543** | **988** | **831,205** | **949,338** | **95.0%** | **902,327** | **-** |
| | **Total** | **-** | **4,427,679** | **4,422,075** | **5,604** | **2,046,064** | **2,376,011** | **92.5%** | **2,197,954** | **-** |