Estimating the 1995 Fraser River Sockeye Salmon (*Oncorhynchus nerka*) Escapement

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ABSTRACT

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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 1995, study techniques included mark-recapture, enumeration fences, counts in artificial spawning channels and visual surveys. The escapement totalled 1,736,763 adults and 18,473 jacks distributed over 121 populations in ten geographic areas and four run timing groups. The proportion that was estimated by each study type is 67% by mark-recapture projects, 15% at enumeration fences, 4% at spawning channels and 14% by visual surveys.

Significant improvements to mark-recapture study designs were implemented in 1995 following a thorough review in 1994. Operational and analytic changes focused primarily on the mark-recapture studies and included: promoting the mixing of tags and the unbiased recovery of carcasses by allocating tag applica-tion and recovery effort more representatively across spatial and temporal strata; assessing tag loss by applying an opercular punch as a secondary mark; improving the resurveys for missed tags; minimizing handling stress by the use of new techniques; and adopting a more structured approach to the assessment of sampling bias and to identify whether the use of the pooled Petersen or the maximum likelihood Darroch estimator is most appropriate. On the basis of the 1995 results, further changes are identified to address issues related to the identification of tag status, the assessment of tag loss, proportional sampling, and the appropriate population estimator.

RÉSUMÉ

Schubert, N.D. 2007. Estimating the 1995 Fraser River sockeye salmon (*Oncorhynchus nerka*) escapement. Can. Tech. Rep. Fish. Aquat. Sci. 2737: ix + 71 p.

Le ministère des Pêches et des Océans (MPO) 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 1995, 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 1 736 763 adultes et 18 473 madeleineaux de 121 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 – 67 %; barrières de dénombrement – 15 %; frayères artificielles – 4 %; relevés visuels – 14 %.

Les modèles d'étude de marquage-recapture ont fait l'objet d'améliorations importantes en 1995 à la suite d'un examen approfondi mené en 1994. Les changements sur le plan de la recherche et de l'analyse étaient axés principalement sur les études de marquage-recapture et comprenaient les suivants : la promotion du mélange des marques et la récupération sans biais des carcasses en distribuant l'effort de marquage-recapture de façon plus représentative dans toutes les strates temporelles et spatiales; l'évaluation du nombre de marques perdues en pratiquant une perforation operculaire en guise de marque secondaire; l'amélioration des contre-expertises relatives aux marques manquées; la réduction au minimum du stress dû à la manipulation par le biais de l'utilisation de nouvelles techniques; l'adoption d'une approche plus structurée pour l'évaluation du biais d'échantillonnage et pour la détermination des différences entre l'estimateur de Darroch de vraisemblance maximale et l'estimateur cumulé de Petersen afin d'identifier le plus approprié. Sur la base des résultats de 1995, d'autres changements sont identifiés pour résoudre les problèmes liés à la détermination de l'état des marques, à l'évaluation du nombre de marques perdues, à l'échantillonnage proportionnel et à la détermination de l'estimateur de population approprié.

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 access-ible portion of the Fraser system. Spawner abun-dance is estimated by staff from Fisheries and Oceans Canada (DFO) using a variety of techni-ques. An annual escapement plan is developed from abundance forecasts provided by DFO's stock assessment sector, and population-speci-fic harvest rates estimated from the fishing plan provided by DFO's fisheries management sector. The choice of assessment technique is based on the expected size of each spawner population. Populations less than 25,000 are assessed us-ing a variety of visual estimation methods; larger populations are assessed using enumeration fences and mark-recapture studies. The 1995 escapement estimation plan was based on an expectation that almost three million sockeye would return to spawn. Large escapements were expected for sub-dominant cycle Early Summer and Late Run populations and other non-cyclic populations (Chilko, Stellako, Birkenhead). Con-sequently, the plan included enumeration fences (8) and mark-recapture studies (5), with the bal-ance of the populations assessed visually.

This report is a part of an annual series, beginning in 1994 (Schubert 1998), that documents the population-specific escapement estimation methods and results for Fraser River sockeye salmon. Because the report draws on diverse data sources, its format is non-standard, consist-ing of a description of the populations, the survey methods, analytic procedures and results, a pre-sentation of escapement estimates for 1995, and a comparison with previous years' escapements for the major populations and for populations ag-gregated by geographic and run timing group. The report concludes with a discussion of es-capement estimation concerns and recommends study design changes and topics of investigation for future years.

DATA SOURCES

Data sources and detailed estimation techniques and analytic details are presented if this information has not been published elsewhere. The report also summarizes a series of companion reports that document the major 1995 es-capement estimation studies in Adams (Hout-man and Fanos 2000), Birkenhead (Houtman *et al.* 2000), Horsefly (Houtman and Cone 2000), Seymour (Houtman and Schubert 2000) and Stellako (Houtman pers. comm.) rivers. Escape-ment data and estimates for the spawning chan-nels and hatchery enumeration fences are pro-vided by DFO's Oceans, Habitat and Enhance-ment Branch.

POPULATION DESCRIPTION

Fraser River sockeye migrate to spawning areas located from tidal influence to as far upstream as 1,270 km (Fig. 1). Nine populations or population 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 populations exhibit a pronounced quadrennial escapement cycle, with a strong dominant, an intermediate subdominant, and two weak years. In 1995, none of the major populations were on the dominant cycle. The Adams and Seymour were in their subdominant year, and significant returns were expected from early Stuart, Weaver, Birkenhead, Chilko and Stellako.

Because the size of the watershed is vast (223,000 km^2) and the spawning migration protracted (June to October), the populations are aggregated 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 populations) are: Lower Fraser (tributaries of the Fraser River from the mouth to the Thompson River, excluding the Harrison-Lillooet) (6); Harrison-Lillooet (4); Seton-Anderson (2); South Thompson Early Summer (16) and Late (31) runs; North Thompson (5); Chilcotin (3); Quesnel (6); Stuart Early (38) and Summer (7) runs; Nechako (2); and Upper Fraser (tributaries of the Fraser River upstream from the Nechako River) (1). The constituent populations are listed for each group in Table 1.

The run timing groups were established for fishery management purposes and consist of

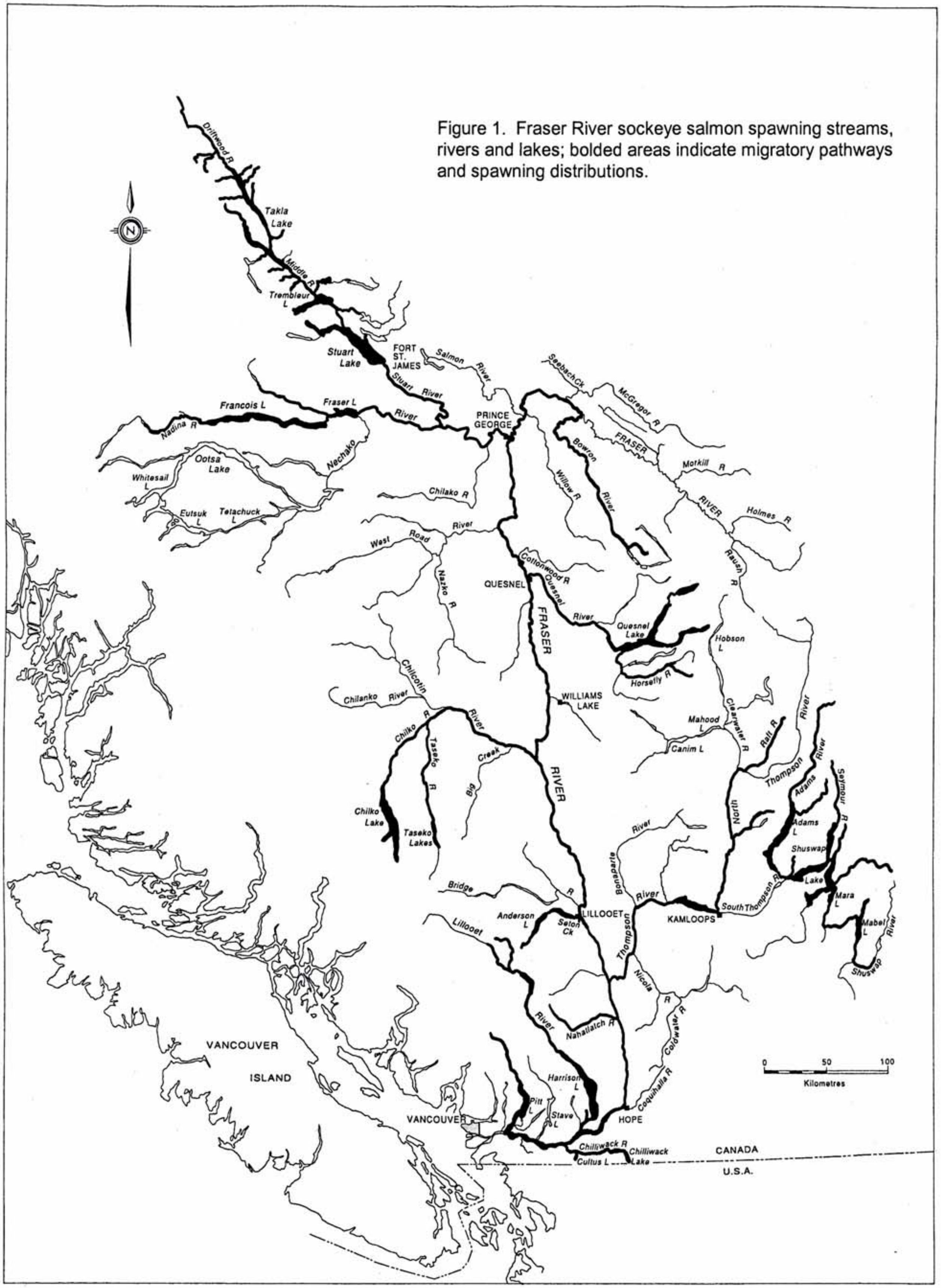

Figure 1. Fraser River sockeye salmon spawning streams, rivers and lakes; bolded areas indicate migratory pathways and spawning distributions.

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

Fraser River sockeye stocks by geographic area			
Lower Fraser	Adams River, lower	***Quesnel***	Sandpoint Creek
Early Summer and Late Run	Adams River, upper	***Summer Run***	*Middle River*
Chilliwack Lake	Anstey River	*Horsefly River*	Baptiste Creek
Cultus Lake	Bush Creek	Horsefly Channel	Forfar Creek
Nahatlatch Lake	Canoe Creek	Horsefly River	Kazchek Creek
Nahatlatch River	Cayenne Creek	Little Horsefly River	Kynock Creek
Pitt River, upper	Celista Creek	McKinley Creek, lower	Middle River
Widgeon Slough	Eagle River	McKinley Creek, upper	Rossette Creek
	Hiuihill Creek	Moffat Creek	*Trembleur Lake*
Harrison-Lillooet	Hunakwa Creek	*Mitchell River*	Felix Creek
Late Run	Little River	Mitchell River	Fleming Creek
Big Silver Creek	Momich River		Paula Creek
Birkenhead River	Nikwikwaia Creek	***Stuart***	***Stuart***
Samson Creek	Onyx Creek	***Early Run***	***Summer Run***
Weaver Channel	Pass Creek	*Driftwood River*	Kazchek Creek
Weaver Creek	Perry River	Blackwater River	Kuzkwa River
	Ross Creek	Driftwood River	Middle River
Seton-Anderson	Salmon River	Kastberg Creek	Pinchi Creek
Early Summer and Late Run	Scotch Creek	Kotsine River	Sakeniche River
Gates Creek	Seymour River	Lion Creek	Sowchea Creek
Portage Creek	South Thompson River	Porter Creek	Tachie River
	Tappen Creek	*Takla Lake, NE Arm*	
South Thompson	*Shuswap Lake*	Ankwill Creek	***Nechako***
Early Summer Run	Anstey Arm	Bates Creek	***Early Summer and***
Adams Channel	Main Arm	Blanchette Creek	***Summer Run***
Adams River, lower	Salmon Arm	Forsythe Creek	Nadina Channel
Adams River, upper	Seymour Arm	French Creek	Nadina River
Anstey River	*Shuswap River*	Frypan Creek	Stellako River
Cayenne Creek	Shuswap River, lower	Hudson's Bay Creek	
Celista Creek	Shuswap River, middle	Shale Creek	***Upper Fraser***
Eagle River	Tsuius Creek	Five Mile Creek	***Early Summer Run***
Hiuihill Creek	Wap Creek	Fifteen Mile Creek	Bowron River
Hunakwa Creek		Twenty-five Mile Creek	
McNomee Creek	***North Thompson***	*Takla Lake, NW Arm*	
Nikwikwaia Creek	***Early Summer Run***	Crow Creek	
Onyx Creek	Barriere River	Dust Creek	
Perry River	Fennell Creek	Hooker Creek	
Salmon River	Harper Creek	McDougall Creek	
Scotch Creek	North Thompson River	Point Creek	
Seymour River	Raft River	Sinta Creek	
Yard Creek		*Takla Lake, Main Arm*	
	Chilcotin	Bivouac Creek	
South Thompson	***Summer Run***	Gluske Creek	
Late Run	Chilko Channel	Leo Creek	
Adams Channel	Chilko River and Lake	Narrows Creek	
Adams Lake	Taseko Lake	Sakeniche River	

[a] Excludes streams with a record of intermittent escapements that were not surveyed in 1995.

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

Early Run	Early Summer Run	Summer Run	----------------------Late Run	--------------------------
Stuart	***Lower Fraser***	***Quesnel***	***Lower Fraser***	Hiuihill Creek
Blackwater River	Chilliwack Lake	*Horsefly River*	Cultus Lake	Hunakwa Creek
Driftwood River	Nahatlatch Lake	Horsefly Channel	Widgeon Slough	Little River
Kastberg Creek	Nahatlatch River	Horsefly River		Momich River
Kotsine River	Pitt River, upper	Little Horsefly River	***Harrison-Lillooet***	Nikwikwaia Creek
Lion Creek		McKinley Creek, lower	Big Silver Creek	Onyx Creek
Porter Creek	***Seton-Anderson***	McKinley Creek, upper	Birkenhead River	Pass Creek
Takla Lake, NE Arm	Gates Creek	Moffat Creek	Samson Creek	Perry River
Ankwill Creek		*Mitchell River*	Weaver Channel	Ross Creek
Bates Creek	***South Thompson***	Mitchell River	Weaver Creek	Salmon River
Blanchette Creek	Adams Channel			Scotch Creek
Forsythe Creek	Adams River, lower	***Chilcotin***	***Seton-Anderson***	Seymour River
French Creek	Adams River, upper	Chilko Channel	Portage Creek	South Thompson River
Frypan Creek	Anstey River	Chilko River and Lake		Tappen Creek
Hudson's Bay Creek	Cayenne Creek		***South Thompson***	*Shuswap Lake*
Shale Creek	Celista Creek	***Stuart***	Adams Channel	Anstey Arm
Five Mile Creek	Eagle River	Kazchek Creek	Adams Lake	Main Arm
Fifteen Mile Creek	Hiuihill Creek	Kuzkwa River	Adams River, lower	Salmon Arm
Twenty-five Mile Creek	Hunakwa Creek	Middle River	Adams River, upper	Seymour Arm
Takla Lake, NW Arm	McNomee Creek	Pinchi Creek	Anstey River	
Crow Creek	Nikwikwaia Creek	Sakeniche River	Bush Creek	*Shuswap River*
Dust Creek	Onyx Creek	Sowchea Creek	Canoe Creek	Shuswap River, lower
Hooker Creek	Perry River	Tachie River	Cayenne Creek	Shuswap River, middle
McDougall Creek	Salmon River		Celista Creek	Tsuius Creek
Point Creek	Scotch Creek	***Nechako***	Eagle River	Wap Creek
Sinta Creek	Seymour River	Stellako River		
Takla Lake, Main Arm	Yard Creek			
Bivouac Creek				
Gluske Creek	***North Thompson***			
Leo Creek	Barriere River			
Narrows Creek	Fennell Creek			
Sakeniche River	Harper Creek			
Sandpoint Creek	North Thompson River			
Middle River	Raft River			
Baptiste Creek				
Forfar Creek	***Chilcotin***			
Kazchek Creek	Taseko Lake			
Kynock Creek				
Middle River	***Nechako***			
Rossette Creek	Nadina Channel			
Trembleur Lake	Nadina River			
Felix Creek				
Fleming Creek	***Upper Fraser***			
Paula Creek	Bowron River			

[a.] Excludes streams with a record of intermittent escapements that were not surveyed in 1995.

populations 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 populations 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 29 populations that spawn throughout the Fraser system, arrives in the river from mid July to mid August. The Summer Run, which consists of 15 populations that spawn in the Chilko, Quesnel, Stellako and Stuart systems, arrives in the river from mid July to early September. The Late Run, which consists of 38 populations that spawn in the lower Fraser, Harrison-Lillooet, Thompson and Seton-Anderson systems, arrives in the river from August to mid October. The constituent populations 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 populations; enumeration fences that are used in spawning channels, and in rivers with appropriate morphology; and stream surveys, where visual counts or estimates of live and dead spawners are expanded to estimate the spawner population size.

ARRIVAL INDICES

The 1995 arrival indices are based on observations from bridges across the Chilko and Quesnel rivers. They provide fishery managers an early indication of the impact of management actions, and mark-recapture staff a means to establish daily tagging targets.

Observations of the arrival patterns of the major populations are made from bridges that are suitably located below the lower limit of spawning provided 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 relatively narrow column where they can be 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 in-season estimate of escapement.

MARK-RECAPTURE STUDIES

In 1995, mark-recapture studies were used to estimate the escapement of one Early Summer Run populations (Seymour), two Summer Run populations (Chilko and Horsefly), and two Late Run populations (Adams and Birkenhead). An additional Summer Run population, the Stellako, was assessed using the mark-recapture technique as part of a study comparing fence and mark-recapture estimates. This section describes general study objectives and operational and analytic procedures, and procedures specific to each of these mark-recapture studies. The study designs are similar to those used in 1994 (Schubert 1998), but incorporate changes that address deficiencies identified by Schubert; the study the design changes include:

- 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;
- Applying an operculum punch as a secondary mark to all tagged fish to permit the assessment of tag loss;
- Improving handling procedures to reduce fish stress;
- Developing a low stress tagging procedure for comparison with standard methods;
- Modifying fish capture procedures and the number and location of tagging sites to make more representative the spatial and temporal distribution of tags; and
- Changes to address study-specific issues.

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 (5% for smaller populations), a level known from previous studies to provide the requisite precision, and by using techniques that distribute tags proportionally over the population. Sockeye are normally captured immediately be-low the spawning grounds to ensure that the entire run is vulnerable to capture while avoiding the disproportionate capture of local spawners. In some cases, 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. Tag-ging begins when sockeye are first observed and continues through the period of spawning ground arrival. Daily 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 cap-tured using beach seine nets, marked with un-iquely numbered, red Petersen disk tags, and released. They are released untagged if obvi-ously stressed, at an advanced stage of matur-ation, or physically damaged. Date and location of capture, tag number, sex, nose-fork length, release condition and predator marks (lamprey, hook or net) and *Flexibacter columnaris* symp-toms are recorded for each tagged fish. Each tagged fish receives a secondary mark to assess tag loss. One or two 7 mm holes are punched in the right operculum of tagged males and fe-males, respectively, using a single hole punch. Fish are not sampled for scales or otoliths during tagging; however, 50 females are retained for fecundity assessment.

Equal numbers of fish are representatively tagged using standard or low stress procedures. Standard procedures entail tagging the fish in a tray elevated from the water surface and re-leasing it by throwing it a short distance over the net’s cork line. Low stress procedures entail tag-ging the fish in a tray immersed in 15 cm of water and releasing it by lowering a section of the cork line; at no time is the fish removed from the water. Handling time for both procedures av-erages 25-30 seconds. In addition to the above, the following general fish handling guidelines were established in 1995: after the net is drawn to shore, net stands are used to raise the cork line and increase the volume in the bagged por-tion of the net; activity in the net is minimized to reduce siltation; a fish is removed from the wa-ter only when a tagger is ready and processed as quickly as possible; when removed from the water, the fish is cradled in two hands rather than dangled by the caudal peduncle; and follow-ing tagging, the fish is immediately returned to the water.

The objective of the recovery survey is to re-cover carcasses in proportion to daily abun-dance. The crews survey the entire spawning area, beginning when the first dead sockeye are observed and continuing until the die-off is com-plete. Each survey requires a fixed period rang-ing from two to six days, depending on the syst-em, to ensure that recovery effort is consistent through the run. Crew sizes are adjusted daily, with more surveyors deployed at the peak of car-cass abundance than at the tails of the abun-dance distribution. After enumeration, the tags are cut from the carcasses, and the carcasses are removed from the study area by either pitch-ing them beyond the mean high water mark or cutting them in two with a machete and returning them to the river. Periodic resurveys of previous-ly processed carcasses are used to estimate the number of tags that are missed on the initial sur-vey. Fresh carcasses are also sampled for leng-th, otoliths and scales following a protocol pro-vided by the Pacific Salmon Commission (PSC).

Summarized below are the field methods us-ed in each of the six mark-recapture studies con-ducted in 1995. New procedures are identified for each study; however, the procedural changes not-ed above in point form apply to all studies and will not be repeated except where study-specific de-tails are required for clarity.

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, Scotch Creek, Little River, and along the fore-shores of Shuswap (west of Scotch Creek) and Little Shuswap lakes. Until 1994, tags were ap-plied at a site on the Shuswap Lake foreshore adjacent to the Adams River mouth. In 1994, the tag site was moved into the Adams River to: reduce the capture of non-study area sockeye; make application more representative; and re-duce handling stress and immediate mortality (Schubert and Fanos 1997a). The 1995 study is similar to that used in 1994, except for changes described in the previous section and the following modifications: new tagging sites were established in the middle and upper rivers; tag-ging targets were based on daily counts in each river section; and carcasses in pools and those drifting out of the Adams River were examined to determine if mark rates differed from standard river recoveries. Because of the size of the study area and the low number of carcasses in many areas, the frequency of recovery surveys varied from daily in the lower Adams River to every 1-4 days in Adams Lake and tributaries.

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. The 1995 study de-sign was similar to that used in 1994 (Schubert and Tadey 1997), except for changes described in the previous section and the addition of a se-cond tagging site in the lower river that was in-tended to reduce the recapture of previously tag-ged fish. 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 3-4 day cycle, *i.e.*, the entire spawning area was surveyed every 3-4 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 Chil-ko River, and along the foreshore of north and south Chilko Lake. Until 1987, the Chilko mark-recapture study was designed to estimate the escapement of the river population only; the lake populations were assessed using a variety of subjective techniques. In 1987, the study was changed to a design that provides a system-wide (spawning channel, river, and north and south lake) estimate of the escapement. 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 1995 study design is similar to that used in 1994 (Schubert and Fanos 1997b) except for the changes described in the previous section, and a radio-telemetry study that was im-plemented in response to recommendations of the Fraser River Sockeye Public Review Board (Anon. 1995) to evaluate post-tagging behaviour and stress (Schubert and Scarborough 1996). Tags were applied to migrating sockeye at Ling-field Creek, with daily tagging goals set at 1% of the previous day's migration as estimated from visual counts at Henry's Bridge (4 km below the tagging site). Recovery surveys were conducted on a 2-4 day cycle.

Horsefly River: The Horsefly River, a tributary of the main arm 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 populations that spawn in the lower and upper Horsefly and Little Horsefly rivers, McKinley and Moffat creeks, and in the spawning channel (25 km above Quesnel Lake). On the 1995 off-cycle, virtually all of the escapement spawns in the Horsefly River. The 1995 mark-recapture study was mobilized in response to unexpectedly high inseason abundance; consequently, it replaced the planned visual surveys, and was implemented late and on a limited bud-get. The study design is similar to that used in 1994 (Cone 1999). It includes few of the chang-es described in the previous section and, be-cause few fish spawn in Horsefly tributaries, they are excluded from the study. Tags were applied to migrating sockeye at a site located 2 km above the lake; daily tag releases were estab-lished from standardized application effort. Full recovery surveys were conducted on a four-day cycle, except the spawning channel was enum-erated by a complete carcass count.

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. The 1995 study design is sim-ilar to that used in 1994 (Schubert 1997) except for the changes described in the previous sec-tion and the following modifications: new tag-ging sites were established in the middle and up-per rivers; and carcasses in pools were examin-ed to determine if mark rates differed from stan-dard river recoveries. Tags were applied to mi-grating sockeye, with daily tag releases estab-lished from standardized application effort. Com-plete recovery surveys were conducted on a 2-3 day cycle.

Stellako River: The Stellako is a short inter-lake river that is part of the Nechako System, located in the northwest portion of the Fraser River watershed (Fig. 1). Summer Run sockeye spawn throughout the 13 km long river. The 1995 study design is similar to that used in 1994 (Schubert 2000), *i.e.,* tags were applied at an enumeration fence that also provided an almost complete census of the escapement. The main modification implemented in 1995 was to apply tags in the river to evaluate mark-recapture biases associated with a more standard capture and tagging procedure.

Analytic Procedures

The analytic process involves four steps. First, the field data are entered into a computer database and their veracity verified. Second, the data are evaluated and corrected for (in order) sex identification error at application, emigration from the study area, missed tags at recovery, tag loss and acute stress effects. Third, a bias pro-file is developed by evaluating four potential bi-ases, temporal, spatial, fish size and fish sex. Fourth, population estimates are calculated for adult males, females and precocious males (hereafter, *jacks*) when more than five tags are recovered. The first step is self-explanatory; the last three steps are described below.

Data Corrections: Before calculating population estimates, the data are evaluated (and corrected when appropriate) 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 operation. Such errors are corrected by comparing the sex of tagged fish recorded at release and recovery using Staley's (1990) form-ula. It is unnecessary to correct the recovery data because carcasses are examined carefully and can be incised for internal examination. Se-cond, tagged sockeye sometimes spawn outside the study area. Their number is estimated from area-specific estimates of tag incidence and population size provided by assessments inde-pendent of the mark-recapture study; the sex-specific estimate is subtracted from the applica-tion sample. Third, the failure to correctly identify tagged carcasses can occur as a result of sur-veyor inexperience, fatigue, or carelessness. Resurvey data are used to estimate the incidence of missed tags and to correct the recovery data. Fourth, fish can lose tags between appli-cation and recovery for a number of reasons. Secondary marks are used to estimate the tag loss rate. These data are used to correct the re-covery group for tag loss.

Sampling Selectivity Assessment: The assumptions of equal probability of capture, simple random recovery sampling and complete mixing (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 a Kolmogorov-Smirnov two-sample test. Application bias (unequal probability of capture and incomplete mixing) is assessed by stratifying the recovery sample (uncorrected for missed tags) and comparing the proportion tag-ged among strata. Recovery bias (nonrandom re-covery sampling and incomplete mixing) is as-sessed by stratifying the application sample and comparing the proportions recovered.

Temporally, the application and recovery samples are stratified into 5-6 periods of approximately equal duration, sampling effort, and sample size. Three significant results are interpreted as a true bias, while a single significant result may be a stratification artifact. Spatially, the application sample is stratified by tagging site, and the recovery sample is stratified into 3-6 geographically contiguous sections. Size bias at recovery (application bias cannot be assessed because unmarked carcasses were not measured) is assessed by comparing the cumulative NF length-frequency distributions of recovered and non-recovered portions of the application sample.

Population Estimation: This section briefly describes estimation procedures for adults and jacks, and females that spawned effectively (hereafter, *effective females*). For adults, the Stratified Population Analysis System (SPAS) software developed by Arnason *et al.* (1996) is us-ed to calculate sex-specific population estimates (the use of sex-specific data avoids potential bias-es resulting from differences in arrival timing and behaviour on the spawning grounds). SPAS cal-culates estimates and standard errors using the pooled Petersen estimator (PPE) (Seber 1982) and the stratified Darroch maximum likelihood es-timator (MLE) (Plante 1990). The latter is gener-ated from application-recovery matrices using temporal:temporal (TxT), temporal:spatial (TxS) and spatial:spatial (SxS; where appropriate) stratifcations. Temporally, the data are stratified into 4-6 application and recovery periods in which the number of tags applied or recovered are approximately equal. Spatially, 2-5 application (multiple tag site studies) and recovery strata are used. Pooling is often required to satisfy the assumptions of model fit, *i.e.*, to minimize the number of low recovery cells and reduce linear dependence in the recovery matrix. The PPE and MLE are evaluated for the most appropriate estimate as follows. First, if the sampling selectivity tests show no evidence of bias, the PPE is used. Second, if sampling bias is detected, the 95% confidence li-mits of the PPE and MLE are compared. If there is overlap, the bias is judged to be minor and the PPE is accepted; if there is no overlap, the MLE is accepted as the most appropriate estimate. The PPE is used in all cases in 1995.

The jack escapement is similarly calculated if five or more tags are recovered (Birkenhead and Chilko). When fewer than five tags are recovered (Adams, Horsefly and Seymour), an alternate population estimator is used. Jack escapement is the product of the number of carcasses recovered, an expansion factor (1.26) and the inverse of the 1995 study-specific mark recovery rate for adult males. The expansion factor is based on comparisons of jack and adult male recovery rates in past mark-recapture studies (Andrew and Webb 1987).

The effective female population is the product of the female escapement estimate and the average spawning success. The latter is calculated from the female carcass recovery sample; daily estimates of spawning success are weighted to that day's total female carcass recovery because egg retention was not recorded for all unmarked carcasses.

ENUMERATION FENCE STUDIES

This section describes: a) enumeration fences, *i.e.* structures that 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 and dead counts. In both cases, it is possible to obtain an almost complete census of the spawner population. In 1995, enumeration fences were used for ten populations: Forfar, Gluske and Kynock creeks on the Early Run; Bowron River, Fennell and Scotch creeks on the Early Summer Run; Stellako River on the Summer Run; and Salmon River and Sweltzer (Cultus) and Weaver creeks on the Late Run. Objectives vary among the studies: the Stuart fences provide inseason calibrations for the visual surveys conducted in the area; the Stellako fence provides a harvest platform for native fishers and permits the evaluation of bias in a major mark-recapture study; the Bowron and Fennell fences respond to a recommendation of the Fraser River Sockeye Public Review Board Report (Anon. 1995) to evaluate visual survey expansion factors; and the Sweltzer fence takes advantage of a permanent sill to assess a population that is difficult to assess visually.

Five spawning channels operated in 1995: Nadina on the Early Summer Run; Chilko and Horsefly on the Summer Run; and Weaver and Adams on the Late Run. Live or carcass counts are used to estimate sockeye escapement in all of the channels.

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 through a counting area where the fish are either intercepted 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-re-capture study). Sex is not recorded because it cannot be reliably determined in moving sock-eye. Sex ratios and female spawning success are estimated from regular surveys above the fence. If spawning occurs below the fence, reg-ular foot surveys are conducted using the visual survey techniques described later.

At the spawning channels, live sockeye are counted as they enter the channel, and carcasses are counted as they are removed.

Analytic Procedures

For the Bowron, Chilko, Horsefly, Salmon and Cultus (Sweltzer) 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 (Fennell, 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 visual survey techniques described later. The sex com-position and female spawning success are esti-mated from the associated carcass survey data. Fecundity is sampled at most fences and chan-nels; carcasses are sampled according to proto-cols provided by the PSC.

For the spawning channels, the estimated escapement is one of the following: the carcass count (if complete); the count of live sockeye en-tering the channel (if complete); or the carcass count plus the live count on the last survey.

VISUAL SURVEYS

Visual surveys are used for populations with expected escapements of less than 25,000 spawners, including both inherently small popu-lations and the major populations in an off-cycle year. Most populations were surveyed visually; specifically: all 38 from the Early Run; 26 from the Early Summer Run; 12 from the Summer Run; and 34 from the Late Run.

Field Methods

Natal areas are inspected visually by an ex-perienced observer. Survey periods are based on historic averages or, if one stream in an ag-gregate is surveyed more intensively, its peak triggers the survey of nearby streams. Each sur-vey covers the entire accessible spawning area using techniques that can include foot or boat surveys and aerial overflights. The actual tech-nique used for a population is determined by the physical features of each lake, river or stream. Surveys are scheduled during the daily period of optimal light conditions to minimize surface glare. Each population is surveyed at least once, with some visited a dozen or more times based on the expected escapement, the study design for that area, and the observations on the initial surveys. The following information is recorded on each trip: visual counts of live and dead sock-eye; viewing conditions; water level and temper-ature; and conditions 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 spawn-ing success can not be recorded during aerial surveys. Carcass samples are obtained for pop-ulations specified by the PSC protocol; fecundity samples are not obtained from these smaller populations. 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 primarily using the International Pacific Salmon Fisheries Commis-sion (PSFC) procedures described by Andrew and Webb (1987). For lake spawning popula-tions where water turbidity or depth preclude the direct observation of live fish, the estimated es-capement is the product of the number of car-casses recovered and an effort expansion that assumes each person-day of survey effort recov-ers 5% of the population. For river spawning populations (and lake spawners where condi-tions permit the direct observation of live fish), the total escapement is the product of the maxi-mum daily count of live spawners, the cumula-tive recovery of all carcasses (males, females and jacks) through the date of the peak live count, and an index expansion factor. Two types of index expansion factors are used: a) the es-capement of most populations is calculated us-ing a factor of 1.8. Both this index and the effort expansion factors identified above are based on historic comparisons of visual survey and mark-recapture or enumeration fence data (Woodey 1984); and b) the escapement of the Stuart Early Run is calculated using the index expansion fac-tor measured 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 propor-tion of adult males, females and jacks from these adjusted data is then applied to the esti-mated total escapement to calculate the num-bers of adult males, females and jacks. Second, if the adult carcass recovery (excluding unsexed carcasses and jacks) is greater than or equal to 10% of the estimated escapement, then the esti-mate is stratified by adult males, females and jacks on the basis of the proportions calculated above. Third, if the total adult carcass recovery is less than 10% of the escapement estimate, then the sex and jack composition and female spawning success is estimated from a nearby populations or group of populations with a simi-lar run timing (jacks are excluded from this cal-culation if none were recovered by the survey of the stream in question). If a similar nearby pop-ulations is unavailable, then the total escape-ment is allocated equally between sexes and spawning success is assumed to be 100%.

Fraser River sockeye escapement estimate, 526,329 males, 648,731 females and 6,361 jacks (Appendix 6). The studies that generated these estimates are evaluated below.

Implementation Of Study Design

This section addresses the following ques-tions: Did tagging begin when sockeye first arriv-ed and continue until the migration was com-pete? Did recovery begin shortly after the start of tagging, cover the entire study area, and con-tinue until the die-off was complete? Was the tagging and recovery effort applied representa-tively over time and space? Were lost and mis-sed tags reliably assessed? Were study preci-sion objectives achieved? Was handling stress likely to have biased the study results?

Tagging: The spawning ground surveys or terminal area counts began before the arrival of sockeye in the Chilko and Adams rivers (Table 3). This permitted tagging to begin when abun-dance reached the threshold at which sockeye become more easily catchable; consequently, tag incidences are near average among the early recoveries in both studies (Figs. 2a). A pre-study survey was also conducted in the Stellako River. In that case, tagging in the river was de-layed for 19 days following the first report of sockeye to permit the earlier migrating Nadina population to clear the study area. This strategy allowed the Nadina fish to be avoided without re-ducing tag incidences among early recoveries in the Stellako River (Fig. 2b). Pre-study surveys were not conducted in the Birkenhead, Horsefly and Seymour rivers, where

Table 3. Dates of first observation, start and completion of tagging and recovery and peak live and dead counts, and proportion of total carcasses recovered on the peak and final recovery cycles, in the 1995 Fraser River sockeye salmon mark-recapture studies.

	1st observation		Tag application		Carcass recovery		Peak of spawning		Peak recovery cycle		% of recoveries	
Stock	Date	# sockeye	Start	End	Start	End	Start	End	Start	End	Peak cycle	Final cycle
Adams	19-Sep	0	25-Sep	30-Oct	25-Sep	9-Nov	15-Oct	20-Oct[b]	23-Oct	23-Oct[b]	6.2%	0.1%
Birkenhead	6-Sep	101 [a]	6-Sep	9-Oct	7-Sep	16-Oct	20-Sep	26-Sep	6-Oct	8-Oct	18.4%	2.2%
Chilko	1-Aug	0	10-Aug	21-Sep	26-Aug	16-Oct	18-Sep	24-Sep[c]	30-Sep	01-Oct[c]	12.2%	2.5%
Horsefly	21-Aug	20 [a]	21-Aug	8-Sep	2-Sep	28-Sep	7-Sep	11-Sep	9-Sep	12-Sep	35.7%	1.1%
Seymour	20-Aug	3,557	19-Aug	8-Sep	21-Aug	19-Sep	25-Aug	1-Sep	12-Sep	13-Sep	28.0%	0.4%
Stellako [d]	18-Aug	255 [e]	28-Aug	27-Sep	15-Sep	16-Oct	20-Sep	24-Sep	29-Sep	1-Oct	24.6%	2.8%

a. Number of sockeye tagged on the first day.
b. Lower Adams River only.
c. Chilko River/North Chilko Lake only.
d. Tags applied both at the Stellako River fence and inriver; carcasses recovered in the river. Inriver application began on 07-Sep.
e. Includes Nadina migrants.

RESULTS

ARRIVAL INDICES

Mean daily sockeye counts in Chilko and Quesnel rivers are presented in Appendix 1. The former encompass virtually the entire immigra-tion; the latter began after the start of the run in response to a request by the Pacific Salmon Commission (J. Woodey, pers. comm.) for ob-servations to confirm inseason abundance esti-mates that were much higher than anticipated.

MARK-RECAPTURE

The five populations assessed using mark-recapture studies account for 67% of the 1995 tagging began after the arrival of sockeye. This resulted in a lower than average tag incidence among early recover-ies in all but the Seymour (Figs. 2a, 2b), where the crew compensated for the late start by tag-ging at a higher rate in the upper river. The Sey-mour and Birkenhead studies were delayed for logistic reasons; the Horsefly delay reflects the decision to replace the planned visual assess-ment with a mark-recapture study after unex-pectedly large abundances were reported in the lower Fraser River. Overall, there are no serious departures from the objective of temporally rep-resentative tagging achieved through standard daily effort or quotas based on live counts. In all studies, tagging continued until it was difficult to capture fresh sockeye, indicating the near com-pletion of the immigration.

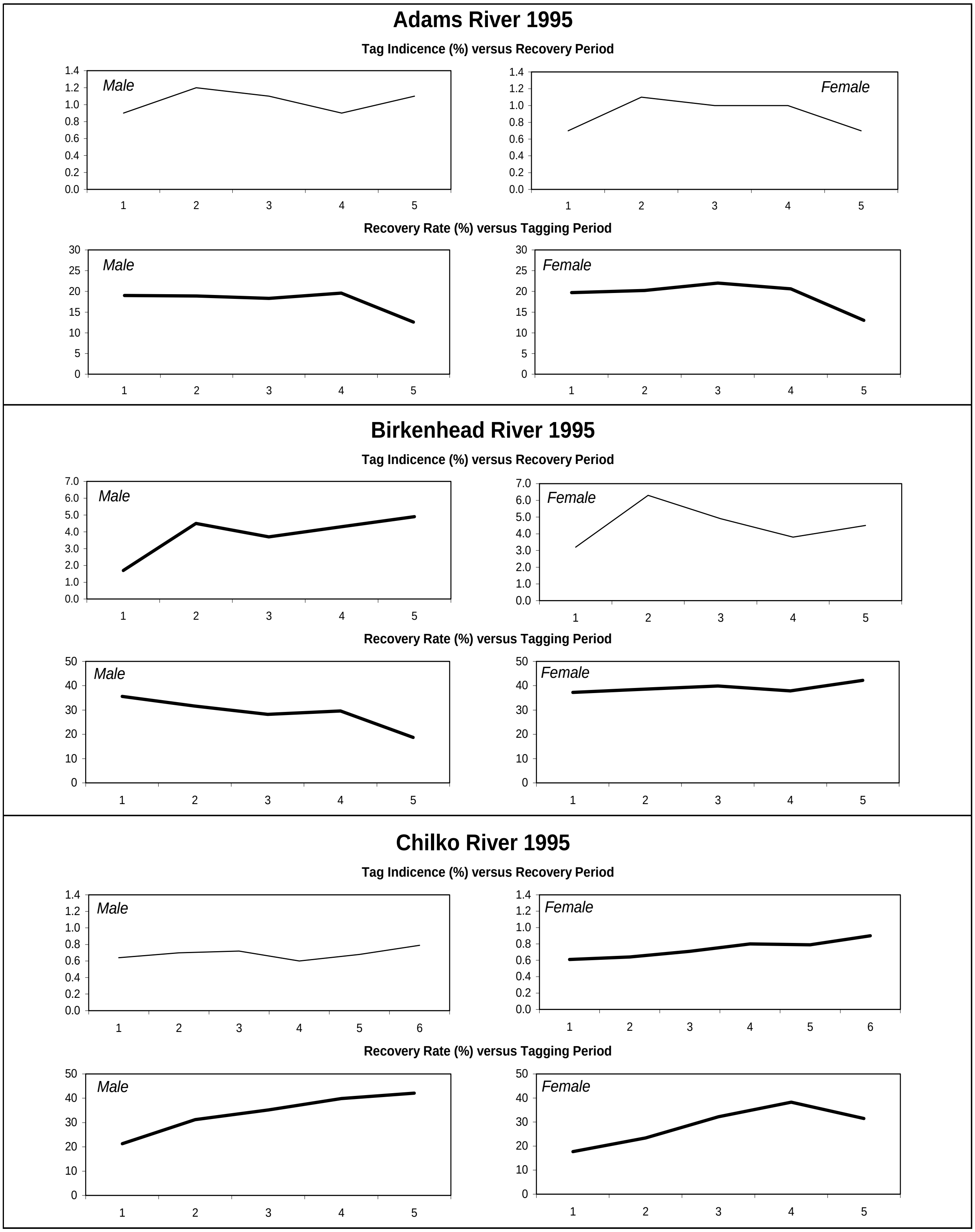

Fig. 2a. Tag incidence across recovery periods, and recovery rate across application periods, for male and female Adams, Chilko and Birkenhead sockeye salmon, 1995. Bold lines indicate significant differences (P>0.05; chi-square) among periods.

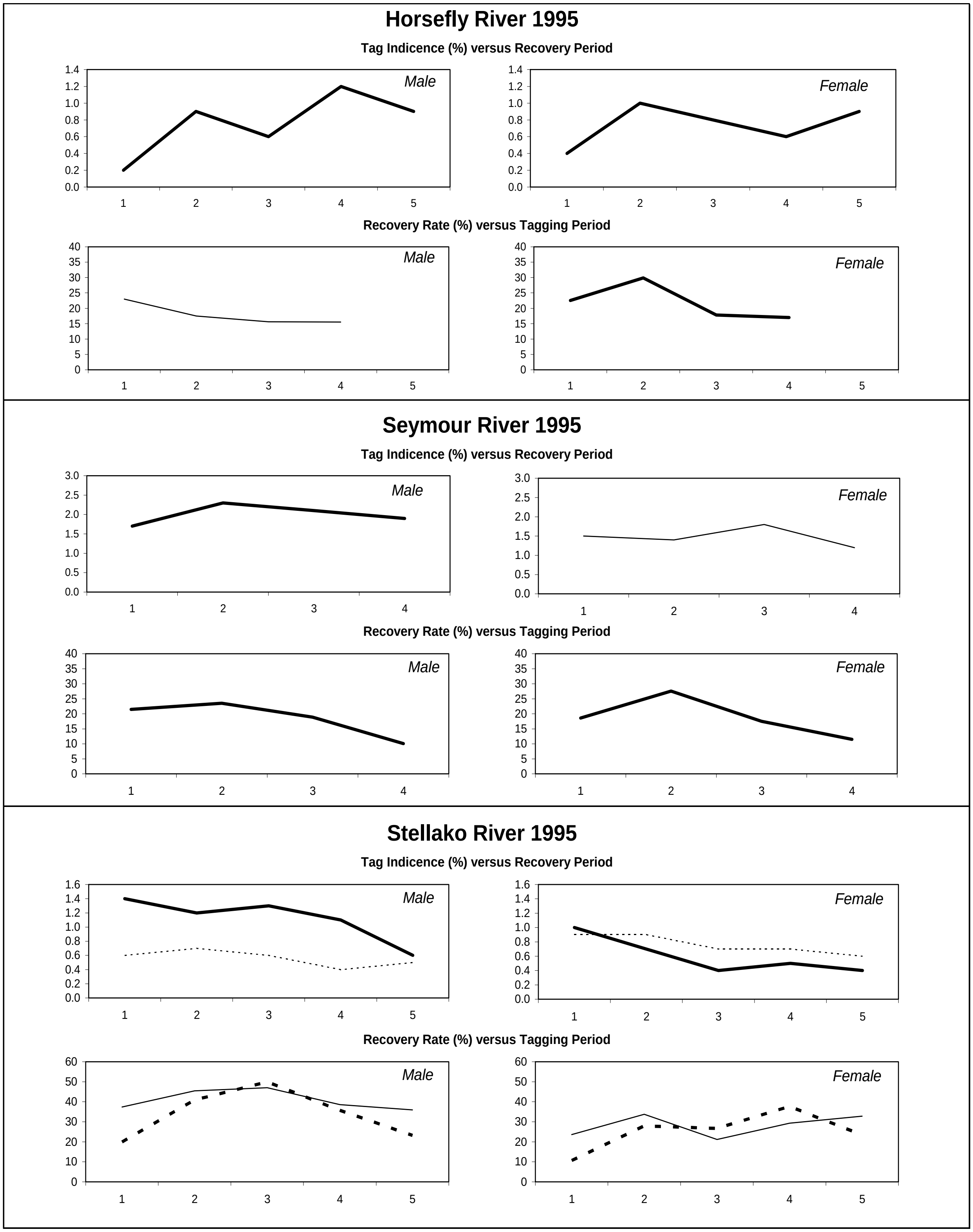

Fig. 2b. Tag incidence across recovery periods, and recovery rate across application periods, for male and female Horsefly, Seymour and Stellako sockeye salmon, 1995. Bold lines indicate significant differences (P>0.05; chi-square) among periods. For Stellako, solid line is disk tags applied on the spawning grounds, dotted line is spaghetti tags applied at the fence.

Table 4. Percent of the escapement tagged and recovered, percent of the carcasses resurveyed, and the proportion of tags missed on the initial survey in the 1995 Fraser River sockeye salmon mark-recapture studies.

	Percent of population tagged		Percent of population recovered		Percent of carcasses resurveyed		Percent of tags missed on the initial survey	
Stock	Males	Females	Males	Females	Males	Females	Males	Females
Adams	1.12%	0.98%	19.4%	21.0%	52.6%	46.3%	5.8%	7.0%
Birkenhead	3.80%	4.56%	28.2%	39.3%	20.1% [a]	20.1% [a]	0.0%	0.0%
Chilko	0.76%	0.84%	36.5%	32.5%	17.5%	15.3%	10.2%	9.9%
Horsefly	0.81%	0.83%	19.6%	24.3%	53.1%	55.2%	9.8%	9.9%
Seymour	2.62%	1.73%	18.9%	18.1%	45.7%	32.6%	2.0%	0.0%
Stellako [b]	0.65%	1.20%	38.6%	38.8%	49.6%	45.0%	5.2%	8.1%
Stellako [c]	1.09%	0.85%	38.6%	38.8%	49.6%	45.0%	9.3%	8.7%
Mean [d]	1.63%	1.69%	26.9%	29.0%	39.7%	35.8%	5.5%	5.8%

a. Sex-specific information was not recorded on the resurvey.

b. Tags applied at the Stellako River fence; carcasses recovered in the river; comparisons are against the known population.

c. Tags applied in the Stellako River; carcasses recovered in the river; comparisons are against the known population.

d. Means exclude spaghetti tags applied at the Stellako River fence.

In 1994, low tag incidences were noted among upper river spawners in a number of studies (Schubert 1998). One approach to improve the distribution of tags in 1995 is tagging at additional sites in the middle and upper parts of the spawning grounds in two studies, the Adams and Seymour. In both cases, the pattern of significantly lower tag incidences in the upper river disappeared in 1995 (Fig. 3a). Contrast this result with the Birkenhead, where tagging was again restricted to the lower river. The same pattern of lower tag incidences in the upper river was maintained in 1995 (Fig. 3b).

Carcass Recovery: In general, recovery surveys began at the start of the die-off and continued until it was complete. Examination of the local tagging area (and spot checks of other parts of the study area) for carcasses always began the day after the start of tagging. Regular recovery surveys began after carcasses were first observed, except in the Horsefly where recovery was delayed by the need to maintain a minimum tagging crew size until abundance declined. During the die-off, recovery surveys were regular and covered the entire spawning area. In all studies, the surveys continued until no new spawners were observed (at least 18 days after the end of the peak spawning period) and few carcasses were present (an average of only 1.7% of the total recovery occurred on the final cycle) (Table 3).

Resurveys: The percentage of the recovered carcasses misidentified as untagged was estimated from the resurvey of an average of one-third of the previously surveyed carcasses (Table 4). In only two studies, Birkenhead (20%) and Chilko (16%), were less than 30% of the carcasses resurveyed. For these studies, the estimate of the number of tagged carcasses misidentified as untagged is relatively imprecise. Overall, the percentage of tagged carcasses misidentified as untagged averages almost 6%, with a high of 10.2% among Chilko males (Table 4). While this is an improvement over 1994, when the missed tag rate averaged 8% with a high of 20% (Schubert 1998), it reflects an ongoing inability to adequate execute this aspect of the mark-recapture study designs.

Tag Loss: The reported loss of primary tags and secondary marks averages 0.1% and 0.0%, respectively (Table 5). This is substantially lower than the average 5.7% of disk tags that were missed during the initial survey (Table 4). Be-cause a tag is much more recognizable than a secondary mark, which is small and easily obscured by fungus, these results suggest that the tag and mark loss rates are almost certainly un-

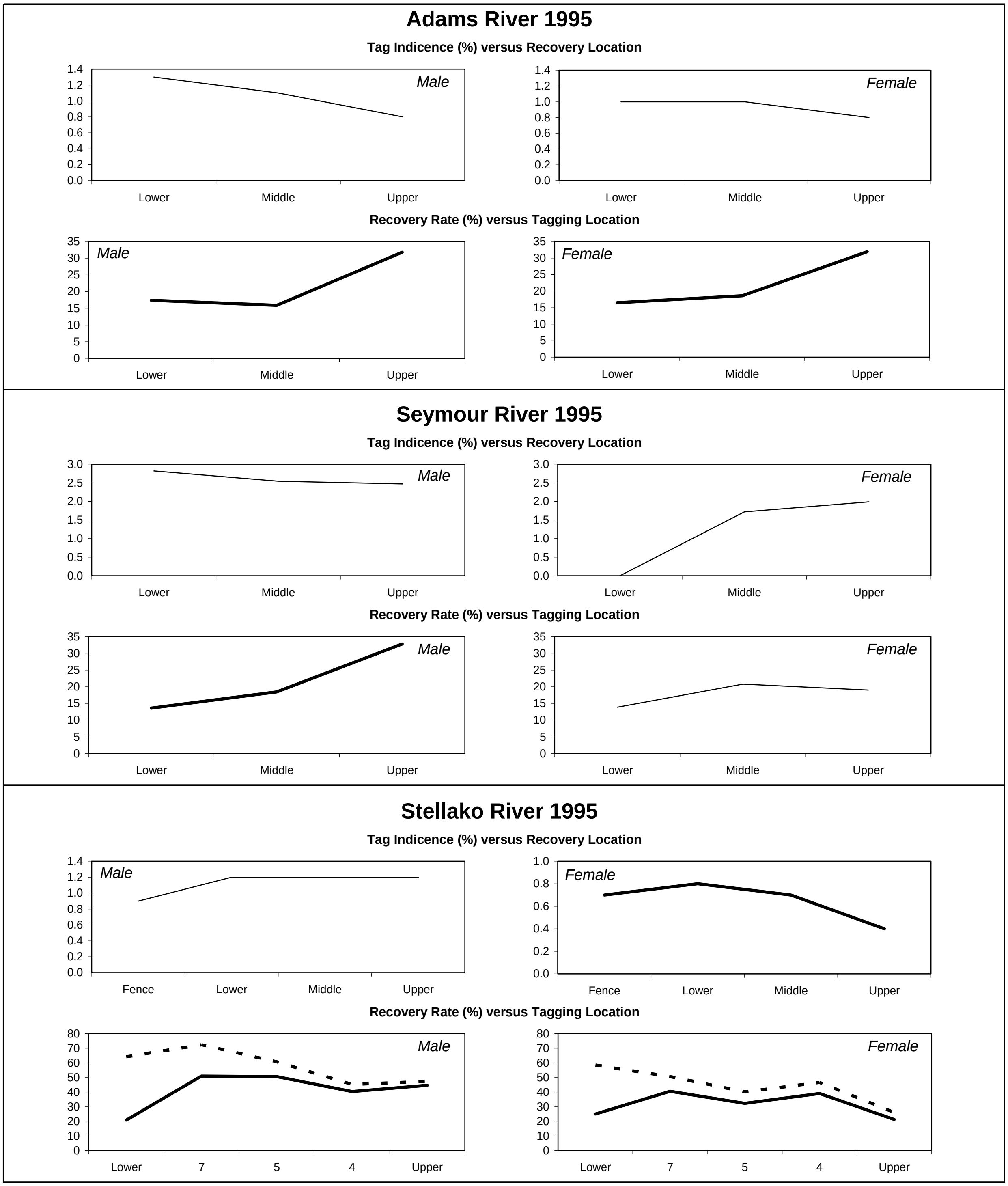

Fig. 3a. Tag incidence across recovery locations, and recovery rate across application locations, for male and female Adams, Seymour and Stellako sockeye salmon, 1995. Bold lines indicate significant differences (P>0.05; chi-square) among locations. For Stellako, tags are disk tags applied in the river; for recovery rates, dotted lines include spawning ground and fence recoveries, solid lines are spawning ground recoveries only.

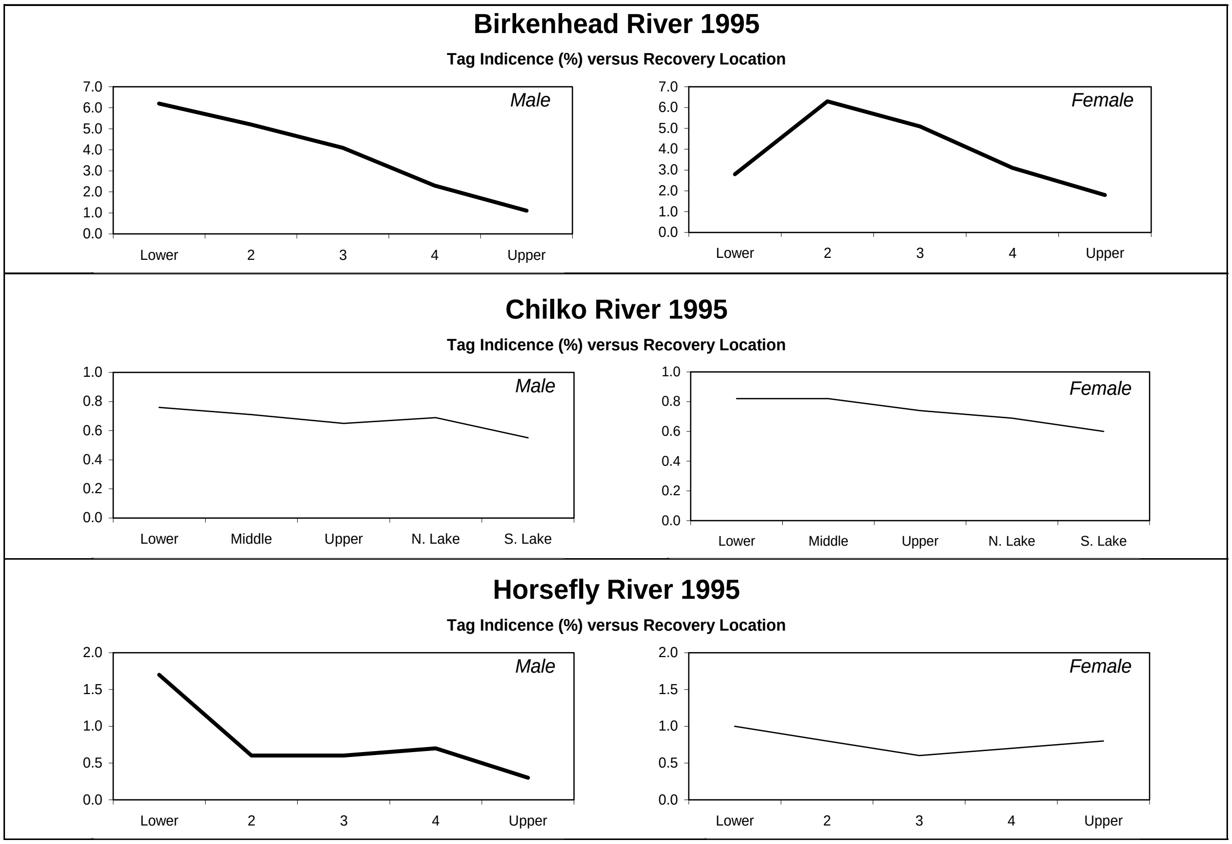

Fig. 3b. Tag incidence across recovery locations for male and female Birkenhead, Chilko and Horsefly sockeye salmon, 1995. Bold lines indicate significant differences (P>0.05; chi-square) among locations.

derestimated by a substantial margin. Consequently, the data should be treated as unreliable; at best, they represent minimum estimates of tag loss.

Tagging and Recovery Rates: The mark-recapture studies are designed to tag 1%, and recover either 10% (Adams, Chilko) or 20% (Birkenhead, Horsefly, Seymour, Stellako) of the population. The average tagging rates exceed 1%, at 1.6% and 1.7% of the estimated population of males and females, respectively (Table 4). All studies have tag rates of 1% or greater, except the Chilko, Horsefly, and Stellako (river tagged females only). Recovery rates average almost 30% (27% and 29% for males and females, respectively), and exceed the target levels for all populations except Seymour (Table 4). Because precision is based largely on the number of tags recovered, tagging and recovery rates interact to determine precision. Despite the failure to achieve tagging goals for three populations, therefore, the precision goal of ±25% of the total population estimate is achieved was all studies (Table 6).

Handling Stress: The 1995 studies are the first to address handling stress, through both the adoption of rigorous new procedures to minimize stress and the use of high and low stress tech-niques to assess its impact. The new pro-cedures (see *Analytic Procedures*) were suc-cessfully implemented in all of the studies and should minimize the impacts of handling stress in the current and future studies. The compare-son of recovery rates between fish tagged using high stress (the method used in previous years) and low stress (the new method) techniques de-tect no differences, suggesting that stress is un-likely to bias the mark-recapture study results. Furthermore, a radio-telemetry study in the Chil-ko System concluded that acute stress is unlike-ly to introduce bias into the mark-recapture esti-

Table 5. Primary disk tag and secondary mark loss, by sex, in the 1995 Fraser River sockeye salmon mark-recapture studies.

	Male recoveries			Male tag loss rates		Female recoveries			Female tag loss rates	
Stock	Total tags recovered	Missing primary tag	Missing second-ary mark	Primary	Second-ary	Total tags recovered	Missing primary tag	Missing second-ary mark	Primary	Second-ary
Adams	432	1	0	0.2%	0.0%	429	1	0	0.2%	0.0%
Birkenhead	212	0	0	0.0%	0.0%	358	0	0	0.0%	0.0%
Chilko	617	2	0	0.3%	0.0%	862	1	0	0.1%	0.0%
Horsefly	115	n/r	n/r	n/r	n/r	183	n/r	n/r	n/r	n/r
Seymour	99	0	0	0.0%	0.0%	63	0	0	0.0%	0.0%
Stellako [a]	156	0	0	0.0%	0.0%	194	0	0	0.0%	0.0%
Stellako [b]	327	0	0	0.0%	0.0%	152	0	0	0.0%	0.0%
Mean [c]	-	-	-	0.1%	0.0%	-	-	-	0.1%	0.0%

a. Tags applied at the Stellako River fence; carcasses recovered in the river.
b. Tags applied in the Stellako River; carcasses recovered in the river.
c. Exclude tags applied at Stellako fence.

Table 6. Tag application and recovery sample sizes, escapement estimates and 95% confidence limits for the 1995 Fraser River sockeye salmon populations estimated using mark-recapture studies.

	Adult males					Adult females				
	Tag applic-ation	Carcass recovery		Escapement [a]		Tag applic-ation	Carcass recovery		Escapement [a]	
Stock		Tagged	Total	Estimate	+/-		Tagged	Total	Estimate	+/-
Adams [b]	2,233	432	38,577	199,070	8%	2,045	429	43,788	208,350	8%
Birkenhead	754	212	5,598	19,838	11%	912	358	7,864	20,008	8%
Chilko	1,689	617	80,705	221,058	6%	2,657	862	102,389	314,990	5%
Horsefly	593	115	14,416	73,632	16%	756	183	22,127	90,977	12%
Seymour	530	99	5,144	20,224	17%	353	63	3,698	20,463	22%
Stellako [c]	422	156	25,151	67,801	12%	687	194	22,313	78,935	12%
Stellako [d]	708	327	25,151	54,302	8%	489	152	22,313	71,348	13%

a. Pooled Petersen estimate with 95% confidence interval.
b. Includes all study area populations.
c. Tags applied at the Stellako River fence.
d. Tags applied in the Stellako River.

mates (Schubert and Scarborough 1996).

Summary: The focus of the 1995 study design changes is four-fold. First, to promote the mixing of tags and the unbiased recovery of carcasses across spatial and temporal strata. Several tactics were used (except in Birkenhead and Horsefly) to address this objective: the studies began early to ensure that the first sockeye that arrive were vulnerable to tagging; crew sizes were increased during the period of concurrent tagging and recovery to ensure that sampling effort was consistent across the immigration and die-off; tag sites were added to some studies to increase the tag incidence in the middle and upper areas; and recovery continued until the die-off was complete. The result is an improvement in the mixing of tags relative to 1994, but the persistence of significant differences in recovery rates across spatial and temporal strata (Figs. 2-3). The latter likely re-flects the correlation between the probability of re-covery and spawning location noted in the mult-iple tag site studies. It is an issue with important implications to future mark-recapture studies that requires further investigation. Second, to improve the design of the resurveys and reduce the inci-dence of missed tags, resurvey effort was in-creased and reallocated spatially and temporally, and staff training was modified. These measures were generally successful; the resurvey rate in-creased by seven percentage points, and the missed tag rate decreased by two percentage points. Third, to directly assess tag loss, a se-condary mark was applied to all tagged fish (ex-cept in Horsefly). Because the reported tag loss rates are unrealistically low, I conclude that car-cass inspection procedures were inadequate to detect the opercular punch; improved staff training or a different mark is required. Fourth, to mini-mize stress and assess its impact, new handling procedures were implemented, high and low stress techniques were compared, and a radio-telemetry study was conducted. No serious stress impacts are noted. In general, then, the mark-recapture study designs were strengthened through the largely successful implementation of several modification in 1995.

Bias Assessment

The 1995 sampling biases (those with signif-icant test results) are described in Table 7, with spatial and temporal trends shown in figures 2 and 3, respectively. Sex biases, although pre-sent, are not a concern because the mark-recap-ture estimates are calculated separately for the two sexes.

Size Bias: Size biases are present at recov-ery in Birkenhead males and Stellako females; however, they are unlikely to bias the population estimates. Such recovery biases would affect the population estimate only when correlated with a similar bias at application (Junge 1963). While application bias could not be evaluated because untagged carcasses were not measure-ed, beach seines are not typically prone to size selective sampling except perhaps when the largest fish avoid the net. The only study that might be affected is Stellako, where larger fe-males have lower recovery rates. It is not a con-cern because the population size is estimated at the enumeration fence. It is the potential impact of spatial and temporal sampling biases, then, that is most important in 1995.

Spatial and Temporal Bias: A number of spatial and temporal sampling biases are present in 1995 (Table 7; Figs. 2-3). In no case is the bias sufficiently severe to cause the rejection of the pooled Petersen estimator in favour of a stratified estimator (the standard assumption is that the impact of sampling bias on estimator accuracy is trivial unless the confidence limits of the pooled Petersen and stratified estimators do not overlap). The results of the Stellako study, however, sug-gest that sampling biases may indeed bias the pooled Petersen estimate even when the confi-dence limits of the estimates overlap (Schubert 2000). Of primary concern are those studies where bias is detected both at tagging and recov-ery, *i.e.,* where the probabilities of tagging and recovery are correlated. Temporally, this occurs in Birkenhead males, Chilko females, Horsefly females, and Seymour males (the only spatial example, Stellako females, is not addressed be-cause the population is estimated at the fence). In these cases, it may be possible to infer the probable direction of the estimation bias from the temporal shapes of the tag incidences and re-covery rates (Fig. 2). A similar shape (*e.g.,* Chilko females and Seymour males) suggests a positive correlation between the probabilities of tagging and recovery that could cause a negative estima-tion bias. Opposite shapes (*e.g.,* Birkenhead males) suggest a negative correlation and a posi-tive bias. Differently shaped profiles (*e.g.,* Horse-fly females) will lead to, at most, a weak cor-relation and little bias. Conclusions from these evaluations are qualitative because the shapes of the sampling profiles are usually complicated (*e.g.,* in Chilko, recovery rates increase through time, but decrease near the end of the run), and the observed trends are only estimates of the true patterns in tag incidence or recovery rate. While this evaluation may provide insights into the prob-able direction of bias, it does not provide quantita-tive estimates of its magnitude. Simulations ex-amining the influence of major sampling biases on the Petersen estimates (Schubert and Fanos 1997b; Schubert and Vivian 1997) indicate that estimation errors as large 10% are rare. Because the probable biases are bidirectional, the overall bias among mark-recapture studies may be small.

Estimation Bias: Positive estimation bias is common in mark-recapture studies and is thought to reflect undetected violations of the assumptions underlying the technique (Cousens *et al.* 1982; Simpson 1984). One mechanism for such bias is a commonly observed pattern of disproportionate sampling that results in declining tag rates and increasing recovery rates with distance upstream. The former was identified in eight studies in 1994 (Schubert 1998) and three studies in 1995 (Fig. 3). There is a tendency for early migrants to swim faster than late migrants (an average three times faster in Chilko River; (Schubert and Scarborough 1996)) and to spawn in the upper part of the spawning distribution. The tag rate pattern, there-

Table 7. Results of statistical tests for bias in the 1995 Fraser River sockeye salmon mark-recapture studies. For significant test results, the bias is described; non-significant tests are indicated by *'No bias'*. Chi-square tests are used in all cases except for the size bias test, for which a Kolmogorov-Smirnov 2-sample test is used.

Stock	Sample	Test type	Male	Female
Adams	Application	Temporal	High tag incidence (1 test), early	High tag incidence (1 test), middle
		Spatial	No bias	Low tag incidence, Little River
		Fish Sex	Bias to males	Bias to males
	Recovery	Temporal	No bias	Low recovery rate (2 tests), late
		Spatial	High recovery rate, upper tag site	High recovery rate, upper tag site
		Fish Sex	No bias	No bias
		Fish Size	No bias	No bias
Birkenhead	Application	Temporal	Low tag incidence (3 tests), early	Low tag incidence (3 tests), early
		Spatial	Low tag incidence, upper river	Low tag incidence, upper river
		Fish Sex	Bias to females	Bias to females
	Recovery	Temporal	Low recovery rate (3 tests), late	No bias
		Spatial	No bias	No bias
		Fish Sex	Bias to females	Bias to females
		Fish Size	High recovery rate, large fish	No bias
Chilko	Application	Temporal	High tag incidence (1 test), early	High tag incidence (3 tests), late
		Spatial	No bias	No bias
		Fish Sex	No bias	No bias
	Recovery	Temporal	Low recovery rate (3 tests), early	Low recovery rate (3 tests), early
		Fish Sex	Bias to females	Bias to females
		Fish Size	No bias	No bias
Horsefly	Application	Temporal	Low tag incidence (3 tests), early	Low tag incidence (2 tests), early
		Spatial	High tag incidence, lower river	No bias
		Fish Sex	No bias	No bias
	Recovery	Temporal	No bias	High recovery rate (2 tests), early
		Fish Sex	No bias	No bias
		Fish Size	No bias	No bias
Seymour	Application	Temporal	No bias	No bias
		Spatial [a]	No bias	No bias
		Fish Sex	Bias to males	Bias to males
	Recovery	Temporal	High recovery rate (3 tests), early	High recovery rate (3 tests), early
		Spatial	High recovery rate, upper tag site	No bias
		Fish Sex	No bias	No bias
		Fish Size	No bias	No bias
Stellako [b]	Application	Temporal	High tag incidence (1 test), early	No bias
		Spatial	High tag incidence, lower river	No bias
		Fish Sex	Bias to males	Bias to males
	Recovery	Temporal	High recovery rate (2 tests), middle	High recovery rate (2 tests), middle
		Fish Sex	Bias to males	Bias to males
		Fish Size	No bias	No bias
Stellako [c]	Application	Temporal	Low tag incidence (3 tests), early	Low tag incidence (3 tests), early
		Spatial	No bias	Low tag incidence, upper river
		Fish Sex	Bias to males	Bias to males
	Recovery	Temporal	Low recovery rate (3 tests), late	No bias
		Spatial	Low recovery rate, lower tag sites	Low recovery rate, lower tag sites
		Fish Sex	Bias to males	Bias to males
		Fish Size	No bias	Low recovery rate, large fish

[a.] McNomee Creek excluded from study area.

[b.] Spaghetti tags applied at the Stellako River fence.

[c.] Disk tags applied in the Stellako River.

Table 8. Dates of fence installation, sockeye arrival, fence removal, and the completion of migration, and an evaluation of operational effectiveness for the 1995 Fraser River sockeye salmon enumeration fence studies.

Stock	Date of: First arrival of sockeye	Fence instal-lation	Comple-tion of migration	Fence removal	% of total count with-in 3-days of fence installation	Fish tight	Downstream: Holding	Mortality	Peak daily count
Bowron	unknown	23-Jul	11-Sep	11-Sep	0.0%	No	No	No	2,803
Fennell	29-Jul	29-Jul	11-Sep	11-Sep	0.0%	Yes	No	No	1,404
Forfar	20-Jul	12-Jul	16-Aug	18-Aug	0.0%	No	No	No	2,520
Gluske	18-Jul	12-Jul	15-Aug	18-Aug	0.0%	Yes	No	No	2,976
Kynoch	19-Jul	12-Jul	16-Aug	18-Aug	0.0%	No	No	No	3,678
Scotch	13-Aug	2-Aug	15-Sep	16-Sep	0.0%	Yes	No	No	2,275
Stellako	18-Aug	25-Aug	13-Oct	18-Oct	0.2%	No	No	No	19,750
Sweltzer [a]	unknown	29-Sep	4-Dec	6-Dec	15.2%	No	No	No	2,342

[a.] Cultus Lake population.

fore, may reflect a lower vulnerability to tagging based on the speed of migration of temporal components of the run and on study designs that limit tagging to a fixed period or number of sets. The effect would be exacerbated by tagging in the low-er river, thereby increasing the vulnerability of loc-al spawners, or by delays in study implementation, thereby further reducing the vulnerability of early migrants. The temporal pattern translates into a spatial pattern because earlier migrants tend to spawn closer to the upper limit of the spawning distribution while later migrants spawn closer to its lower limit. The second sampling effect, increas-ing recovery rates with distance upstream, was identified in 1995 when the Adams and Seymour studies were modified by adding tag sites in the middle and upper parts of the spawning distribu-tions. In both cases, recovery rates are highest among sockeye tagged in the upper river (Fig. 3a), probably because upriver locations maximize the downstream habitat on which carcasses can wash ashore or snag following death. The Stellako study clearly shows that, among lower river spawners, there is a much higher proportion of the carcasses that never become vulnerable to recov-ery surveys because they drift out of the system (Fig. 3a). This is a structural attribute to this type of study; it cannot be effectively corrected by pro-cedural modifications. This issue, then, has im-portant impacts on the optimal allocation of sam-pling effort and requires further investigation.

ENUMERATION FENCE

Populations that were assessed by essentially complete censuses at either spawning channels (Appendix 2) or fences (Appendix 3) account for 19% (4% and 15%, respectively) of the 1995 Fraser River sockeye escapement estimate, 158,064 males, 165,941 females and 585 jacks. By far the largest escapements were counted at fences in the Stellako (122,780) and Bowron (34,431) rivers. The studies that generated these estimates are evaluated below.

Implementation of Study Design

This section addresses the following questions for the fence studies (spawning channels and most of the fences operated by other agencies are excluded because detailed information is unavailable): Was the fence installed after the arrival of sockeye? Were operations interrupted during the migration? Was the fence removed before the migration was complete? Did it cause sockeye to hold or die downstream? Did large daily abundances confound the operational pro-cedures and reduce the accuracy of the counts?

Installation Timing: All of the fences remained in the rivers until zero or very low daily counts were observed and downstream surveys reported no sockeye immigrants. Most were installed well before the arrival of sockeye, except for those in the Bowron, Fennell, Stellako and Sweltzer systems (Table 8). The late install-ation of the Bowron and Fennell fences is not of concern because significant migrations were not yet underway; less than 0.1% of the total count in those system occurred within three days of fence installation (Table 8). In the Stellako, the project was intentionally delayed to permit the earlier Nadina populations to clear the area before the fence was installed. Stellako sockeye that were already in the river were counted and included in the population estimate. In Sweltzer, the migra-tion of Cultus Lake sockeye was unexpectedly early; over 15% of the total count was recorded in the first three days of operation. It is likely, therefore, that the Cultus escapement is esti-mated with a negative bias that may be substan-tial.

Fence Integrity: The fences either operated without interruption (Fennell, Gluske, Scotch), or experienced incidents that ranged from minor (Kynoch, Forfar) to severe (Bowron, Forfar, Stel-lako, Sweltzer) (Appendix 3). Minor incidents are breeches that are of short duration or occur when few sockeye are in the river; therefore, it is unnecessary to correct the daily counts. Examples are Forfar Creek, where the fence was left open for up to 25 minutes on August 11 and 14 when a bear occupied the area, and Forfar (August 17-18) and Kynoch (August 14) creeks, where broom sticks broke during the final few days of the migration. Severe incidents are breeches that are undetected for extended periods or occur when sockeye abundance is high; the counts are corrected by applying the passage rate (sockeye per 15 minutes) observed when the breech is discovered to its estimated duration. This occurred in the Bowron on five occasions when chinook salmon broke through the wooden broom sticks, twice in the Stellako when the fence undermined, once in Forfar (July 21) when a broom stick broke, and once in Sweltzer when vandals opened the fence.

Obstructions to Migration: There were no observations of unusual holding behaviour or prespawn mortality downstream from the fences in 1995. As well, daily migrations were within the levels anticipated during project planning; in only two studies did the daily peaks exceed 3,000 sockeye: Kynoch Creek (3,678) and Stellako River (up to 19,750) (Table 8). Even daily migrations of this magnitude are unlikely to introduce error in the counts, however, because the counts were pulsed over the entire 24-hour period, the number of sockeye in each pulse was strictly controlled, and multiple crews were used to reduce observer fatigue.

Bias Assessment

In general, the enumeration fence study designs were well executed in 1995. With the exception of Sweltzer Creek, the fences operated over the entire immigration period of the populations and were either fish-tight or the counts are adjusted for breeches based on the estimated passage rate. There is no evidence that the fences obstructed upstream passage and, while daily abundances were sometimes large, they were anticipated and operational procedures were in place to accommodate them. This does not mean, however, that these escapement estimates are absolutely accurate. Errors can occur for at least four reasons: a) sex and species identification error can occur when live fish are counted while swimming past a fixed point; b) counting errors can occur at night due to poor lighting, surface glare or viewer fatigue; c) count-ing errors can occur if there is a rapid migration of large numbers of fish; and d) channel dead counts can underestimate escapement due to the loss of carcasses to predators or wash-outs. The study designs address the first three issues: sex is not recorded from live fish; spawning col-ouration makes sockeye highly recognizable; night observations are avoided when possible, and supported by adequate lighting when necessary; and high daily abundances are anticipated and accommodated with adequate staff levels. Andrew and Webb (1987) recommend a coefficient of variation of 5% for all complete counts (approximate 95% confidence limits of $\pm$10%). This probably overstates the error in 1995. While error could conceivably approach this level during peak daily migrations of 20,000 fish, it is unlikely during the balance of the run and does not apply to smaller populations. The error bound also ignores the likelihood of asymmetric confidence intervals, whereby underestimates are more likely than overestimates. It is concluded, therefore, that the fence and channel escapements are likely estimated with a negative bias of less than 5%.

VISUAL SURVEYS

In 1995, 117 populations or components of populations were assessed using visual techniques (Appendix 4). They account for 14% of the 1995 Fraser River sockeye escapement estimate, 118,044 males, 119,654 females and

11,527 jacks.

Implementation of Study Design

This section addresses the following questions: Were the visual surveys directed only at the smaller (<25,000) populations? Was the extent and frequency of the surveys adequate? Did the peak live count occur on the first or last survey? Did local conditions permit the effective observation of fish?

Population Size: Of the populations surveyed, 41% have fewer than 100 spawners, while only one (Mitchell River) exceed the maximum 25,000 spawners intended for assessment by this technique (Appendix 6). The Mitchell is a large river where visual observations of large populations are likely to underestimate the true population size. For example, a comparison of estimation techniques in Mtichell River in 1994 show the more reliable mark-recapture estimate exceeds the visual estimate by almost two-fold (Schubert 1998). Errors of similar magnitude are likely in 1995.

Survey Extent: The extent of the surveys was adequate in that each was designed to cover the entire spawning area for the populations. The only exception, Canoe Creek, was surveyed up to a beaver dam that prevented further fish access. In such cases, nearby non-traditional areas are inspected (in this case, Salmon Arm tributaries) to document potential straying to other spawning areas. A deficiency in the adequacy of the extent of previous surveys of Bowron River was noted when aerial overflights reported sockeye well above what was thought to be the upper limit of spawning. While the upper areas where known to IPSFC staff, the knowledge was lost after DFO assumed responsebility for escapement estimation in 1985. Consequently, the Bowron escapement is likely underestimated in at least some years between 1986-1994,

Survey Frequency: Survey frequency is allocated on the basis of population size. Of the streams surveyed 1-3 times, 61% had estimated populations of less than 100 spawners, while 84% of those surveyed 4+ times had estimated populations of more than 100 spawners (52%

Table 9. Summary of study design execution indicators for the 1995 Fraser River visual surveys. Indicators include number of studies with: estimated escapements >25,000; the peak live observed on the first or last survey; and a total survey effort of 1, 2-3, 4-6, and 7+ surveys.

				Number of stocks by survey frequency and average estimated escapement for those stocks [α]							
				1 survey		2-3 surveys		4-6 surveys		7+ surveys	
Geographic area [a]	Number of stocks surveyed [b]	25,000+ Escapement	Peak on first or last survey [c]	No. stocks	Escapement	No. stocks	Escapement	No. stocks	Escapement	No. stocks	Escapement
Lower Fraser	4	0	2	0	-	1	100	3	1,100	0	-
Harrison-Lillooet	4	0	3	0	-	2	900	1	16,800	1	9,300
Seton-Anderson	2	0	1	0	-	1	8,400	0	-	1	17,800
South Thompson (ES)	16	0	0	6	0	1	0	8	1,000	1	8,100
South Thompson (L)	31	0	2	6	100	16	300	6	2,800	2	5,300
North Thompson	5	0	0	3	0	1	0	1	1,000	0	-
Chilcotin	1	0	0	1	1,800	0	-	0	-	0	-
Quesnel	4	1	0	3	100	1	35,200	0	-	0	-
Stuart, Early Run	37	0	1	9	1,000	2	100	22	1,700	4	4,500
Stuart, Summer Run	7	0	0	7	4,900	0	-	0	-	0	-
Total	111	1	9	35	1,300	26	1,900	41	2,000	9	7,100

a. ES - Early Summer Run; L - Late Run.
b. Excludes populations or components of populations 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 populations that were surveyed only once or twice, and below-fence surveys that intentionally started late to permit upriver spawners to clear the area.
α. Average escapements are rounded to the nearest 100.

had 1,000+). Exceptions occurred for at least three reasons: a) remoteness inhibited frequent access to Driftwood River (1 survey, 3,000 spawners) and Taseko Lake (1 survey, 1,800 spawners); b) frequent surveys in the early Stuart group permitted the delay of surveys in Fleming Creek (1 survey, 5,200 spawners) until the peak of spawning, and c) budget restrictions prevented the use of adequate methodologies in Eagle (1 survey, 900 spawners) and Mitchell (1 survey, 35,200 spawners) rivers and the Stuart Summer Run (34,200 spawners); each was surveyed once by helicopter. When survey effort is limited, the level of carcass recovery is often insufficient to estimate sex composition. This occurs in 39 cases in 1995 (Appendix 5), the most serious of which was the Stuart Summer Run.

The peak of spawning was observed on the first survey of nine populations (Table 9), Chilliwack, Widgeon, Harrison, Big Silver, Samson, Portage, lower and middle Shuswap, and Fifteen Mile (Appendix 4). Of those, four (Big Silver, Harrison, Portage, and lower Shuswap) have estimated escapements of more than 1,000 spawners. This is a concern because surveys that begin at or after the peak will estimate the population with a negative bias because early carcasses will not be recovered and the true peak may have occurred before the start of the surveys. The bias from the former is small be-cause few fish (typically about 5%) die before the peak. The latter, however, can potentially intro-duce a substantial negative bias. That few car-casses were observed on the first survey of most of these populations suggests that the surveys were temporally close to the peak. The possibil-ity of a negative bias that may be substantial cannot be discounted, however, because sub-stantial abundance changes can occur in only a few days.

Sighting Conditions: Sighting conditions were generally good in 1995. The few cases of poor visibility resulted from glacial run-off (upper Adams, upper Pitt and lower Eagle rivers and Taseko Lake), deep water spawning (Harrison, North/South Thompson and Tachie rivers), and tea-coloured water (Middle and Tachie rivers).

Bias Assessment

Population Size: In general, the visual survey technique was directed at populations of the appropriate size and the study designs were well executed. Exceptions include the inappropriate use of the technique on one large population (Mitchell), single surveys of significant populations in Driftwood and Eagle rivers, Taseko Lake and the entire Stuart Late Run, and the late start of surveys in Big Silver and Portage creeks and Harrison and lower Shuswap rivers. These deficiencies likely introduce negative biases that could be substantial. The late surveys should be corrected through improved execution of the stu-dy designs. The other issues require structural changes to improve survey frequency and to en-sure that large populations are assessed using the appropriate technique.

Fixed Expansion Factor: The application of a fixed expansion factor to stream survey data provides an escapement estimate about which there is clearly error. The reliability of the technique depends on the similarity of characteristics (stream morphology and clarity, climatic conditions, survey intensity, observer efficiency) between the index stream and the stream or streams where the expansion factor is calculateed. 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. The variability is exemplified by the range in expansion factors calculated at five fences in 1995: 1.7 at Gluske; 1.3 at Forfar; 1.6 at Ky-noch; 2.9 at Bowron; and 2.6 at Fennell (Appen-dix 5). The source of this variability is unclear, although the accessible length of the spawning area may be a factor (Bowron and Fennell both have extensive spawning areas). A structured investigation is required to determine if additional calibration fences are required.

Inseason Calibration: The assessment of the Stuart Early Run is a refinement of the technique whereby the expansion factor is calculated each year. Three calibration streams were used in 1995; therefore, the expansion factors should accurately index the other streams provided they were surveyed at a similar frequency or their peaks were identified accurately. Although the surveys were less frequent than in the calibration streams (Appendix 4), they should have been adequate to permit the identification of the spawning peak. Exceptions are the Driftwood System and Fleming Creek; both were 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 these populations because the single flight may not coincide with the actual peak of abundance.

Summary: It is not possible to quantify the bias in visual estimates from the available data. Cousens *et al.* (1982) suggest that the method can be as accurate as ±30% if observations are made by experienced staff in small, clear, stable streams. Because a large number of streams are surveyed using this technique, central tendency may balance over and underestimates, resulting in less biased estimates for the aggregate. The exceptions are the inappropriate use of single surveys, visual surveys of large populations, and late survey starts, all of which likely introduce a large negative bias in the overall visual estimates. Regardless, these populations comprise a small proportion of the total escapement in 1995. Even gross errors, therefore, would introduce a relatively small bias in the overall escapement estimate.

ESCAPEMENT

The 1995 Fraser River sockeye escapement totals 1,736,763 adults and 18,473 jacks (Table 10). The sockeye adult escapement declined by 47% from the 1991 brood year escapement of 3,306,272, but is the third largest reported on this cycle since 1939 (Fig. 4).

Geographic Group

Lower Fraser: The Lower Fraser group con-sists of four early summer run and two late run populations from relatively small streams that enter the Fraser River between the Pitt and Thompson rivers (Fig. 5). The largest populations on this cycle spawn in the upper Pitt River and Cultus Lake. Most of the Lower Fraser populations were surveyed visually, with three to five surveys per populations (Appendix 5). Cultus sockeye were counted at a fence in Sweltzer Creek (Appendix 3) that has operated in most years since 1926.

The 1995 Lower Fraser group escapement of 19,200 adults and 85 jacks comprises 1% and <1%, respectively, of the Fraser River total (Table 10). The adult escapement is less than half that of the brood year (Fig. 5), with reduced escapements in all populations but especially in the upper Pitt and Cultus. Spawning success (82%; range 74%-90%) (Appendix 6) declined from the brood year (97%; range 94%-100%),

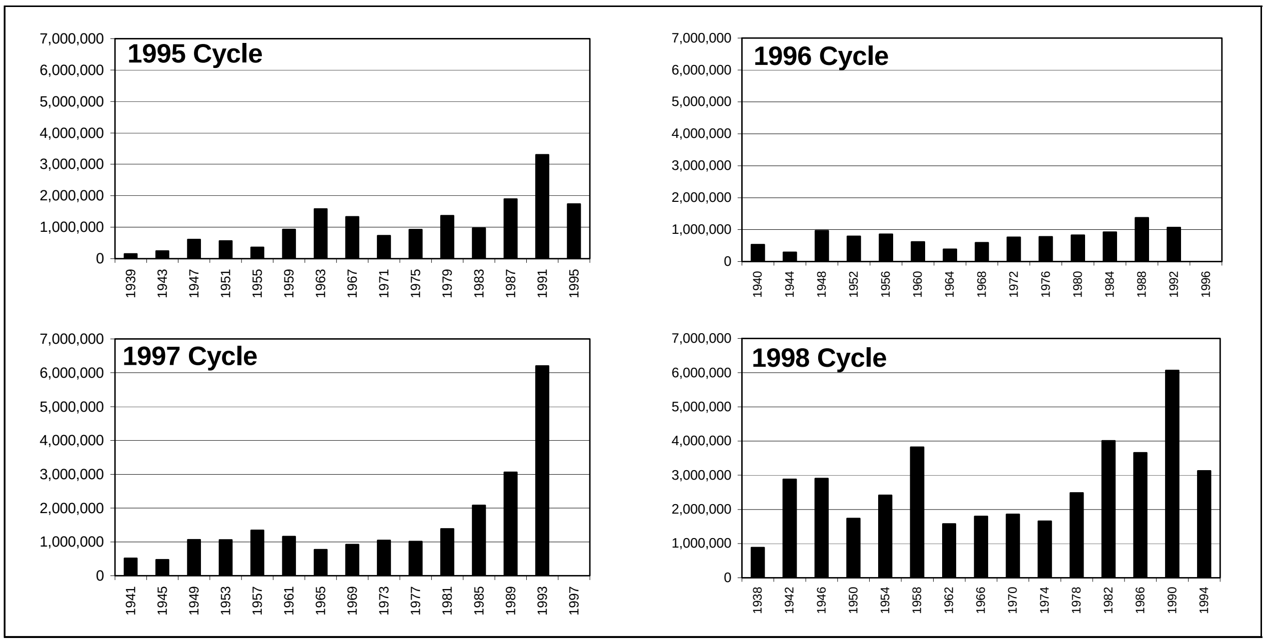

Fig. 4. Fraser River adult sockeye escapement by cycle.

with poor success in Cultus and Nahatlatch lakes.

The accuracy of the Lower Fraser estimates depends largely on the Cultus and upper Pitt populations that comprise 82% of the total. The former, assessed at a fence, is considered a complete census for the operational period; however, the late fence installation results in a negative bias that may have exceeded 10%. The latter was assessed visually by the hatchery operator. Because the Pitt is a glacial system, turbid water likely introduces a substantial negative bias in the escapement estimate. Assuming random error in the remaining visual estimates, the escapement of this group was likely assessed with a negative bias that may exceed 20%.

Table 10. Estimated escapement of Fraser River sockeye salmon adults and jacks, by population group and selected major populations, for cycle years 1983, 1987, 1991 and 1995.

Stock group	Stock	1995 Period of peak spawning	Estimated sockeye adult escapement 1983	1987	1991	1995	Jack escape-ment 1995
Lower Fraser	Chilliwack Lake	Early Sep	270	1,716	1,050	968	20
	Cultus Lake	Early Dec	19,944	32,184	20,157	10,316	33
	Nahatlatch System	06-Sep to 13-Sep	2,186	13,501	2,755	2,297	32
	Pitt River, upper	-	16,852	13,637	22,500	5,500	0
	Total [a]	-	**40,285**	**62,587**	**47,416**	**19,200**	**85**
Harrison-Lillooet	Birkenhead River	20-Sep to 26-Sep	44,029	164,849	293,626	39,846	3,139
	Harrison River	01-Nov to 10-Nov	4,239	5,228	15,000	16,618	142
	Weaver Channel	12-Oct to 16-Oct	18,614	33,696	27,942	21,199	248
	Weaver Creek	12-Oct to 16-Oct	20,727	26,272	10,179	12,832	110
	Total [a]	-	**88,085**	**230,680**	**349,236**	**91,234**	**3,654**
Seton-Anderson	Gates System	31-Aug to 06-Sep	7,384	9,417	9,040	7,181	10,617
	Portage Creek	03-Nov to 09-Nov	7,747	6,820	12,053	7,875	572
	Total [a]	-	**15,145**	**16,277**	**21,212**	**15,056**	**11,189**
South Thompson	Scotch Creek	26-Aug to 03-Sep	239	2,089	9,954	14,772	1
Early Summer Run	Seymour River	06-Sep to 12-Sep	29,831	84,315	128,253	40,687	0
	Total [a]	-	**30,870**	**89,540**	**147,324**	**71,118**	**1**
South Thompson	Adams River, lower	07-Oct to 16-Oct	201,610	567,989	1,201,179	394,250	0
Late Run	Little River	07-Oct to 16-Oct	b	17,998	13,500	9,124	0
	Shuswap River	10-Oct to 18-Oct	7,335	11,130	16,259	12,485	0
	Total [a]	-	**211,365**	**617,325**	**1,255,791**	**427,174**	**0**
North Thompson	Fennell Creek	24-Aug to 02-Sep	4,977	16,633	20,466	11,245	14
	Raft River	01-Sep to 09-Sep	2,780	1,436	464	1,040	6
	Total [a]	-	**8,507**	**18,069**	**21,311**	**12,406**	**20**
Chilcotin	Chilko Channel	18-Sep to 24-Sep	0	0	20,495	8,316	170
	Chilko River and Lake	18-Sep to 24-Sep	382,833	421,015	1,017,242	536,048	3,221
	Taseko Lake	Late Sep	1,630	3,571	n/r	1,840	0
	Total	-	**384,463**	**424,586**	**1,037,737**	**546,204**	**3,391**
Quesnel	Horsefly System	07-Sep to 11-Sep	2,036	16,795	38,569	180,872	1
	Mitchell System	mid Sep	119	3,751	7,690	35,190	0
	Total [a]	-	**2,155**	**20,546**	**46,259**	**216,062**	**1**
Stuart	Takla System	02-Aug to 11-Aug	6,911	47,577	45,963	36,524	1
Early Run	Middle System	01-Aug to 09-Aug	14,710	82,070	63,711	59,421	5
	Trembleur System	28-Jul to 05-Aug	2,246	18,547	31,445	26,911	0
	Total	-	**23,867**	**148,194**	**141,119**	**122,856**	**6**
Stuart	Middle River	Late Sep	639	2,441	16,331	7,462	0
Summer Run	Tachie River	Late Sep	853	2,398	50,841	22,368	0
	Total [a]	-	**2,246**	**6,472**	**76,860**	**34,362**	**0**
Nechako	Nadina System	19-Sep to 23-Sep	28,213	38,515	61,074	23,998	8
	Stellako River	22-Sep to 27-Sep	121,692	211,085	94,884	122,676	104
	Total [a]	-	**151,478**	**250,600**	**157,088**	**146,674**	**112**
Upper Fraser	**Bowron System**	Early Sep	**6,451**	**11,071**	**4,919**	**34,417**	**14**
Total [a]	**Total**	**Adults**	**964,917**	**1,895,947**	**3,306,272**	**1,736,763**	
		Jacks	**10,984**	**18,796**	**35,191**	**18,473**	
		Total	**975,901**	**1,914,743**	**3,341,463**	**1,755,236**	

[a.] Includes smaller, miscellaneous populations; see Appendix 6.
[b.] Included in Adams River estimate.

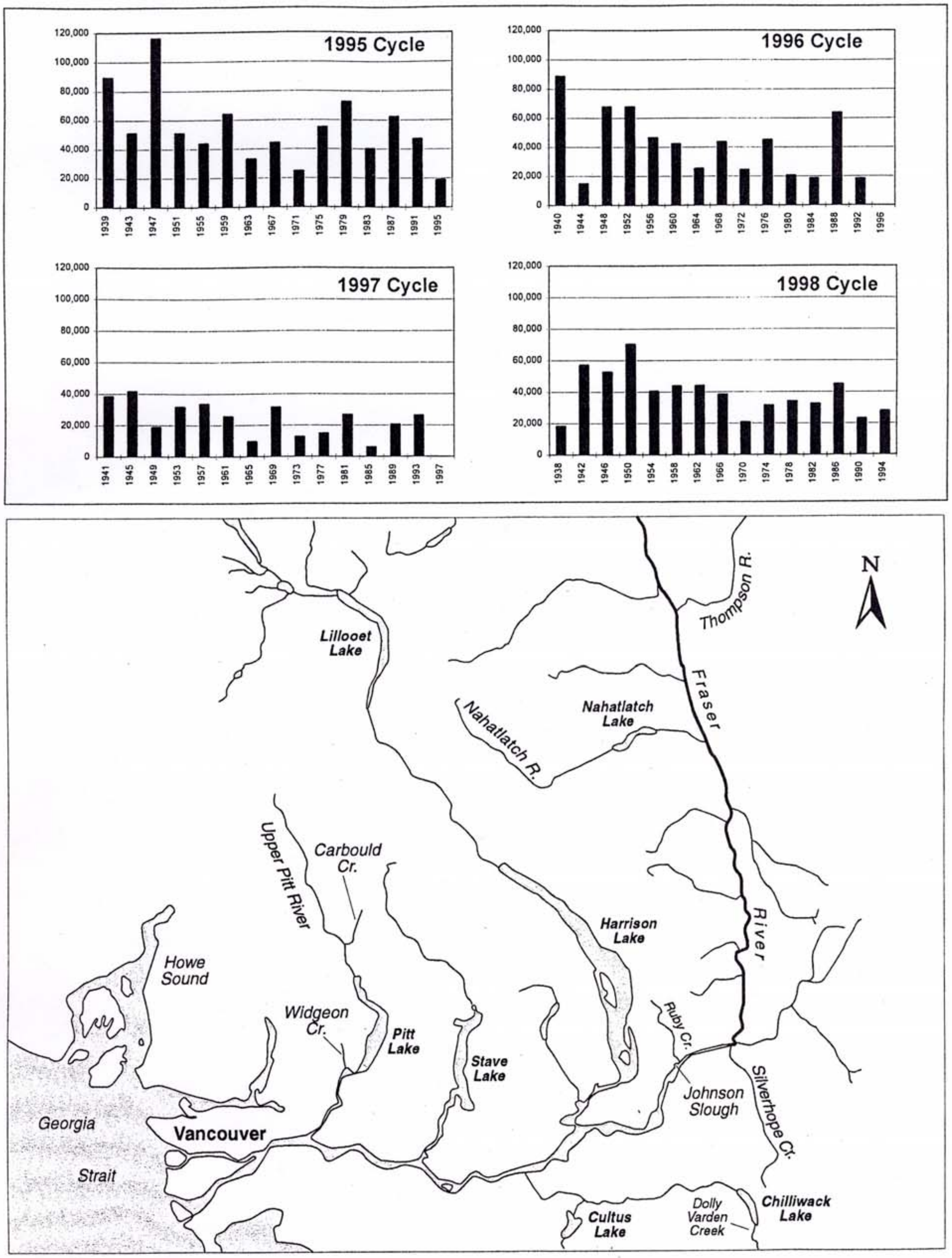

Fig. 5. Adult escapement by cycle and spawning distribution map for Lower Fraser sockeye salmon.

Harrison-Lillooet: The Harrison-Lillooet group consists of five late run populations that spawn in Harrison River and its tributaries, and in streams tributary to Harrison Lake, Lillooet River and Lillooet Lake (Fig. 6). The largest populations on this cycle spawn in the Birkenhead River, which was assessed by mark-recapture, and Weaver Creek, which was assessed by visual surveys in the lower creek and a fence in the upper creek and channel (Appendix 3). The other populations were surveyed visually. Sur-vey frequency varied from two in Samson Creek to five in Harrison River (Appendix 5). The latter, although intensively surveyed, likely results in a negative estimation bias because observations are confounded by the size and depth of the river and the large coincident spawning populations of chinook and chum salmon.

The 1995 Harrison-Lillooet group escapement of 91,234 adults and 3,654 jacks comprises 5% and 20%, respectively, of the Fraser River total (Table 10). The adult escapement is one-quarter that of the brood year (Fig. 6). This reflects the weak escapement of 39,800 to the Birkenhead River, a decline from 293,600 in 1991. The escapement of all other populations in this group is similar to the brood year. Average spawning success (83%; range 56%-99%) (Appendix 6) declined from the brood year (98%; range 97%-100%).

The accuracy of the Harrison-Lillooet estimates depends largely on the Birkenhead and Weaver populations that comprise 80% of the estimated total. Birkenhead males may be estimated with a small positive bias, while the Weaver Channel is a census. The use of visual surveys in the Harrison River likely introduces a negative bias in that estimate that may be large. Assuming random error in the remaining visual estimates, the identified biases are off-setting to some extent and likely result in a negative estimation bias for the group.

Seton-Anderson: The Seton-Anderson group consists of an early summer run and a late run population in Gates and Portage creeks, respectively (Fig. 7). The Gates escapement is estimated visually from seven surveys (Appendix 5); the spawning channel did not operate in 1995. The Portage escapement is estimated from three visual surveys.

The 1995 Seton-Anderson group escapement of 15,056 adults and 11,189 jacks compris-es 1% and 61%, respectively, of the Fraser River total (Table 10). The adult escapement declined by 29% from the brood year level (Fig. 7). Aver-age spawning success (95%; range 93%-98%) (Appendix 6) increased from the brood year (average 92%; range 82% to 100%), largely reflecting the closure of the spawning channel where survivals tend to be poor.

The Seton-Anderson group was assessed using visual techniques that are prone to random errors of up to ±30% among the individual estimates. The Portage estimate is a concern because the peak was observed on the first survey; consequently, the escapement is likely underestimated.

South Thompson (Early Summer Run): The early South Thompson group consists of 16 Early Summer Run populations that spawn in streams tributary to Shuswap Lake (Fig. 8). The largest populations on the 1995 subdominant cycle spawn in Scotch Creek and Seymour River. The Scotch Creek escapement is estimated at a fence (Appendix 3), the Seymour River escapement is estimated by a mark-recapture study, and the remaining populations are estimated from visual surveys, with 1-9 surveys each (Appendix 5).

The 1995 early summer South Thompson group escapement of 71,118 adults and 1 jack comprises 4% and 0%, respectively, of the Fraser River total (Table 10). The adult escapement is one-half that of the brood year (Fig. 8). Declines are consistent among all of the major populations. Average spawning success (99%; range 98%-100%) (Appendix 6) is similar to the brood year (99%; range 99%-100%).

The accuracy of the 1995 South Thompson early summer run escapement estimates depends largely on the Scotch and Seymour populations that comprise 78% of the total. The Scotch population was enumerated at a fence and is likely estimated with only a small negative bias. The Seymour population was estimated by a mark-recapture study; males may be estimated with a small negative bias. Assuming random error in the remaining visual estimates, the identified biases are off-setting to some extent and likely result in a small negative estimation bias for the group.

South Thompson (Late Run): The late South Thompson group consists of 31 late run

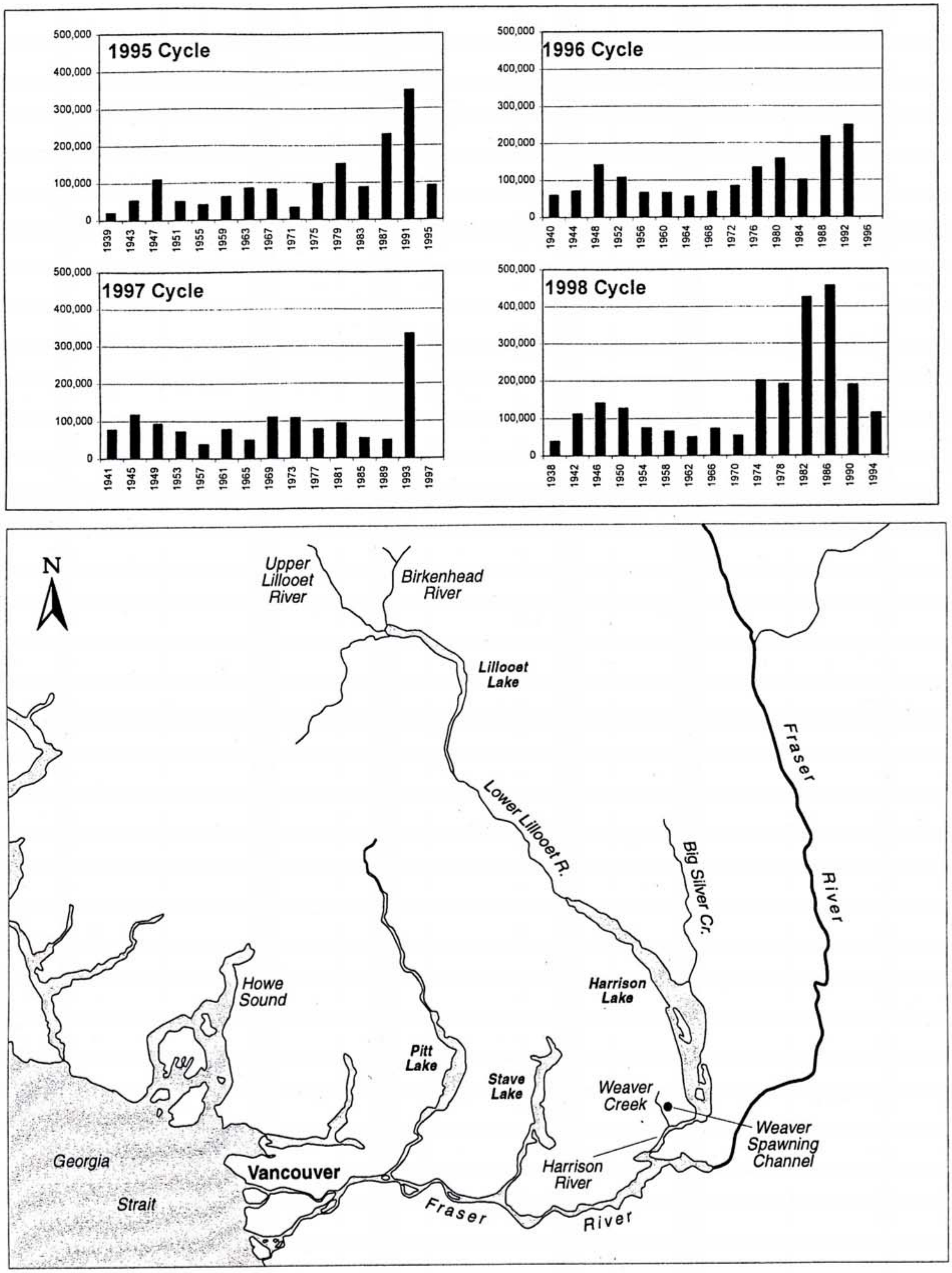

Fig. 6. Adult escapement by cycle and spawning distribution map for Harrison-Lillooet sockeye salmon.

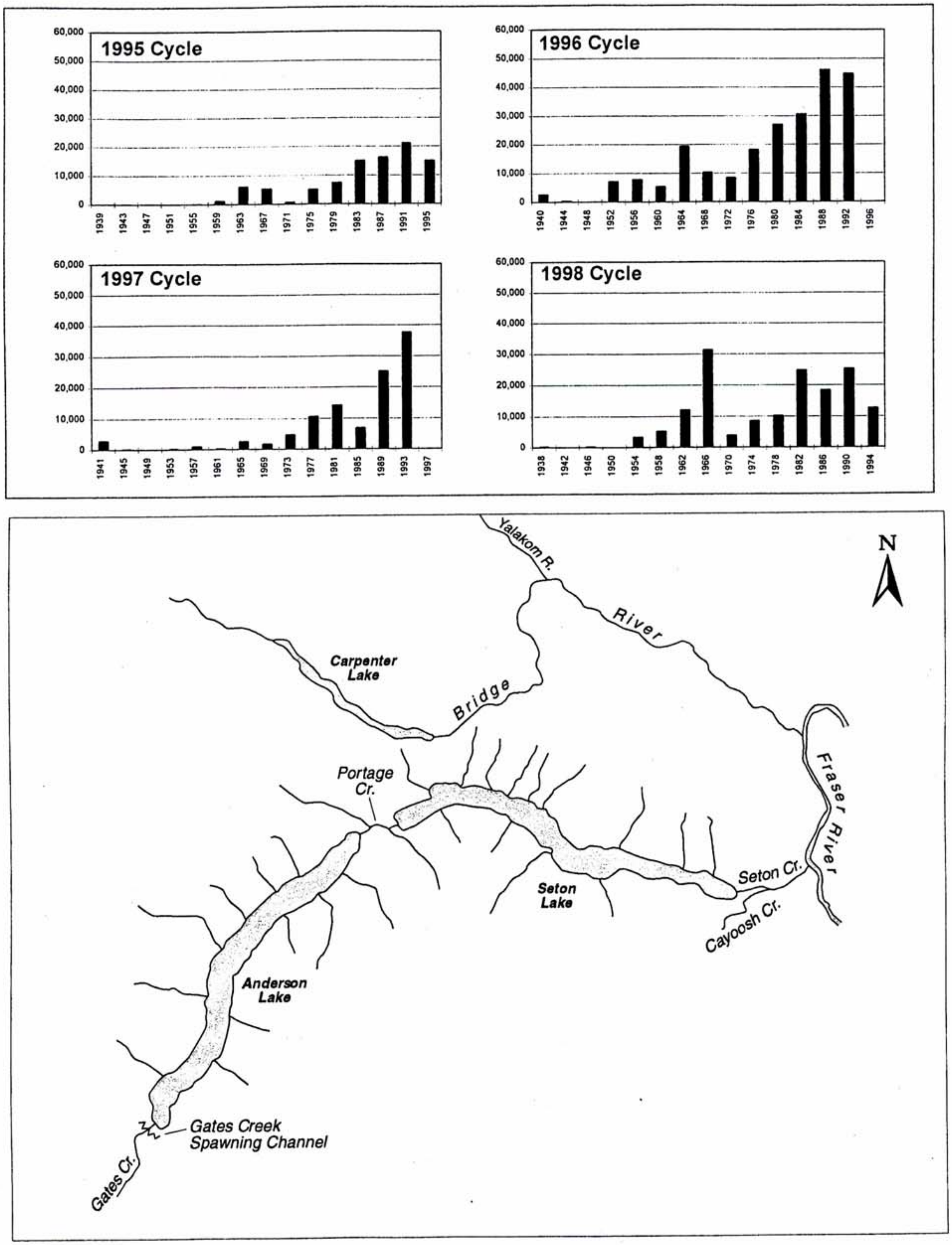

Fig. 7. Adult escapement by cycle and spawning distribution map for Seton-Anderson sockeye salmon.

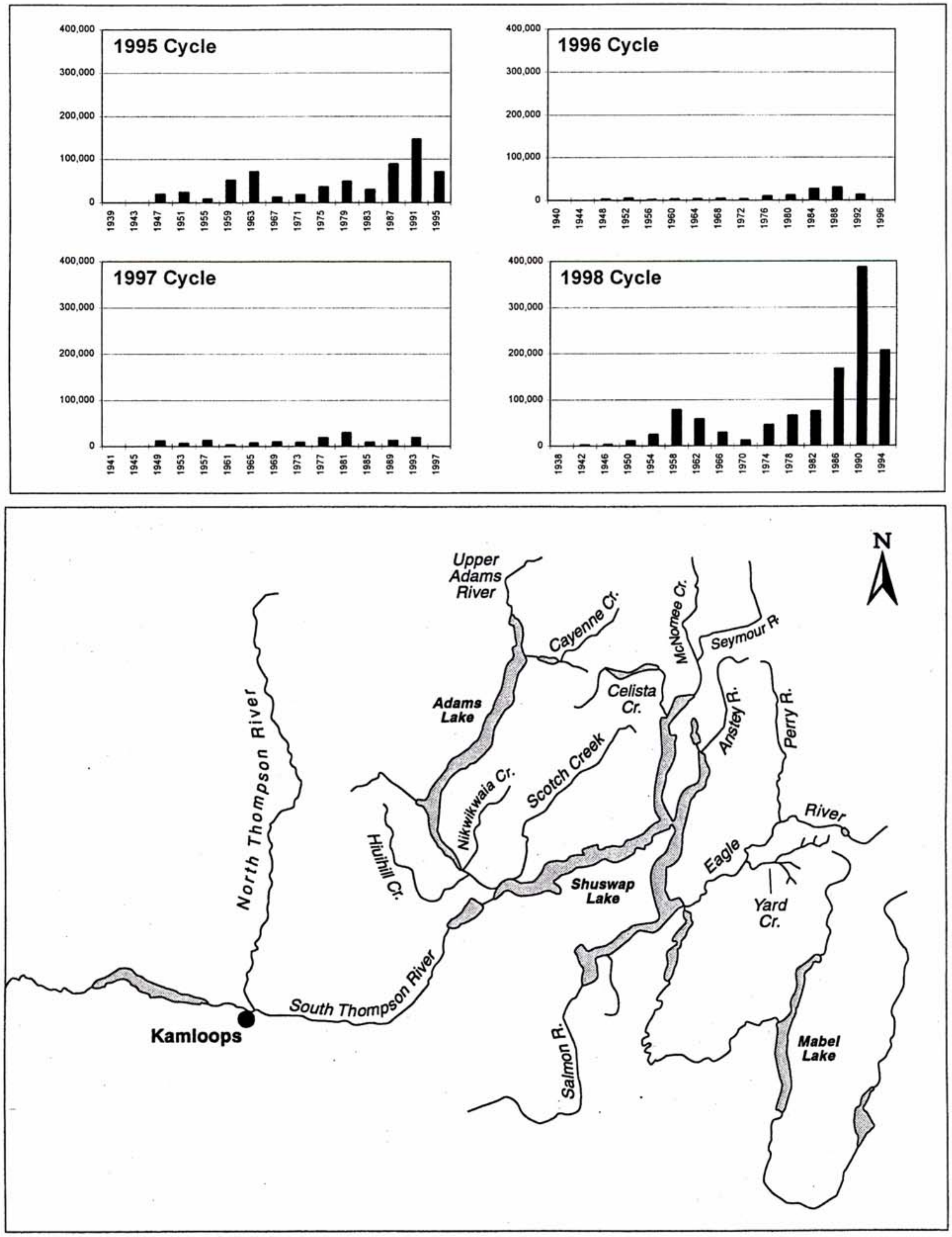

Fig. 8. Adult escapement by cycle and spawning distribution map for South Thompson Early Summer Run sockeye salmon.

populations that spawn primarily in the lower Adams River complex (Adams, Little and South Thompson rivers and Scotch Creek), Adams and Shuswap lake foreshores and tributaries, and the Shuswap River system (Fig. 9). The largest populations on the 1995 sub-dominant cycle are those that comprise the Adams complex; their escapement is estimated from a mark-recapture study. The remaining populations are estimated from visual surveys, with 1-21 surveys each (Ap-pendix 5).

The 1995 late South Thompson group escapement of 427,174 adults (no jacks were observed) comprises 25% of the Fraser River total (Table 10). The adult escapement is one-third of the brood year, but is near the average on this cycle (Fig. 9). Relative to the brood year, escapement to the lower Adams River declined from 1,201,200 to 394,300, while escapement to the Shuswap River system declined from 16,300 to 12,500. Average spawning success (94%; range 60%-100%) (Appendix 6) declined from the brood year (99%; range 83%-100%).

The accuracy of the 1995 South Thompson late run escapement estimates depends entirely on the Adams estimate that comprises 92% of the total. No unusual sampling biases were detected in the Adams study; consequently, the population estimate may be relatively unbiased.

North Thompson: The North Thompson group consists of five early summer run populations that spawn in Fennell, Barriere, Raft and North Thompson systems (Fig. 10). The largest population on the 1995 cycle is in Fennell Creek. Escapements are estimated from a fence install-ed in Fennell Creek (Appendix 3) and from visual surveys in the remaining systems, with 1-5 sur-veys each (Appendix 5).

The 1995 North Thompson group escapement of 12,406 adults and 20 jacks comprises 1% and <1% of the Fraser River total (Table 10). The adult escapement declined by 42% from the 1991 brood year (Fig. 10), largely a result of the decline in Fennell Creek from 20,500 to 11,200. Average spawning success (97%; range 97%-98%) (Appendix 6) was similar to the brood year (97%; range 88%-100%).

The accuracy of the 1995 North Thompson escapement estimate depends entirely on the Fennell estimate that comprises 91% of the estimated total escapement. The fence operated without interruption; consequently, the population estimate is relatively unbiased.

Chilcotin: The Chilcotin group consists of a summer run population that spawns in the Chilko River, Chilko channel, and the north end of Chil-ko Lake, and two Early Summer Run populations that spawn in Taseko Lake and the south end of Chilko Lake (Fig. 11). Escapements of the Chil-ko River and Lake populations are estimated in aggregate by a mark-recapture study; conse-quently, it is not possible to provide separate es-timates for the south lake and north lake and river populations or for the early summer and summer runs in aggregate. The Taseko Lake escapement is estimated from visual surveys; the remoteness of the area, the difficult viewing conditions (glacial runoff), and the small expect-ed escapement limited the assessment of this population to a single survey (Appendix 5).

The 1995 Chilcotin group escapement of 546,204 adults and 3,391 jacks comprises 31% and 18%, respectively, of the Fraser River total (Table 10). The adult escapement is about one-half of the 1991 brood year, but remains the third largest on this cycle since 1939 (Fig. 10). Aver-age spawning success (93%; range 80%-100%) (Appendix 6) declined from the brood year (97%; range 82%-97%).

Over 98% of the Chilcotin group escapement was estimated from the Chilko mark-recap-ture study. The evaluation of sampling biases in-dicates that the population may have been esti-mated with a small negative bias.

Quesnel: The Quesnel group consists of six summer run populations that spawn the Horsefly and Mitchell River systems (Fig. 12). Additional populations likely spawn in smaller streams tributary to Quesnel Lake and along the Quesnel Lake foreshore; however, these areas have nev-er been surveyed on this cycle. The largest pop-ulations on the 1995 off-cycle spawn in Horsefly and Mitchell rivers. The Horsefly escapement is estimated from a mark-recapture study, and the remaining populations are estimated from up to 2 visual surveys (Appendix 5).

The 1995 Quesnel group escapement of 216,062 adults and 1 jack comprises 12% and <1% of the Fraser River total (Table 10). The adult escapement is almost five times larger than the record brood year escapement of

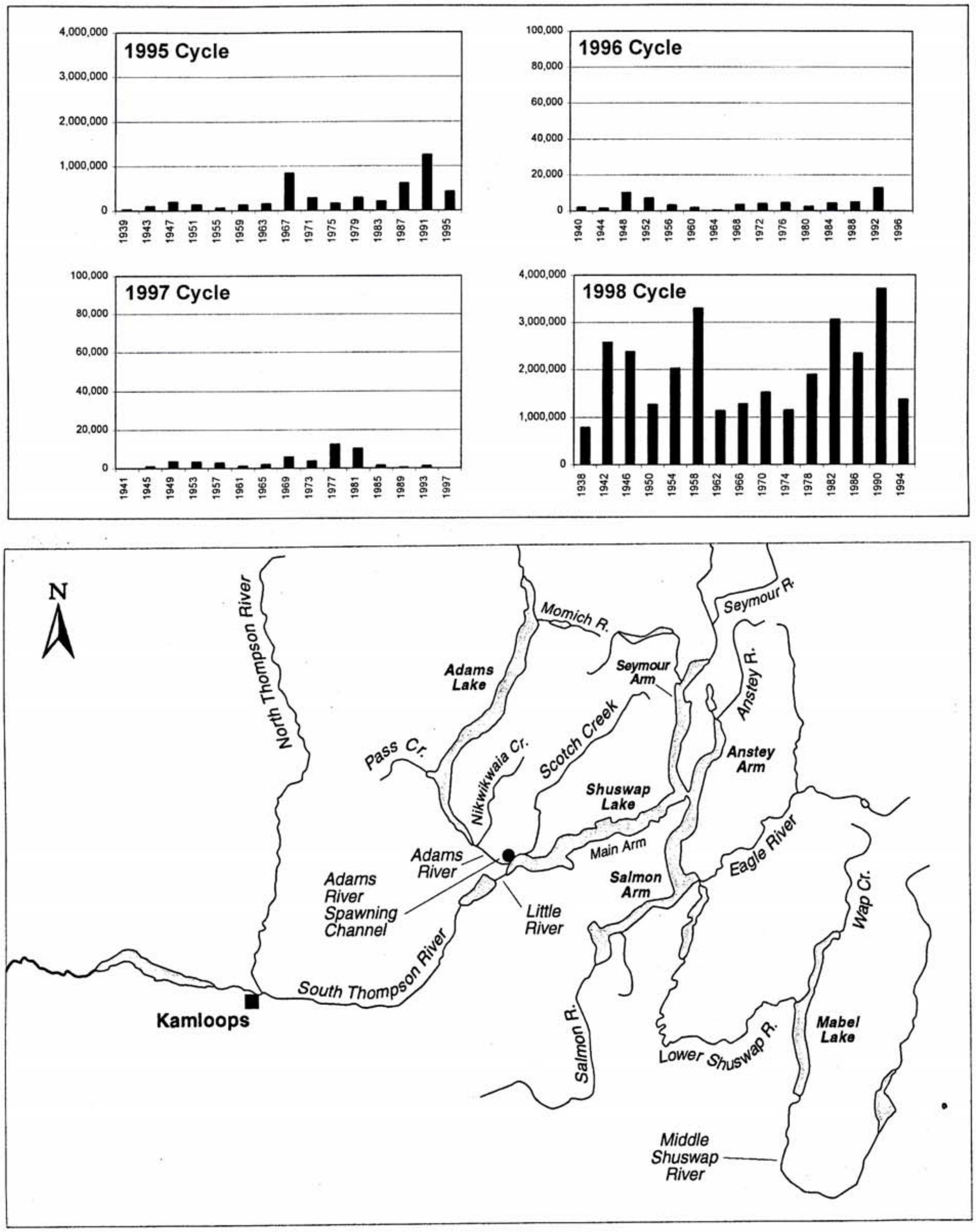

Fig. 9. Adult escapement by cycle and spawning distribution map for South Thompson Late Run sockeye salmon.

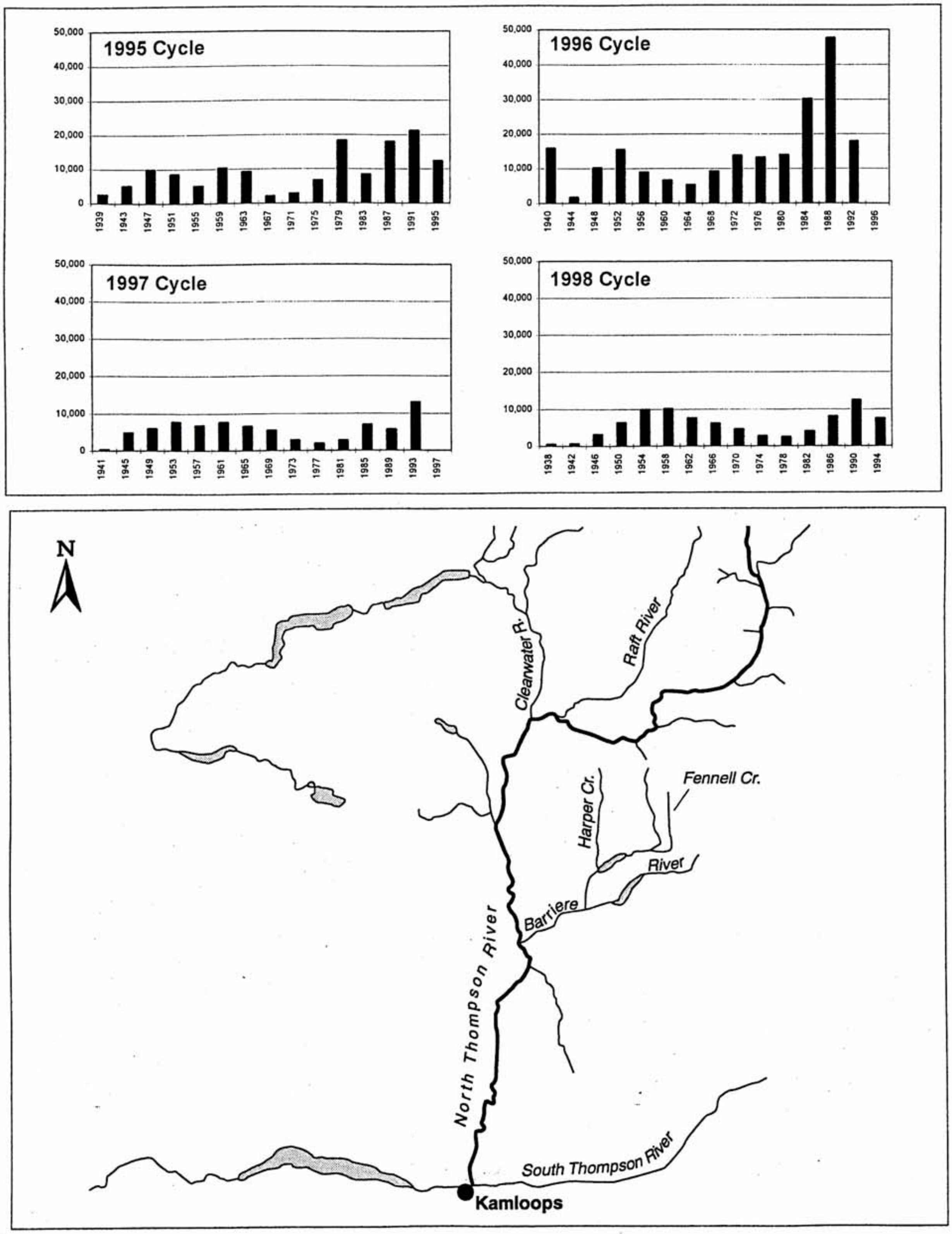

Fig. 10. Adult escapement by cycle and spawning distribution map for North Thompson sockeye salmon.

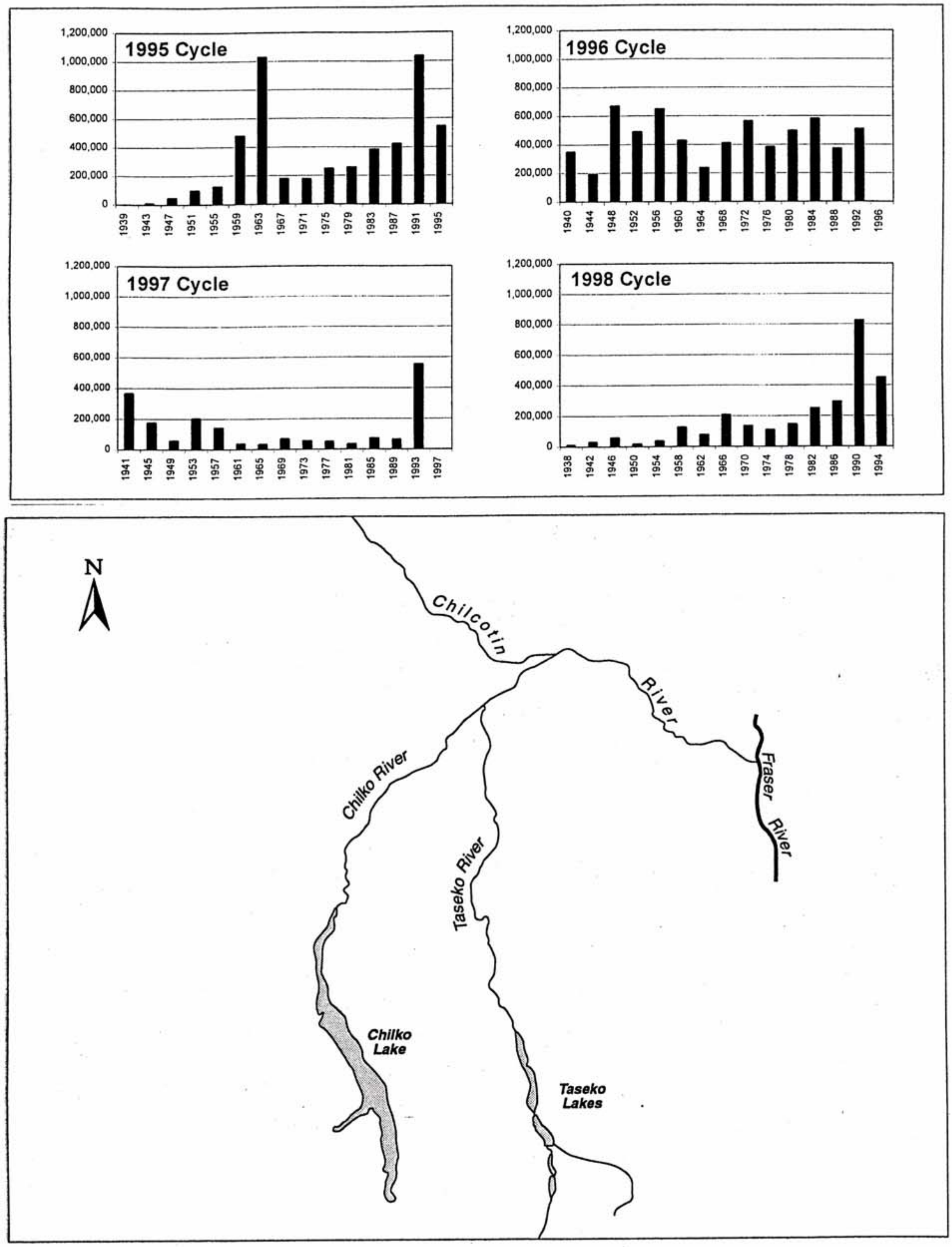

Fig. 11. Sockeye adult escapement by cycle and spawning distribution map for Chilcotin stocks.

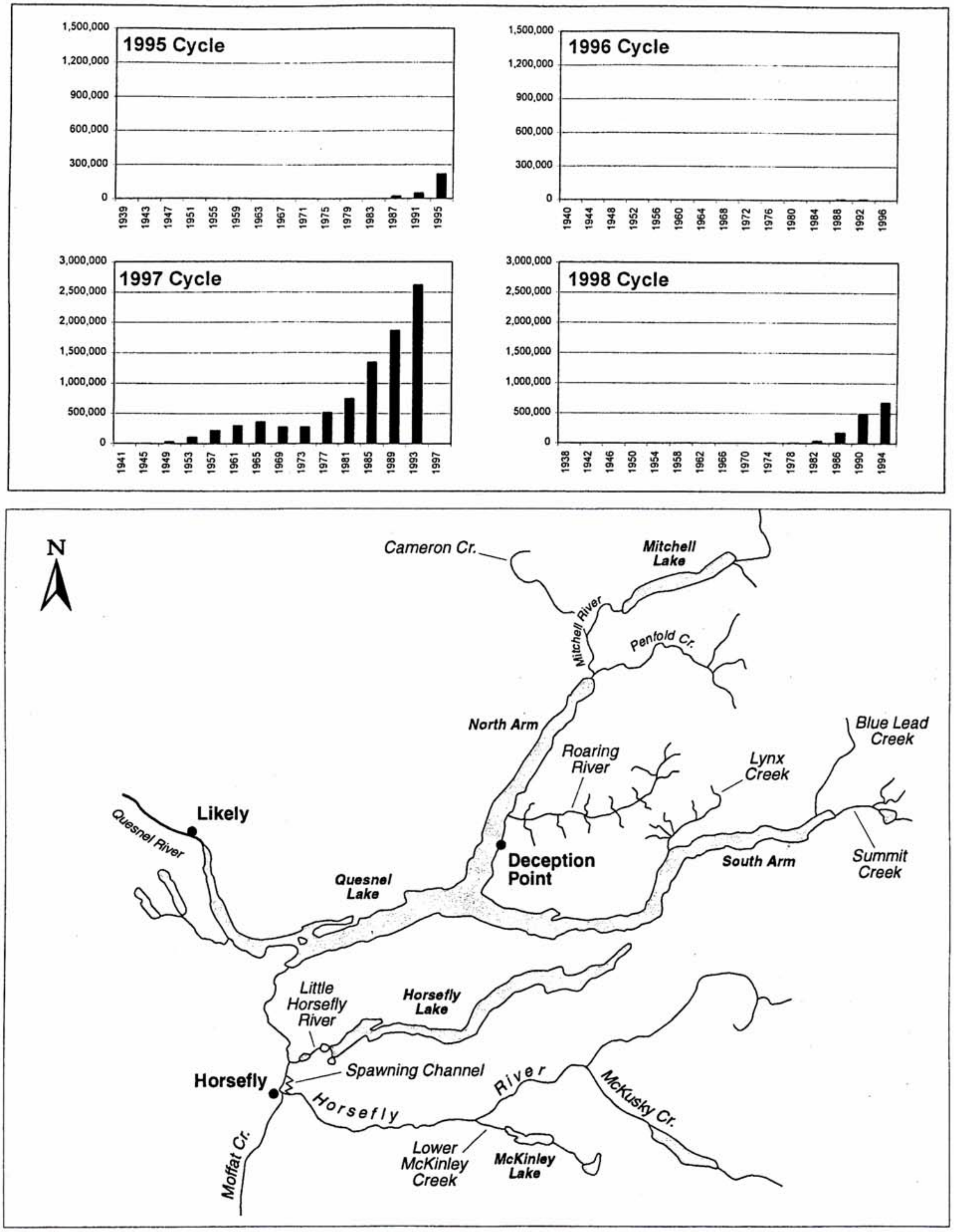

Fig. 12. Sockeye adult escapement by cycle and spawning distribution map for Quesnel stocks.

46,300. This continues the strong rebuilding trend on the first off-cycle (Fig. 12). Escapements are strong in both the Mitchell and Horsefly rivers, where they quadruple the brood year levels. Average spawning success (97%; range 97%-100%) (Appendix 6) is similar to the brood year (98%; range 95%-100%).

The accuracy of the Quesnel escapement is a concern. The late implementation of the Horsefly mark-recapture study resulted in a num-ber of study design deficiencies that likely intro-duced estimation biases of unknown direction and magnitude. Similarly, there were deficiencies in the visual surveys that would introduce a neg-ative estimation bias: the Mitchell population was too large for reliable visual assessment; and the Quesnel Lake populations were not assessed. Overall, the total escapement to this group is likely estimated with a negative bias that may be substantial in magnitude.

Stuart (Early Run): The Stuart early run group consists of 38 populations that spawn in streams tributary to the Middle River and Trembleur and Takla lakes (Fig. 13). The largest populations on the sub-dominant cycle spawn in streams tributary to south Takla Lake (Gluske Creek) and Middle River (Forfar, Kynoch and Rossette creeks). Escapements are estimated from visual observations, with 1-14 surveys per population (Appendix 5). Visual data are calibrated from comparisons of visual observations and fence counts in Forfar, Gluske and Kynoch creeks (Appendix 3).

The 1995 Stuart early run escapement of 122,856 adults and 6 jacks comprises 7% and <1%, respectively, of the Fraser River total (Table 10). The adult escapement declined from the two previous brood year escapements, but was the third largest on this cycle since 1939 (Fig. 13). Average spawning success (88%; range 71%-100%) (Appendix 6) declined from the brood year (93%; range 95%-100%).

The Stuart escapement was assessed using visual surveys that were calibrated from inseason observations in 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. The assessment of the Driftwood system and Fleming Creek using a single helicopter flight may introduce a negative bias if the flight did not coincide with the spawning peak.

Stuart (Summer Run): The Stuart summer run consists of seven summer run populations that spawn in Tachie and Middle rivers, and in several small streams tributary to Takla and Stuart lakes (Fig. 14). The largest populations on the 1995 off-cycle spawn in Tachie and Middle rivers. All populations are estimated solely from a single aerial survey (Appendix 5).

The 1995 late Stuart escapement of 34,362 adults (no jacks were observed) comprises 2% of the Fraser River total (Table 10). The adult escapement is less than one-half the record brood year escapement of 76,900, but is the third largest on this cycle since 1939 (Fig. 14). Spawning success is unknown because ground surveys were not conducted (Appendix 4).

The assessment of this group using a single visual survey likely results in a negative estimation bias of substantial but unknown magnitude.

Nechako: The Nechako group consists of a relatively small early summer run (Nadina) and a large summer run (Stellako) population (Fig. 15). The Stellako escapement is estimated from an enumeration fence (Appendix 3), the Nadina Channel escapement is a census (Appendix 2), and the Nadina River escapement is estimated from visual surveys (Appendix 5).

The 1995 Nechako group escapement of 146,674 adults and 112 jacks comprises 8% and 1%, respectively, of the Fraser River total (Table 10). While the total adult escapement is similar to the 1991 brood year (Fig. 15), the Stellako increased from 94,900 to 122,700 and the Nadina declined from 61,100 to 24,000. Average spawning success (71%; range 69%-72%) (Appendix 6) declined from the brood year (99% for both populations).

Over 98% of the escapement of this group was enumerated at a fence and in the spawning channel; consequently, its escapement is likely estimated with little bias.

Upper Fraser: The Upper Fraser group con-sists of the Bowron River and tributaries (Fig. 16). Although sockeye previously have been ob-served spawning in the upper Fraser River and Swift Creek (L. W. Kalnin, DFO technician, pers. comm.), there is no evidence of sustained pro-duction from those areas. In

1995, the Bowron River escapement is estimated from an enumer-

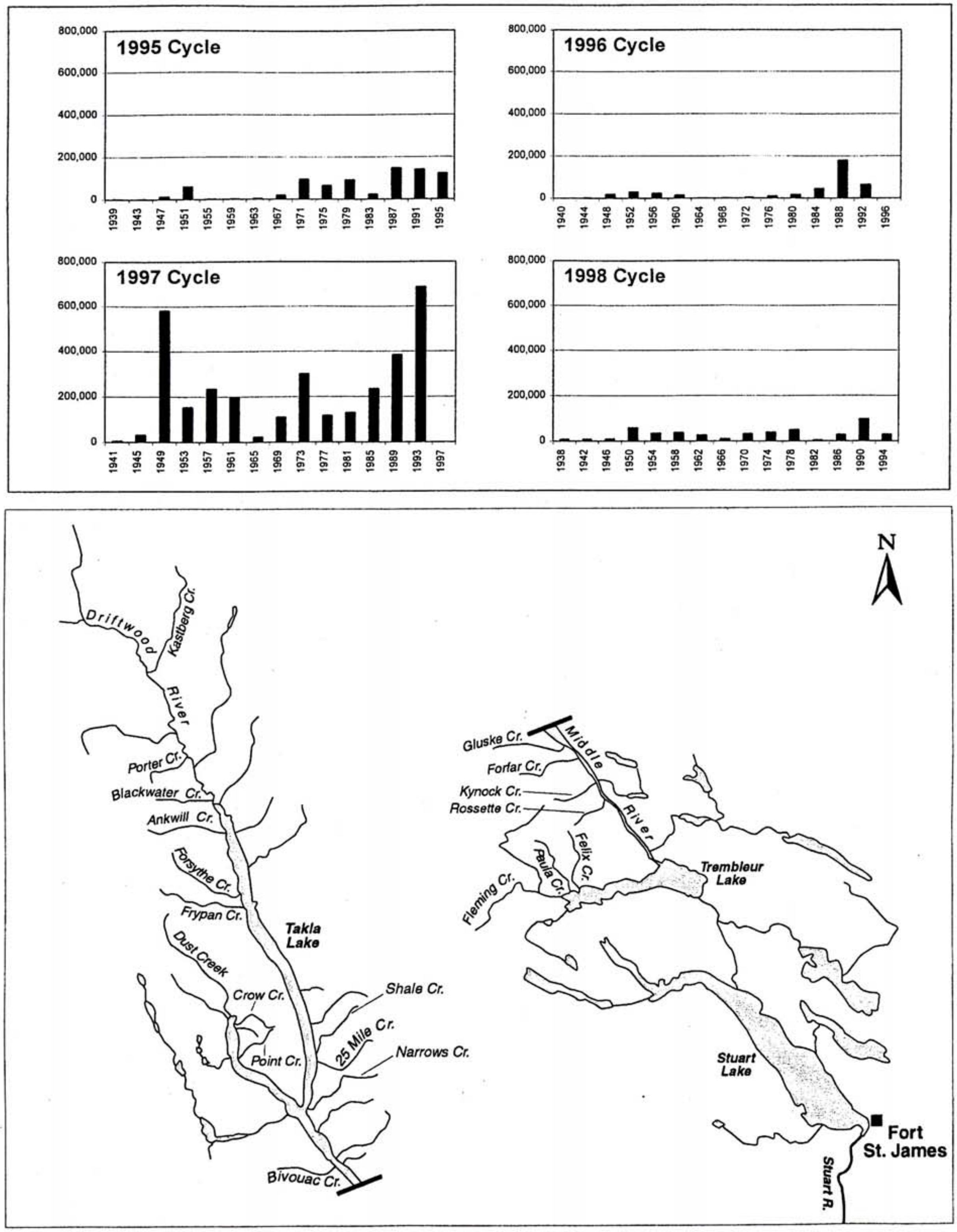

Fig. 13. Sockeye adult escapement by cycle and spawning distribution map for Stuart Early Run sockeye stocks.

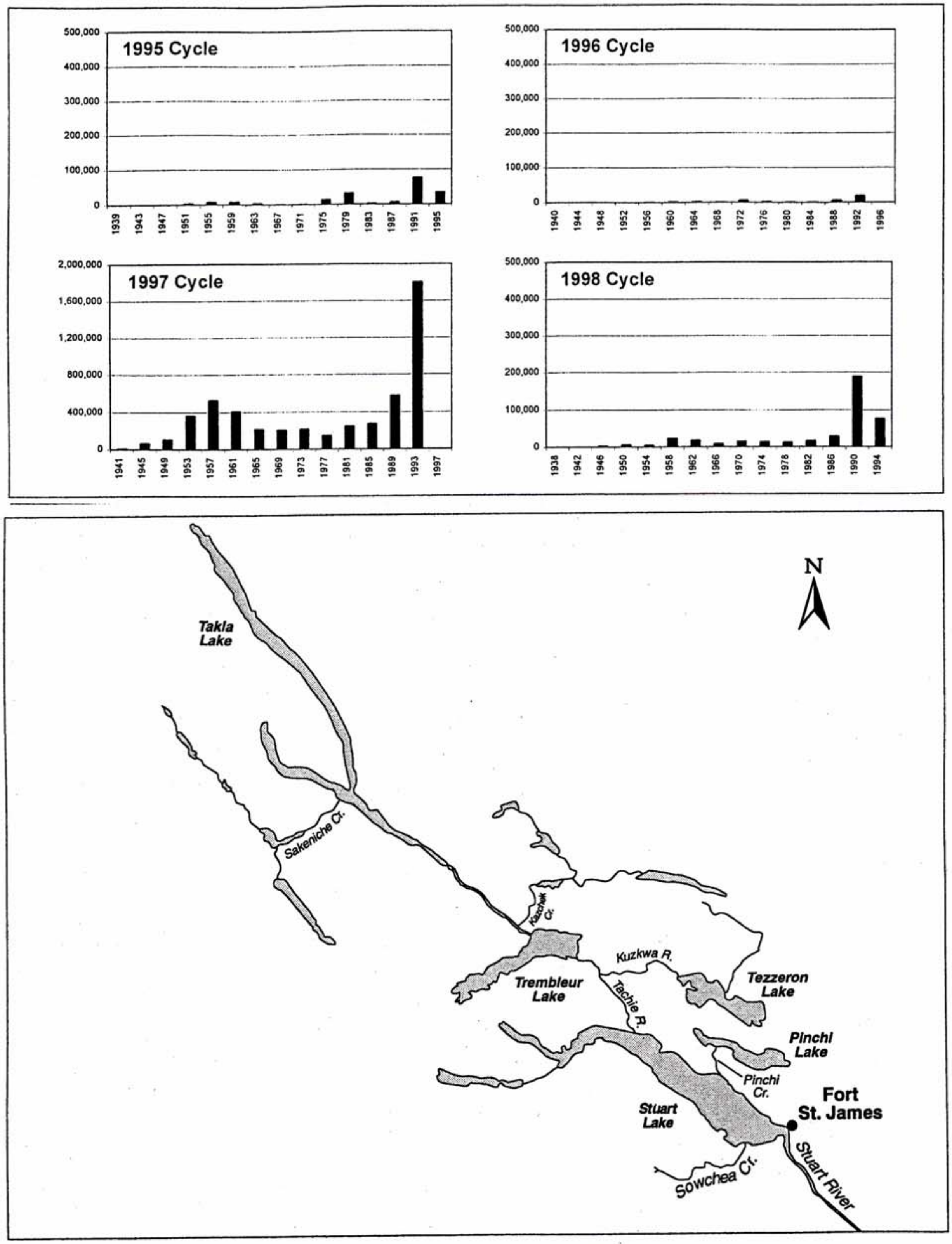

Fig. 14. Sockeye adult escapement by cycle and spawning distribution map for Stuart Summer Run sockeye stocks.

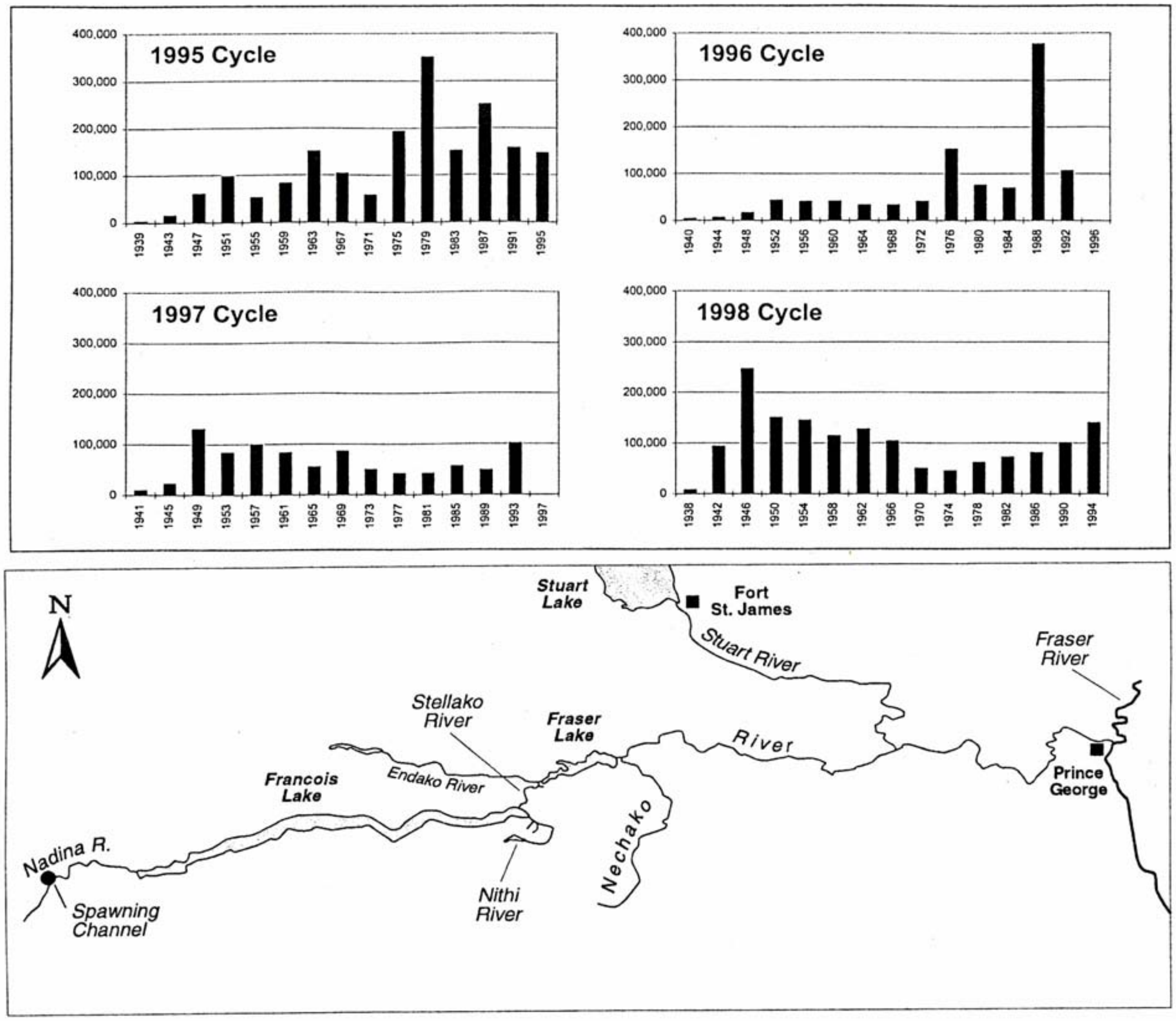

Fig. 15. Adult escapement by cycle and spawning distribution map for Nechako sockeye salmon

ation fence (Appendix 3) installed at the lake out-let in response to a FRSPRB recommendation (Anon. 1995) to evaluate expansion factors.

The 1995 Upper Fraser group escapement of 34,417 adults and 14 jacks comprises 2% and <1%, respectively, of the Fraser River total (Table 10). The adult escapement increased by almost seven-fold from the 1991 brood year escapement of 4,900 (Fig. 16). Average spawning success (80%) is well below the brood year level (100%).

The Bowron River population was assessed using an enumeration fence for the first time since 1986. This permitted the reevaluation of the expansion factor used to calibrate visual surveys of this system. The factor calculated for 1995, 2.9, is considerably higher than the standard of 1.8 that is typically used in this system. Consequently, previous surveys may underestimate the true escapement. The underestimation is exacerbated in recent years because the more extensive surveys in 1995 report sockeye well above what was previously thought to be the up-per limit of spawning.

Run Timing Group

Early Run: The Early Run consists of 38 populations that spawn in the Stuart River system (Fig. 13). The largest populations on the subdominant cycle typically spawn in streams tributary to south Takla Lake (Gluske Creek) and

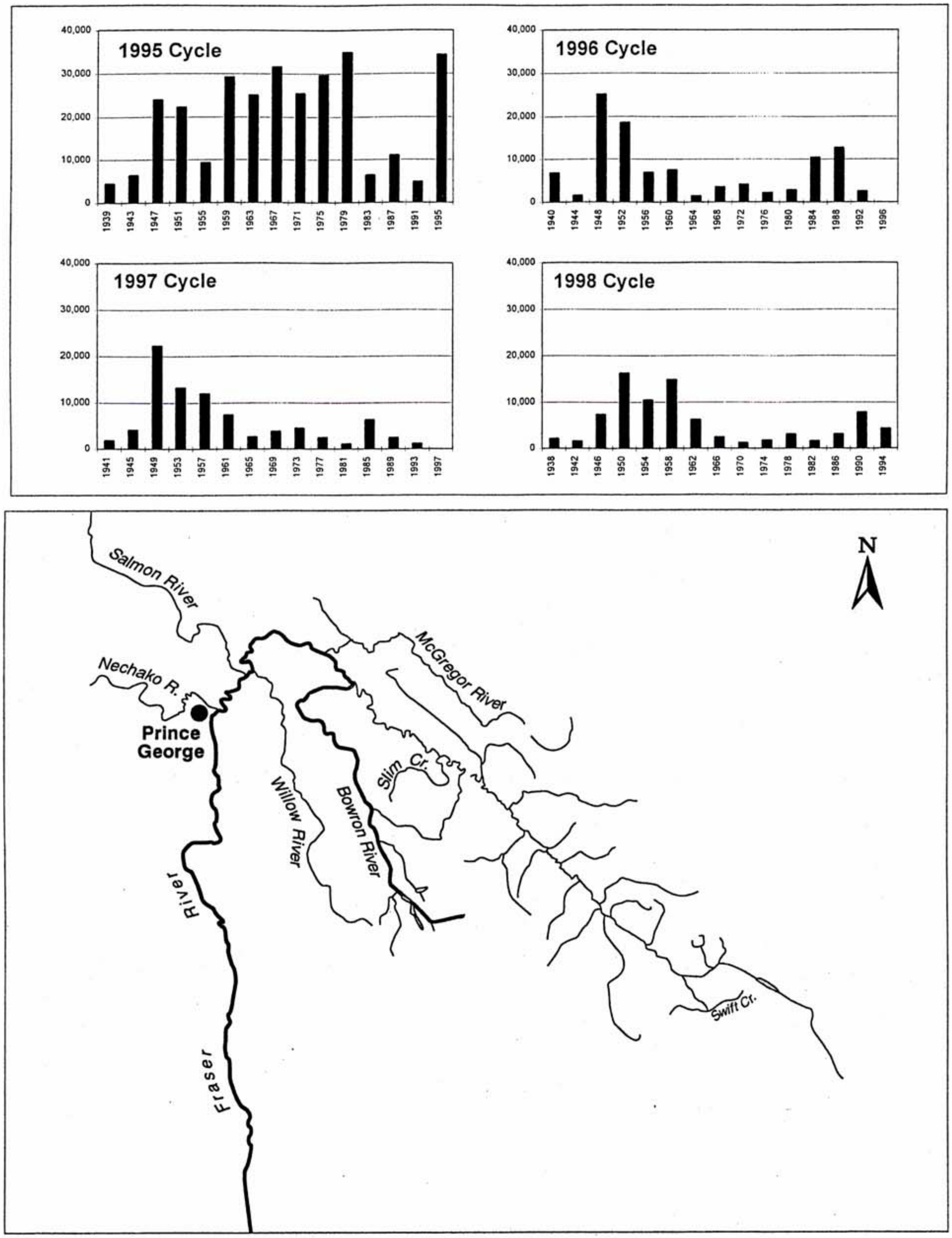

Fig. 16. Adult escapement by cycle and spawning distribution map for Upper Fraser sockeye salmon.

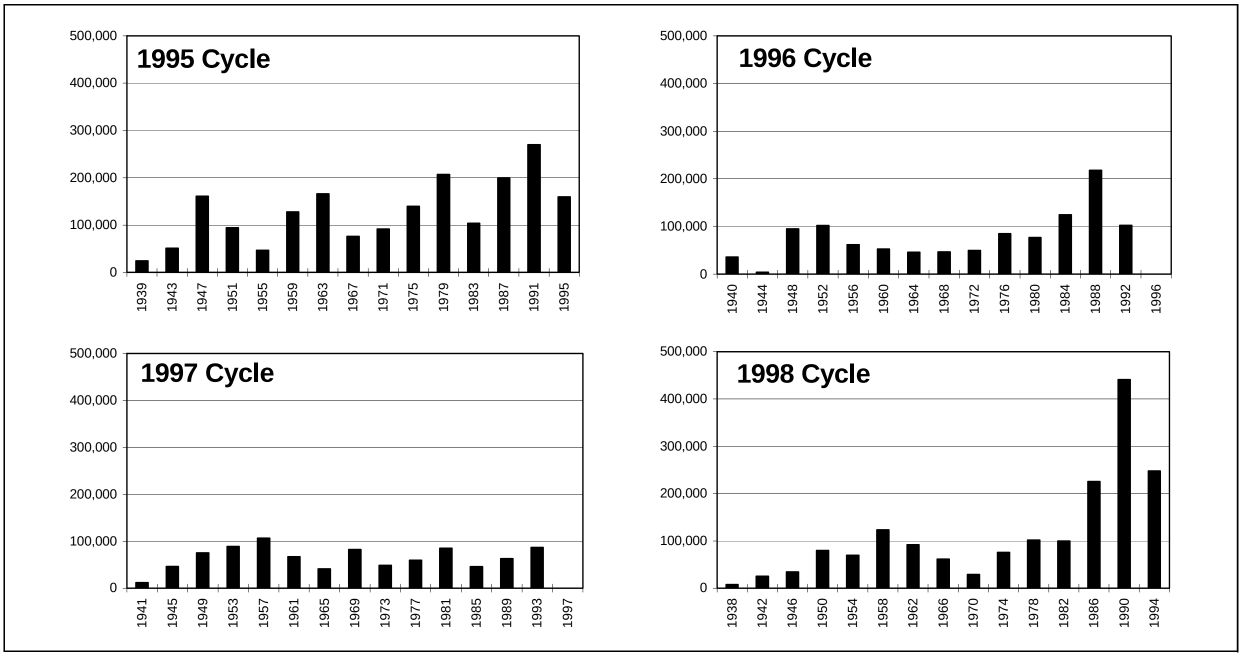

Fig. 17. Adult escapement by cycle for Early Summer Run Fraser sockeye salmon.

Middle River (Forfar, Kynoch and Rossette creeks). Escapements are estimated from fences in Forfar, Gluske and Kynoch creeks (Appendix 3) and visual surveys conducted in all streams every 1-14 days (Appendix 5). Escapement is estimated from the relationship between the peak live and cumulative dead counts to the date of the peak count and the known escapement in the fenced streams. The 1995 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 29 populations that spawn in most sub-basins of the Fraser system. They migrate into the river from mid July to mid August and spawn from late August to mid September. The largest populations on this cycle are Gates in the Seton-Anderson, Seymour and Scotch in the South Thompson, Fennell in the North Thompson, Nadina in the Nechako, and Bowron in the Upper Fraser. The escapements of all of the largest populations except Gates are estimated using either enumeration fences or mark-recapture studies; the escapements of Gates and other smaller populations are estimated from visual surveys.

The 1995 Early Summer Run escapement of 159,725 adults and 10,712 jacks comprises 9% and 58%, respectively, of the Fraser River total (Appendix 6). Relative to the 1991 brood year, the adult escapement declined by 41% and is near the long-term average on this cycle (Fig. 17). Adult escapements declined in all areas except the Upper Fraser, where escapements increased from 4,900 to 34,400; however, this increase may reflect the change in assessment technique rather than a real increase in escapement. Spawning success averages 90% (equal to the long term average), ranging from 69% in the Nadina system to up to 100% among several other populations (Appendix 6).

The escapement of the Early Summer Run was intensively assessed in 1995, with a mark-recapture study on Seymour River (24% of the estimated escapement), enumeration fences on Scotch and Fennell creeks and Bowron River (35%), and channel counts at Nadina (13%). Assuming random error in most of the remaining visual estimates, the overall accuracy of the Early Summer Run group depends on the Seymour mark-recapture study and the upper Pitt visual survey. The evaluation of sampling biases suggests there is a potential for a negative bias in the Seymour male estimate. Similarly, there is likely a substantial negative bias in the upper Pitt estimate resulting from the use of visual surveys in a glacial system. Consequently, there is likely a negative bias in the total escapement estimate for this group.

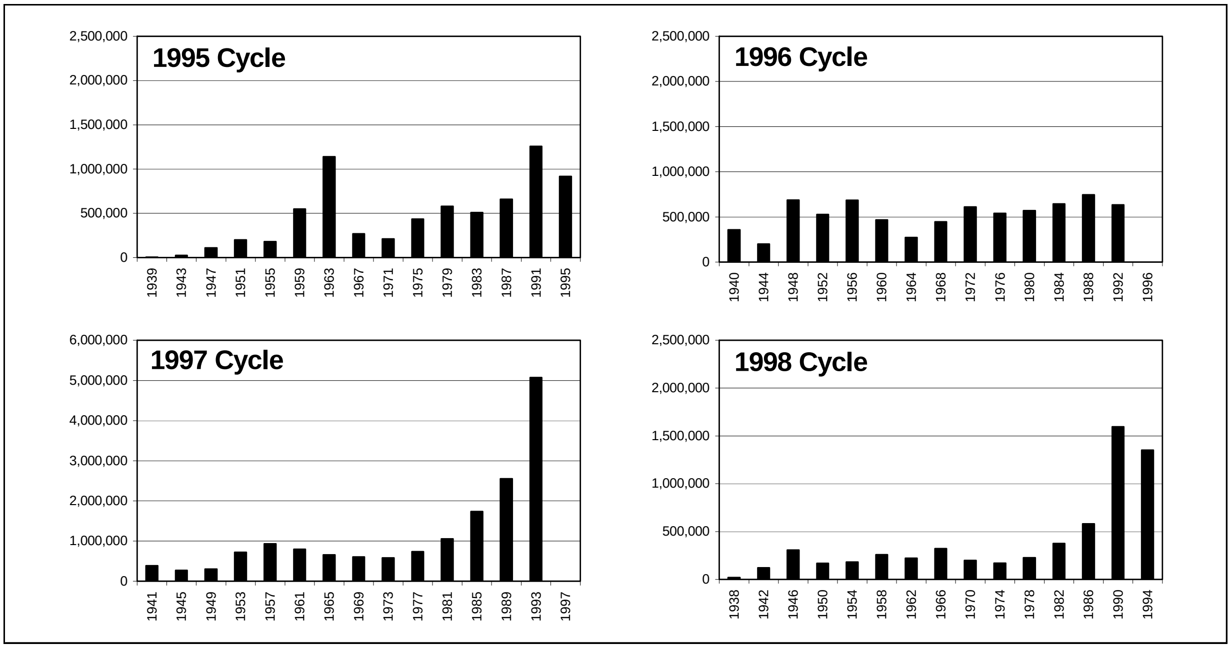

Fig. 18. Adult escapement by cycle for Summer Run Fraser River sockeye salmon.

Summer Run: The Summer Run consists of 15 populations that spawn in the Chilcotin, Ques-nel, Nechako and Stuart systems (Fig. 1). The escapement of the major populations is esti-mated using either mark-recapture studies (Chil-ko and Horsefly rivers) or enumeration fences (Stellako River). The escapements of the small-er populations, such as Mitchell, Tachie, Middle and others, are estimated from visual surveys.

The 1995 Summer Run escapement of 917,464 adults and 3,496 jacks comprises 53% and 19%, respectively, of the Fraser River total (Appendix 6). Relative to the 1991 brood year, adult escapements declined by 27% from the brood year escapement of 1,256,770 (Fig. 18); however, it is the third largest escapement report-ed on this cycle since 1939. Adult escapements increased from 46,300 to 216,100 in the Quesnel system and from 94,900 to 122,700 in the Stellako. Elsewhere, escapements declined, from 1,017,200 to 536,100 in the Chilko, and from 76,900 to 34,400 in the Stuart. Spawning success for Summer Run sockeye averages 91%, ranging from 72% in the Stellako River to up to 100% among several other populations (Appendix 6). This was slightly above the long term cycle aver-age of 87%.

The escapement of Summer Run sockeye was intensively assessed in 1995, with mark-re-capture studies on the Chilko and Horsefly rivers (76% of the estimated escapement), an enumer-ation fence on Stellako River (13%), and channel counts at Horsefly and Chilko (3%). For several reasons, there is likely a negative bias in the escapement estimate for this group. An evalu-ation of sampling biases suggests there is a potential for a negative bias in the Chilko female estimate. There were also deficiencies in the visual estimates that likely result in a negative bias: the large escapement in the Mitchell River was inappropriately assessed using visual tech-niques; the Quesnel Lake spawning areas were not assessed; and the escapement of the Stuart populations was estimated from a single survey. Overall, the summer run is likely estimated with a negative bias of substantial but unknown mag-nitude.

Late Run: The Late Run consists of 38 populations that spawn in the Lower Fraser, Harri-son-Lillooet, Seton-Anderson and South Thomp-son areas. The largest populations on the 1995 cycle are the Birkenhead River and Weaver Creek in the Harrison-Lillooet group, Portage Creek in the Seton-Anderson group, and lower Adams, Lit-tle and Shuswap rivers in the South Thompson group. The escapements to

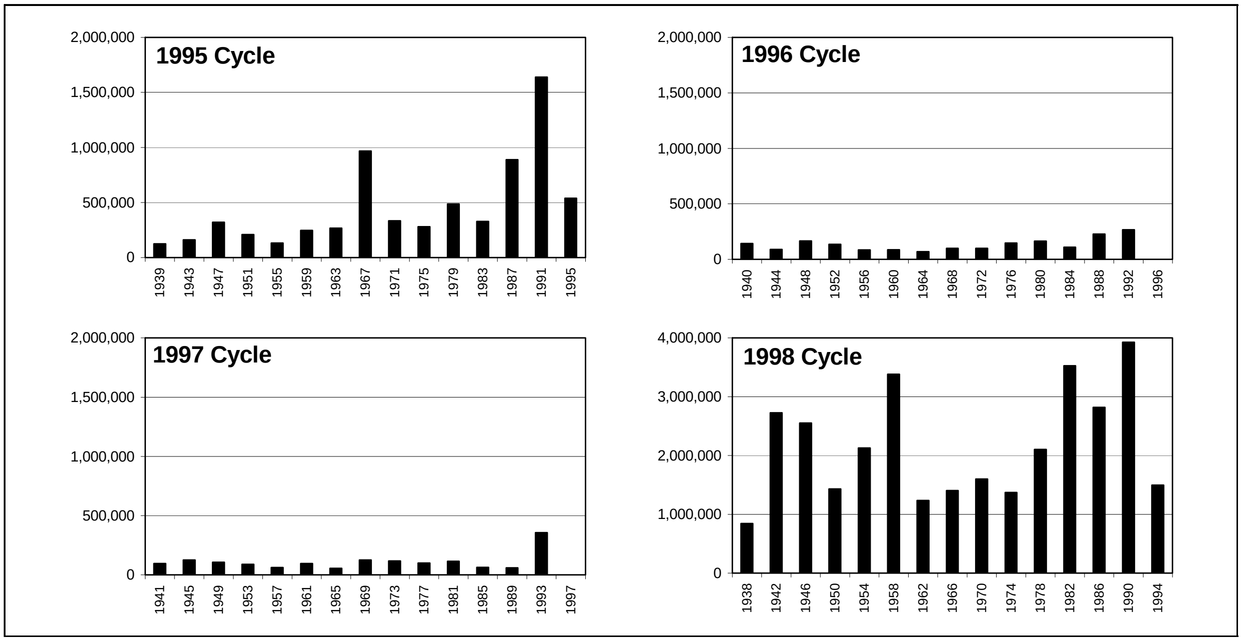

Figure 19. Adult escapement by cycle for Late Run Fraser River sockeye salmon.

Birkenhead and lower Adams rivers are estimated using mark-recapture studies, while the Weaver Channel escapement is estimated from a census. The escapements for the remaining populations are estimated from visual surveys.

The 1995 Late Run escapement of 536,718 adults and 4,259 jacks comprises 31% and 23%, respectively, of the Fraser River total (Appendix 6). The adult escapement was about one-third of that (1,638,200) in the record brood year (Fig. 19) and is the fourth largest on this cycle since 1939. The jack escapement is the third smallest on this cycle, continuing the long-term decline among jack populations. Relative to the 1991 brood year, adult escapements declined in all four geographic areas: from 47,400 to 19,200 in the Lower Fraser; from 349,200 to 91,200 in the Harrison-Lillooet; from 21,200 to 15,100 in the Seton-Anderson; and from 1,255,800 to 427,200 in the South Thompson. Spawning success for Late Run sockeye averages 94%, above the long-term cycle average of 89%. Among the major populations, spawning success ranges from 56% in Weaver Creek to 100% in the lower Shuswap River.

The escapement of Late Run sockeye was intensively assessed in 1995, with mark-recapture studies on Birkenhead and Adams rivers (81% of the estimated escapement), enumeration fences on Sweltzer Creek and Salmon River (2%), and channel counts at Weaver (4%). The overall accuracy of the Late Run estimate depends on the mark-recapture studies. An evaluation of sampling biases suggests there is a potential for a small positive bias among Birkenhead males, while no bias was identified among the remaining estimates. Other concerns in this group are negative biases in the Cultus Lake, Harrison River, and Portage Creek estimates. In Cultus, the bias results from the late fence instal-lation; in Harrison, it results from the use of visu-al surveys in a large, deep river where observa-tions are complicated by the presence of chum and chinook salmon; in Portage, it results from the late start of the survey. The potential biases off-set each other to some extent; consequently, the total escapement estimate for this group may be relatively unbiased.

ESCAPEMENT ESTIMATION ISSUES

The 1994 sockeye studies were the first to be subject to a thorough evaluation of the study designs and their execution (Schubert 1998). A number of study design modifications were recommended to address deficiencies that were common among the mark-recapture studies and visual surveys. This section describes the changes that were implemented in 1995, identifies other deficiencies, and recommends methods for their resolution.

IDENTIFICATION OF TAG STATUS

The Issue: The correct identification of the tag status of a recovered carcass is a fundamental assumption underlying mark-recapture studies (*e.g.*, Otis *et al.* 1978). Deficiencies identified in 1994 include inadequate resurveys of previously recovered carcasses and a high missed tag rate (7.6%) in studies where the resurveys were adequate. Schubert (1998) recommended a number of changes: incorporating a missed tag assessment in all mark-recapture studies; improving staff training and supervision, with the provision of immediate feedback and retraining to staff who miss tags; increasing the frequency of resurveys and improving their spatial and temporal representativeness; and conducting simulation studies to determine the optimum allocation of effort between the initial and resurveys.

The 1995 changes to the design and execution of the resurveys improved the spatial and temporal effort allocations (an increase by seven percentage points in the average resurvey rate to over 37%) and reduced the missed tag rate by two percentage points to 5.6%. While these changes represent significant improvements, the missed tag rate remains at a level that reflects poor study execution. While the simulation studies were not completed, Rajwani (1995) did develop analytic procedures to estimate the variance of the resurvey sample and to optimally allocate effort between the initial and resurveys. Unfortu-nately, the data were not collected in a way that permits the calculation of resurvey variance.

Recommendations: Reduce the incidence of missed tags and incorporate estimation variance into the population estimate; specifically:

- Continue training surveyors and crew chiefs to ensure that each carcass is thoroughly examining for a tag and that the resurveys are conducted on schedule and by experienced staff. Deviations should be corrected through immediate feedback and retraining;
- Implement Rajwani's (1995) procedures by ensuring that all tagged or marked carcasses are treated in a way that ensures they cannot be confused with unmarked carcasses during the resurvey.

TAG LOSS

The Issue: In 1994, the failure to assess tag loss was identified as a chronic study design deficiency that originated from the IPSFC practice of assuming the loss rate is constant at 5%. A sex-specific opercular punch was applied as a secondary mark in 1995 to assess tag loss. This resulted in an estimate of only 0.1% that seems unrealistically low when considered in the context of the 5.6% missed tag rate estimated from the resurvey data. Because its small size and the presence of fungus make an opercular punch difficult to observe, it is likely that an even greater proportion of the punches were not detected by the surveyors relative to the much more visible disk tags. The low tag loss estimate, therefore, likely reflects a failure of staff to detect the opercular punch rather than a real measure of tag loss. Consequently, an opercular punch is not well suited to mark-recapture studies of sockeye populations that require the inspection of large numbers of carcasses.

Recommendations: A second disk tag should be applied as a secondary mark to all tagged sockeye. As noted previously, staff training needs to improve and performance should be tested by inserting marked carcasses into planned recovery areas. Errors should be corrected by immediate feedback and retraining.

TAGGING STRESS

The Issue: Capture, holding and tagging can cause physiological stresses (Ricker 1975) that change fish behaviour, sometimes to the point of death. The 1994 studies assessed stress by eval-uating fish condition at release, the time between tag release and recovery, female spawning suc-cess, tag distributions, and the effect of recapture in subsequent beach seine sets. The results were equivocal because the tests could not distinguish between sampling selectivity and stress, and were often hampered by the late start of the re-covery surveys. Consequently, improved handl-ing procedures were recommended to reduce stress, and surveys near the tagging site immed-iately after the start of tagging were recommend-ed to permit the detection of an early die-off. Other changes recommended to differentiate be-tween stress and sampling selectivity included comparing low stress tagging procedures with current methods, and tag incidences among car-casses recovered on shore and in deep pools, and using radio telemetry to assess the role of stress in the behaviour of tagged fish.

The 1995 fish handling procedures are a sig-nificant improvement over those used in previ-ous years. This may in part account for the sim-ilar recovery rates between fish tagged using the low stress and standard tagging techniques (no significant differences in any of the studies). No serious stress impacts are noted in other tests, including the Chilko radio telemetry study that concluds that stress is unlikely to introduce bias into the population estimates (Schubert and Scarborough 1996).

Recommendations: The 1995 procedures should be repeated in 1996, including the im-proved handling procedures and the comparison of low stress and current tagging methods.

PROPORTIONAL SAMPLING

The Issue: Equal probability of capture and recapture and simple random sampling are the virtually unachievable goals of all mark-recapture studies. The 1994 analyses identified two issues that were common to a number of studies. First, tag incidences are lower in upper river spawners that likely migrate in the early part of the runs. This may result from starting tagging after the early migrants arrive in the river, from handling stress that causes fish to remain in the lower river, or from a higher vulnerability to capture of spawn-ers destined for the lower river (because the tag-ging site is proximal to their spawning area) ver-sus the upper river (because of their active migra-tion past the tagging site). Second, staffing levels did not permit consistent effort during concurrent tagging and recovery periods, impairing the as-sessment of stress effects and introducing tem-poral recovery biases that may bias the population estimates. Four changes were recommended: begin tagging as soon as sockeye appear in the river and increase effort during the early part of the run; establish additional tagging sites in the middle or upper parts of the rivers; begin recovery surveys above and below the tagging site immed-iately after the start of tagging; and allocate suf-ficient staff to allow consistent recovery effort through the die-off, including the period of coinci-dental application and recovery surveys.

In 1995, staff levels in most studies were adequate to permit tagging and recovery effort that was spatially and temporally representative. The additional tagging sites also reduced the number of studies with low tag incidences in the upper spawning areas. At the same time, how-ever, fish tagged in the upper river had higher re-covery rates than those tagged near the lower li-mit of spawning because the former are recover-able through the entire spawning area while the latter are more likely to drift out of the system. This is a simple mechanism that explains positive biases in mark-recapture studies where tags are applied near the lower limit of spawning. It clearly demonstrates that, when tagging at multiple sites in a river, unbiased population estimates depend on an allocation of sampling effort that considers the subsequent recoverability of the tags. Ongo-ing analysis of the 1995 Stellako study will provide recommendations on study design issues that ad-dress this bias (R. Houtman, pers. comm.).

ANALYTIC ISSUES

The Issue: The procedure used to estimate population size when biases are identified is to compare the pooled and stratified estimates. When the confidence limits of the respective estimates do not overlap (*i.e.*, the difference is significant), the stratified estimator is assumed to address the bias and its estimate is accepted as the most appropriate. In 1995, the pooled Peter-sen was accepted as the most appropriate esti-mator in all of the mark-recapture studies.

Schubert (2000) evaluated the performance of the pooled Petersen and stratified estimators against a known escapement in the Stellako Riv-er in 1994. He concludes that the Schaefer esti-mator should be rejected outright, the maximum likelihood Darroch estimator should not be used pending the development of techniques to select between accurate and biased estimates generat-ed under alternate stratifications, and the pooled Petersen be adopted as the sole population esti-mator.

Recommendation: The pooled Petersen

should be adopted as the sole population estimator, and alternate procedures should be developed to permit the qualitative and, ultimately, quantitative evaluation of bias.

VISUAL SURVEYS

The Issue: Population estimates are derive-ed from visual survey data using unsophisticated analytic procedures that rely on expansion fac-tors whose origins have been lost over the last half century and are now almost mythical in na-ture. The source data for these factors may no longer be accessible and they do not correspond well to more recent assessments such as those described earlier. There has been little effort to improve the process because such estimates comprise only a small proportion of the total Fra-ser River escapement (6% and 14% in 1994 and 1995, respectively). These procedures certainly underestimate the variability in population sizes and likely underestimate the true population size, especially among the large populations. In 1994, Schubert (1998) recommended the documenta-tion of source data, the development of variance estimators, and the evaluation of physical, geo-graphic and climatic factors likely to influence the estimates. No progress has been made on any of these recommendations.

Recommendation: Alternatives should be explored with the intention of adopting an analytic procedure that is sufficiently sophisticated to allow the incorporation of uncertainty from, for example, observer efficiency, expansion factor, or survey timing.

The Issue: Visual surveys provide an indication of abundance that is most reliable for small populations that spawn during a compress-ed period in shallow streams where live spawn-ers and carcasses are highly visible. They rep-resent a trade-off between survey cost and ac-curacy that is acceptable if the population is small and the estimation error does not unduly bias the overall abundance estimate for a geo-graphic or timing group. In 1995, visual surveys were used for a number of populations where it was inappropriate to do so, thereby biasing esti-mates for some of the aggregates. Examples include the use of visual surveys in the upper Pitt, Harrison and Mitchell rivers where glacial silt, river depth and population size, respectively, make large negative biases likely. While the latter results from a unanticipated large escape-ment and, therefore, could not be avoided, the Pitt and Harrison represent structural character-istics of the systems that are not suited to visual techniques.

Recommendations: The following changes are recommended for future studies:

- Assess the Upper Pitt and Harrison populations using mark-recapture studies; and
- Assess the Quesnel Lake tributaries on the off-cycles using visual surveys.

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APPENDICES

Appendix 1. Mean daily sockeye counts during 15-minute index periods at bridge crossings in the Chilko and Quesnel rivers, 1995.

	Chilko River Henry's Bridge		Quesnel River Likely 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	Date	Number of counts per day [A]	Mean sockeye count	Number of counts per day [A]	Mean sockeye count
1-Aug	5	0	-	-	1-Sep	14	6,942	8	1,040
2-Aug	-	-	-	-	2-Sep	14	5,192	8	155
3-Aug	5	0	-	-	3-Sep	14	1,156	8	19
4-Aug	5	0	-	-	4-Sep	14	1,024	8	29
5-Aug	-	-	-	-	5-Sep	14	588	8	15
6-Aug	7	1	-	-	6-Sep	14	1,272	8	82
7-Aug	7	0	-	-	7-Sep	-	-	8	69
8-Aug	6	3	-	-	8-Sep	14	408	8	7
9-Aug	14	119	-	-	9-Sep	14	276	8	4
10-Aug	14	48	-	-	10-Sep	14	183	8	4
11-Aug	9	4	-	-	11-Sep	14	190	8	5
12-Aug	14	22	-	-	12-Sep	14	276	8	13
13-Aug	14	152	-	-	13-Sep	14	247	8	18
14-Aug	14	134	-	-	14-Sep	11	110	8	35
15-Aug	14	510	-	-	15-Sep	14	329	8	23
16-Aug	14	311	-	-	16-Sep	14	431	8	23
17-Aug	14	175	-	-	17-Sep	14	309	8	22
18-Aug	14	333	-	-	18-Sep	14	268	8	16
19-Aug	14	651	-	-	19-Sep	14	288	-	-
20-Aug	14	765	-	-	20-Sep	14	113	-	-
21-Aug	14	739	6	599	21-Sep	-	-	-	-
22-Aug	14	549	6	957	22-Sep	14	84	-	-
23-Aug	14	1,251	7	996	23-Sep	14	31	-	-
24-Aug	14	1,357	8	1,648	24-Sep	14	88	-	-
25-Aug	14	887	8	648	25-Sep	-	-	-	-
26-Aug	14	1,659	8	358	26-Sep	-	-	-	-
27-Aug	14	1,026	8	923	27-Sep	-	-	-	-
28-Aug	14	4,065	8	1,706	28-Sep	-	-	-	-
29-Aug	14	2,211	8	1,232	29-Sep	-	-	-	-
30-Aug	14	4,509	8	835	30-Sep	-	-	-	-
31-Aug	14	4,828	8	945					

[A.] Fifteen minute counts every half hour.

Appendix 2. Daily live counts, male, female and jack carcass recoveries, and female spawning success from the Nadina and Weaver spawning channels, 1995.

	Nadina River Channel							Weaver Creek Channel [A]						
		Carcasses recovered			% spawned				Carcasses recovered			% spawned		
Date	Live count	Male	Female	Jack	0%	50%	100%	Live count	Male	Female	Jack	0%	50%	100%
13-Aug	154	0	0	0	0	0	0	-	-	-	-	-	-	-
14-Aug	608	0	0	0	0	0	0	-	-	-	-	-	-	-
15-Aug	131	0	0	0	0	0	0	-	-	-	-	-	-	-
16-Aug	81	1	0	0	0	0	0	-	-	-	-	-	-	-
17-Aug	64	1	0	0	0	0	0	-	-	-	-	-	-	-
18-Aug	282	1	2	0	2	0	0	-	-	-	-	-	-	-
19-Aug	438	0	0	0	0	0	0	-	-	-	-	-	-	-
20-Aug	227	0	0	0	0	0	0	-	-	-	-	-	-	-
21-Aug	305	1	0	0	0	0	0	-	-	-	-	-	-	-
22-Aug	915	0	0	0	0	0	0	-	-	-	-	-	-	-
23-Aug	1,544	0	0	0	0	0	0	-	-	-	-	-	-	-
24-Aug	1,360	0	0	0	0	0	0	-	-	-	-	-	-	-
25-Aug	1,337	0	0	0	0	0	0	-	-	-	-	-	-	-
26-Aug	623	1	1	0	1	0	0	-	-	-	-	-	-	-
27-Aug	954	0	0	0	0	0	0	-	-	-	-	-	-	-
28-Aug	563	1	2	0	2	0	0	-	-	-	-	-	-	-
29-Aug	864	1	3	0	3	0	0	-	-	-	-	-	-	-
30-Aug	552	1	5	0	5	0	0	-	-	-	-	-	-	-
31-Aug	435	3	5	0	5	0	0	-	-	-	-	-	-	-
1-Sep	56	7	6	0	6	0	0	-	-	-	-	-	-	-
2-Sep	820	8	7	0	7	0	0	-	-	-	-	-	-	-
3-Sep	794	17	19	0	16	0	3	-	-	-	-	-	-	-
4-Sep	2,045	32	38	0	36	0	2	-	-	-	-	-	-	-
5-Sep	1,927	45	48	0	46	0	2	-	-	-	-	-	-	-
6-Sep	1,074	30	32	0	31	0	1	-	-	-	-	-	-	-
7-Sep	650	60	114	0	111	0	3	-	-	-	-	-	-	-
8-Sep	675	63	112	0	107	0	5	-	-	-	-	-	-	-
9-Sep	518	77	97	0	89	0	8	-	-	-	-	-	-	-
10-Sep	665	134	193	0	168	0	25	-	-	-	-	-	-	-
11-Sep	507	139	224	0	167	0	57	-	-	-	-	-	-	-
12-Sep	213	286	299	0	197	0	102	-	-	-	-	-	-	-
13-Sep	75	412	464	0	286	0	178	-	-	-	-	-	-	-
14-Sep	50	575	647	2	344	0	303	-	-	-	-	-	-	-
15-Sep	-	462	500	1	364	0	236	-	-	-	-	-	-	-
16-Sep	-	540	510	1	220	0	290	-	-	-	-	-	-	-
17-Sep	-	473	608	0	248	0	360	-	-	-	-	-	-	-
18-Sep	-	385	395	0	119	0	276	-	-	-	-	-	-	-
19-Sep	-	692	666	1	111	0	555	-	-	-	-	-	-	-
20-Sep	-	540	573	0	104	0	469	-	-	-	-	-	-	-
21-Sep	-	775	715	0	79	0	636	-	-	-	-	-	-	-
22-Sep	-	636	620	0	57	0	563	-	-	-	-	-	-	-
23-Sep	-	456	521	0	51	0	470	-	-	-	-	-	-	-
24-Sep	-	554	422	0	34	0	388	-	-	-	-	-	-	-
25-Sep	-	466	452	0	13	0	439	-	-	-	-	-	-	-
26-Sep	-	408	398	0	16	0	382	-	-	-	-	-	-	-
27-Sep	-	395	321	0	5	0	316	-	-	-	-	-	-	-
28-Sep	-	268	228	1	2	0	226	-	-	-	-	-	-	-
29-Sep	-	180	192	0	1	0	191	-	-	-	-	-	-	-
30-Sep	-	215	180	0	1	0	179	-	-	-	-	-	-	-
1-Oct	-	120	131	0	0	0	131	-	-	-	-	-	-	-
2-Oct	-	78	82	0	0	0	82	-	-	-	-	-	-	-

Continued

Appendix 2. Daily live counts, male, female and jack carcass recoveries, and female spawning success from the Nadina and Weaver spawning channels, 1995, continued.

	Nadina River Channel							Weaver Creek Channel [A]						
		Carcasses recovered			% spawned				Carcasses recovered			% spawned		
Date	Live count	Male	Female	Jack	0%	50%	100%	Live count	Male	Female	Jack	0%	50%	100%
3-Oct	-	76	81	0	0	0	81	-	-	-	-	-	-	-
4-Oct	-	24	22	0	0	0	22	-	-	-	-	-	-	-
5-Oct	-	56	64	0	0	0	64	821	-	-	-	-	-	-
6-Oct	-	-	-	-	-	-	-	1,393	-	-	-	-	-	-
7-Oct	-	-	-	-	-	-	-	2,319	-	-	-	-	-	-
8-Oct	-	-	-	-	-	-	-	1,943	-	-	-	-	-	-
9-Oct	-	-	-	-	-	-	-	1,082	-	-	-	-	-	-
10-Oct	-	-	-	-	-	-	-	2,773	-	-	-	-	-	-
11-Oct	-	-	-	-	-	-	-	1,008	327	541	3	218	46	277
12-Oct	-	-	-	-	-	-	-	1,047	-	-	-	-	-	-
13-Oct	-	-	-	-	-	-	-	839	638	1,001	0	288	16	697
14-Oct	-	-	-	-	-	-	-	716	703	1,076	30	293	34	749
15-Oct	-	-	-	-	-	-	-	730	865	1,076	15	305	44	727
16-Oct	-	-	-	-	-	-	-	1,038	504	664	15	204	36	424
17-Oct	-	-	-	-	-	-	-	1,151	970	960	16	394	58	508
18-Oct	-	-	-	-	-	-	-	344	1,311	1,323	34	548	82	693
19-Oct	-	-	-	-	-	-	-	739	230	304	6	133	20	151
20-Oct	-	-	-	-	-	-	-	425	791	954	13	366	49	539
21-Oct	-	-	-	-	-	-	-	530	326	350	9	130	25	195
22-Oct	-	-	-	-	-	-	-	313	340	644	0	128	24	492
23-Oct	-	-	-	-	-	-	-	361	260	465	9	76	11	378
24-Oct	-	-	-	-	-	-	-	93	-	-	-	-	-	-
25-Oct	-	-	-	-	-	-	-	260	415	783	17	82	22	679
26-Oct	-	-	-	-	-	-	-	255	-	-	-	-	-	-
27-Oct	-	-	-	-	-	-	-	218	354	475	26	40	9	426
28-Oct	-	-	-	-	-	-	-	45	58	88	0	10	2	76
29-Oct	-	-	-	-	-	-	-	81	189	267	10	19	4	244
30-Oct	-	-	-	-	-	-	-	48	125	282	17	29	11	242
31-Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-Nov	-	-	-	-	-	-	-	-	127	177	14	14	3	160
4-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6-Nov	-	-	-	-	-	-	-	-	77	139	0	13	8	118
7-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12-Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13-Nov	-	-	-	-	-	-	-	-	27	56	3	5	1	50
Total	-	9,695	9,999	6 [B]	3,054	0	7,045	20,572	8,637	11,625	237	3,295	505	7,825

[A.] Does not include 948 sockeye surplus to channel requirements.
[B.] Carcasses recoveries not adjusted for age misidentification.

Appendix 3. Daily sockeye counts at enumeration fences constructed in the Fraser River system, 1995.

						Early Stuart Group				
Date	Bowron River	Fennell Creek	Salmon River [A]	Scotch Creek [A]	Stellako River	Forfar Creek	Gluske Creek	Kynoch Creek	Sweltzer Creek	Weaver Creek
12-Jul	-	-	-	-	-	0	0	0	-	-
13-Jul	-	-	-	-	-	0	0	0	-	-
14-Jul	-	-	-	-	-	0	0	0	-	-
15-Jul	-	-	-	-	-	0	0	0	-	-
16-Jul	-	-	-	-	-	0	0	0	-	-
17-Jul	-	-	-	-	-	0	0	0	-	-
18-Jul	-	-	-	-	-	0	1,223	0	-	-
19-Jul	-	-	-	-	-	0	600	163	-	-
20-Jul	-	-	-	-	-	419	547	893	-	-
21-Jul	-	-	-	-	-	749 [E]	592	1,878	-	-
22-Jul	-	-	-	-	-	917	1,752	3,085	-	-
23-Jul	28	-	-	-	-	2,078	2,496	1,789	-	-
24-Jul	51	-	-	-	-	638	526	1,642	-	-
25-Jul	33	-	-	-	-	2,520	2,976	3,678	-	-
26-Jul	0	-	-	-	-	1,170	913	2,240	-	-
27-Jul	158	-	-	-	-	287	390	223	-	-
28-Jul	97	-	-	-	-	531	160	37	-	-
29-Jul	68	1	-	-	-	448	378	1,192	-	-
30-Jul	177	0	-	-	-	195	321	214	-	-
31-Jul	126	0	-	-	-	336	545	832	-	-
1-Aug	239	0	-	-	-	1,534	81	782	-	-
2-Aug	378	1	-	0	-	538	202	977	-	-
3-Aug	22	0	-	0	-	1,746	238	1,280	-	-
4-Aug	150 [E]	1	-	0	-	383	268	939	-	-
5-Aug	278	0	-	0	-	431	138	945	-	-
6-Aug	153	0	-	0	-	315	202	570	-	-
7-Aug	1,306	1	-	0	-	287	369	750	-	-
8-Aug	377	1	-	0	-	304	45	347	-	-
9-Aug	180	0	-	0	-	399	3	293	-	-
10-Aug	327	3	-	0	-	93	30	79	-	-
11-Aug	583	1	-	0	-	41 [E]	16	21	-	-
12-Aug	2,190	19	-	0	-	31	3	77	-	-
13-Aug	1,485	331	-	5	-	12	16	8	-	-
14-Aug	1,699	241	-	204	-	72 [E]	4	50 [E]	-	-
15-Aug	573	118	-	101	-	0	10	0	-	-
16-Aug	1,058	400	-	133	-	4	0	1	-	-
17-Aug	1,316	874	-	139	-	0 [E]	0	0	-	-
18-Aug	2,803	1,165	-	277	-	0 [E]	0	0	-	-
19-Aug	1,919	522	-	1,187	-	-	-	-	-	-
20-Aug	1,100	1,404	-	2,275	-	-	-	-	-	-
21-Aug	1,289 [E]	815	-	1,091	-	-	-	-	-	-
22-Aug	1,383 [E]	162	-	963	-	-	-	-	-	-
23-Aug	1,477	506	-	1,251	-	-	-	-	-	-
24-Aug	1,355	241	-	728	-	-	-	-	-	-
25-Aug	703	962	-	1,157	3	-	-	-	-	-
26-Aug	571	928	-	769	229	-	-	-	-	-
27-Aug	853	575	-	698	20	-	-	-	-	-
28-Aug	1,797	428	-	493	261	-	-	-	-	-
29-Aug	1,178 [E]	195	-	1,082	4,486	-	-	-	-	-
30-Aug	558	459	-	1,054	7,215	-	-	-	-	-
31-Aug	507	452	-	354	2,303	-	-	-	-	-
1-Sep	0	209	-	138	19,750	-	-	-	-	-

Continued

Appendix 3. Daily sockeye counts at enumeration fences constructed in the Fraser River system, 1995 continued.

						Early Stuart Group				
Date	Bowron River	Fennell Creek	Salmon River [A]	Scotch Creek [A]	Stellako River	Forfar Creek	Gluske Creek	Kynoch Creek	Sweltzer Creek	Weaver Creek
2-Sep	1,537	95	-	128	2,596	-	-	-	-	-
3-Sep	1,023 [E]	24	-	68	3,291	-	-	-	-	-
4-Sep	508	23	-	105	6,391	-	-	-	-	-
5-Sep	333	22	-	44	429	-	-	-	-	-
6-Sep	260	25	-	74	1,666	-	-	-	-	-
7-Sep	69	17	-	34	9,381	-	-	-	-	-
8-Sep	63	10	-	18	2,245	-	-	-	-	-
9-Sep	47	13	-	15	14,947	-	-	-	-	-
10-Sep	30	5	-	14	12,864 [E]	-	-	-	-	-
11-Sep	18	2	-	10	3,189	-	-	-	-	-
12-Sep	-	-	-	5	1,211	-	-	-	-	-
13-Sep	-	-	-	5	3,663	-	-	-	-	-
14-Sep	-	-	-	5	8,918	-	-	-	-	-
15-Sep	-	-	-	1	1,690	-	-	-	-	-
16-Sep	-	-	-	0	3,427 [E]	-	-	-	-	-
17-Sep	-	-	-	-	1,195	-	-	-	-	-
18-Sep	-	-	-	-	2,131	-	-	-	-	-
19-Sep	-	-	-	-	473	-	-	-	-	-
20-Sep	-	-	-	-	1,651	-	-	-	-	-
21-Sep	-	-	-	-	4,151	-	-	-	-	-
22-Sep	-	-	-	-	2,267	-	-	-	-	-
23-Sep	-	-	-	-	1,032	-	-	-	-	-
24-Sep	-	-	-	-	362	-	-	-	-	-
25-Sep	-	-	-	-	65	-	-	-	-	-
26-Sep	-	-	-	-	253	-	-	-	-	-
27-Sep	-	-	-	-	359	-	-	-	-	-
28-Sep	-	-	-	-	351	-	-	-	-	-
29-Sep	-	-	-	-	468	-	-	-	81	-
30-Sep	-	-	-	-	170	-	-	-	1,375	-
1-Oct	-	-	-	-	101	-	-	-	116	-
2-Oct	-	-	-	-	539	-	-	-	199 [E]	-
3-Oct	-	-	-	-	43	-	-	-	2,342	-
4-Oct	-	-	-	-	286	-	-	-	1,512	-
5-Oct	-	-	-	-	122	-	-	-	227	135
6-Oct	-	-	-	-	477	-	-	-	34	237
7-Oct	-	-	-	-	14	-	-	-	25	103
8-Oct	-	-	-	-	11	-	-	-	0	424
9-Oct	-	-	-	-	0	-	-	-	77	486
10-Oct	-	-	-	-	0	-	-	-	575	24
11-Oct	-	-	-	-	46	-	-	-	449	638
12-Oct	-	-	-	-	0	-	-	-	478	264
13-Oct	-	-	-	-	0	-	-	-	215	556
14-Oct	-	-	-	-	0	-	-	-	202	384
15-Oct	-	-	-	-	0	-	-	-	327	167
16-Oct	-	-	-	-	0	-	-	-	168	0
17-Oct	-	-	-	-	0	-	-	-	258	0
18-Oct	-	-	-	-	0	-	-	-	143	7
19-Oct	-	-	-	-	-	-	-	-	55	8
20-Oct	-	-	-	-	-	-	-	-	86	6
21-Oct	-	-	-	-	-	-	-	-	71	0
22-Oct	-	-	-	-	-	-	-	-	28	124
23-Oct	-	-	-	-	-	-	-	-	61	93
24-Oct	-	-	-	-	-	-	-	-	29	0

Continued

Appendix 3. Daily sockeye counts at enumeration fences constructed in the Fraser River system, 1995 continued.

						Early Stuart Group				
Date	Bowron River	Fennell Creek	Salmon River [A]	Scotch Creek [A]	Stellako River	Forfar Creek	Gluske Creek	Kynoch Creek	Sweltzer Creek	Weaver Creek
25-Oct	-	-	-	-	-	-	-	-	66	3
26-Oct	-	-	-	-	-	-	-	-	104	0
27-Oct	-	-	-	-	-	-	-	-	25	0
28-Oct	-	-	-	-	-	-	-	-	7	0
29-Oct	-	-	-	-	-	-	-	-	24	0
30-Oct	-	-	-	-	-	-	-	-	37	0
31-Oct	-	-	-	-	-	-	-	-	32	0
1-Nov	-	-	-	-	-	-	-	-	1	0
2-Nov	-	-	-	-	-	-	-	-	6	0
3-Nov	-	-	-	-	-	-	-	-	3	0
4-Nov	-	-	-	-	-	-	-	-	31	0
5-Nov	-	-	-	-	-	-	-	-	68	0
6-Nov	-	-	-	-	-	-	-	-	28	0
7-Nov	-	-	-	-	-	-	-	-	133	0
8-Nov	-	-	-	-	-	-	-	-	134	0
9-Nov	-	-	-	-	-	-	-	-	19	0
10-Nov	-	-	-	-	-	-	-	-	48	0
11-Nov	-	-	-	-	-	-	-	-	46	0
12-Nov	-	-	-	-	-	-	-	-	53	0
13-Nov	-	-	-	-	-	-	-	-	117	0
14-Nov	-	-	-	-	-	-	-	-	31	-
15-Nov	-	-	-	-	-	-	-	-	15	-
16-Nov	-	-	-	-	-	-	-	-	8	-
17-Nov	-	-	-	-	-	-	-	-	29	-
18-Nov	-	-	-	-	-	-	-	-	17	-
19-Nov	-	-	-	-	-	-	-	-	16	-
20-Nov	-	-	-	-	-	-	-	-	27	-
21-Nov	-	-	-	-	-	-	-	-	17	-
22-Nov	-	-	-	-	-	-	-	-	16	-
23-Nov	-	-	-	-	-	-	-	-	9	-
24-Nov	-	-	-	-	-	-	-	-	10	-
25-Nov	-	-	-	-	-	-	-	-	10	-
26-Nov	-	-	-	-	-	-	-	-	9	-
27-Nov	-	-	-	-	-	-	-	-	6	-
28-Nov	-	-	-	-	-	-	-	-	6	-
29-Nov	-	-	-	-	-	-	-	-	5	-
30-Nov	-	-	-	-	-	-	-	-	0	-
1-Dec	-	-	-	-	-	-	-	-	2	-
2-Dec	-	-	-	-	-	-	-	-	0	-
3-Dec	-	-	-	-	-	-	-	-	0	-
4-Dec	-	-	-	-	-	-	-	-	1	-
5-Dec	-	-	-	-	-	-	-	-	0	-
6-Dec	-	-	-	-	-	-	-	-	0	-
Male	17,598 [B]	5,048 [B]	5	7,271 [B]	67,072 [C]	7,144 [B]	6,826 [B]	12,454 [B]	4,744 [D]	2,395 [B]
Female	16,819 [B]	6,194 [B]	3	7,353 [B]	59,595 [C]	9,332 [B]	8,217 [B]	14,529 [B]	5,572 [D]	1,264 [B]
Jack	14 [B]	9 [B]	0	1 [B]	76 [C]	2 [B]	1 [B]	2 [B]	33 [D]	0 [B]
Total	34,431	11,251	8	14,625	126,742	16,478	15,044	24,985	10,349	3,659

A. Salmon River data provided by HEB (daily counts unavailable); Scotch Creek data provided by Shuswap Nation Fisheries Commission.
B. From observations at the fence.
C. Sex ratio was from the total carcass sample. Fence count does not include a number of spawners already in river.
D. Sex ratio and jack composition estimated from carcass surveys upstream from the fence.
E. Fence was not fish-tight.

Appendix 4. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by population group, population and date, for Fraser River sockeye salmon assessed using visual surveys, 1995.

Stock group	Stock	Date	Live count	Carcasses recovered: Male	Female	Jack	Total	Cum.	% spawned: 0%	50%	100%
Lower	Chilliwack Lake	25-Aug	30	2	6	0	8	8	2	1	3
Fraser		1-Sep	7	16	19	1	36	44	6	1	12
		7-Sep	6	47	25	2	74	118	2	1	22
		12-Sep	3	48	29	2	79	197	0	0	29
		18-Sep	0	28	19	2	49	246 [A]	0	0	19
	Nahatlatch Lake	24-Aug	7	0	1	0	1	1	1	0	0
		30-Aug	0	2	4	0	6	7	2	2	0
		5-Sep	8	26	25	2	53	60	9	0	16
		8-Sep	1	9	7	0	16	76	1	0	6
		22-Sep	0	31	16	0	47	123	0	0	16
	Nahatlatch River	30-Aug	930	1	0	0	1	1	0	0	0
		8-Sep	994	10	14	1	25	26	2	1	11
		13-Sep	506	25	18	0	43	69	2	0	16
		22-Sep	72	1	5	0	6	75	0	0	5
	Widgeon Slough	10-Nov	61	3	2	0	5	5	0	0	2
		16-Nov	47	12	17	0	29	34	2	2	13
		22-Nov	12	6	10	0	16	50	0	0	10
Harrison-	Big Silver Creek	27-Sep	782	51	33	2	86	86	8	0	25
Lillooet		6-Oct	474	12	25	1	38	124	0	0	25
		13-Oct	17	0	3	0	3	127	0	0	3
	Harrison River	6-Nov	9,311	0	0	0	0	0	0	0	0
		14-Nov	4,768	10	22	0	32	32	2	0	20
		20-Nov	0	23	106	2	131	163	1	1	104
		23-Nov	0	47	131	0	178	341	0	0	131
		27-Nov	0	48	106	0	154	495	0	0	106
	Samson Creek	26-Sep	60	8	9	1	18	18	0	1	8
	(Railroad Creek)	8-Oct	1	0	0	0	0	18	0	0	0
	Weaver Cr, lower	11-Oct	1,685	143	136	0	279	279	78	19	39
		14-Oct	2,505	372	349	4	725	1,004	177	36	136
		17-Oct	1,350	140	102	1	243	1,247	61	12	29
		20-Oct	2,205	742	556	16	1,314	2,561	244	83	229
		23-Oct	1,285	522	428	6	956	3,517	183	54	191
		26-Oct	390	182	126	2	310	3,827	12	7	107
		29-Oct	295	261	110	1	372	4,199	16	16	78
		1-Nov	260	326	120	2	448	4,647	15	15	90
		4-Nov	132	222	142	2	366	5,013	10	6	126
		7-Nov	40	109	34	1	144	5,157	4	1	29
Seton-	Gates Creek	22-Aug	5,204	0	0	0	0	0	0	0	0
Anderson		28-Aug	9,888	0	0	0	0	0	0	0	0
		31-Aug	9,480	7	7	41	55	55	6	0	1
		6-Sep	n/r	11	35	58	104	159	4	0	31
		11-Sep	6,815	44	81	184	309	468	1	0	80
		14-Sep	2,926	283	434	673	1,390	1,858	0	0	434
		19-Sep	644	49	150	336	535	2,393	1	0	149
	Portage Creek	2-Nov	4,589	57	38	9	104	104	0	0	0
		9-Nov	1,384	101	131	18	250	354	8	0	30
		17-Nov	27	27	100	6	133	487	9	1	121
South	Adams Channel	3-Sep	0	0	0	0	0	0	0	0	0
Thompson	Adams R, lower	3-Sep	0	0	0	0	0	0	0	0	0
Early	Adams R., upper	21-Aug	0	0	0	0	0	0	0	0	2
Summer		28-Aug	50	0	0	0	0	0	0	0	0
Runs		7-Sep	15	2	0	0	2	2	0	0	0
		13-Sep	1	0	3	0	3	5	0	0	3

Continued

Appendix 4. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by population group, population and date, for Fraser River sockeye salmon assessed using visual surveys, 1995 continued.

Stock group	Stock	Date	Live count	Carcasses recovered Male	Female	Jack	Total	Cum.	% spawned 0%	50%	100%
South	Anstey River	22-Aug	281	1	0	0	1	1	0	0	0
Thompson		29-Aug	1,971	4	3	0	7	8	0	0	3
Early		5-Sep	1,856	90	23	0	113	121	0	0	23
Summer		11-Sep	515	127	89	0	216	337	0	0	89
Runs	Cayenne Creek	21-Aug	15	0	0	0	0	0	0	0	0
Continued		28-Aug	25	0	1	0	1	1	0	0	1
		7-Sep	15	0	2	0	2	3	0	0	2
		13-Sep	0	1	1	0	2	5	0	0	1
	Celista Creek	22-Aug	0	0	0	0	0	0	0	0	0
		2-Sep	116	0	0	0	0	0	0	0	0
		9-Sep	37	1	6	0	7	7	0	0	6
		13-Sep	0	1	1	0	2	9	0	0	0
	Eagle River	23-Aug	322	0	0	0	0	0	0	0	0
		30-Aug	1,050	0	0	0	0	0	0	0	0
		6-Sep	850	13	8	0	21	21	0	0	8
		14-Sep	284	31	65	0	96	117	0	0	65
	Hiuihill Creek	3-Sep	0	0	0	0	0	0	0	0	0
	Hunakwa Creek	22-Aug	0	0	0	0	0	0	0	0	0
		5-Sep	0	4	3	0	7	7	0	0	3
	McNomee Creek	21-Aug	578	0	0	0	0	0	0	0	0
		25-Aug	1,614	3	2	0	5	5	0	0	2
		28-Aug	3,700	15	5	0	20	25	0	0	5
		1-Sep	4,330	100	22	0	122	147	0	2	20
		5-Sep	3,871	454	201	0	655	802	0	2	196
		9-Sep	0	486	532	0	1,018	1,820	0	1	527
		11-Sep	0	168	272	0	440	2,260	0	1	269
		14-Sep	0	95	158	0	253	2,513	0	0	158
		19-Sep	7	5	3	0	8	2,521	0	0	3
	Nikwikwaia Creek	3-Sep	0	0	0	0	0	0	0	0	0
	Onyx Creek	3-Sep	0	0	0	0	0	0	0	0	0
	Perry River	23-Aug	17	0	0	0	0	0	0	0	5
		30-Aug	131	0	0	0	0	0	0	0	6
		6-Sep	129	1	5	0	6	6	0	0	0
		14-Sep	38	1	6	0	7	13	0	0	1
	Salmon River	14-Sep	0	0	0	0	0	0	0	0	0
	Scotch Creek	19-Aug	2,284	0	1	0	1	1	1	0	0
	(above fence)	25-Aug	5,485	25	24	0	49	50	14	0	10
		1-Sep	9,592	365	157	0	522	572	9	9	133
		8-Sep	1,280	1,067	1,392	0	2,459	3,031	4	0	884
		15-Sep	21	172	326	0	498	3,529	0	0	320
	Scotch Creek	19-Aug	13	0	0	0	0	0	0	0	0
	(below fence)	25-Aug	150	0	0	0	0	0	0	0	0
		1-Sep	207	21	27	0	48	48	0	0	27
		15-Sep	58	0	0	0	0	48	0	0	0
	Yard Creek	23-Aug	223	1	0	0	1	1	0	0	0
		30-Aug	854	8	0	0	8	9	0	0	0
		6-Sep	671	41	24	0	65	74	0	0	24
		14-Sep	30	15	57	0	72	146	0	0	57
South	Adams Channel [B]	n/r	n/r	8	6	0	14	14	5	0	1
Thompson		n/r	n/r	2	2	0	4	18	0	0	0
Late Run		n/r	n/r	8	6	0	14	32	0	0	0
		n/r	n/r	7	7	0	14	46	0	0	0
		n/r	n/r	22	13	0	35	81	0	0	0
		n/r	n/r	24	15	0	39	120	0	0	0
		n/r	n/r	33	29	0	62	182	0	0	0

Continued

Appendix 4. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by population group, population and date, for Fraser River sockeye salmon assessed using visual surveys, 1995 continued.

Stock group	Stock	Date	Live count	Carcasses recovered					% spawned		
				Male	Female	Jack	Total	Cum.	0%	50%	100%
South	Adams Channel [B]	n/r	n/r	11	10	0	21	203	0	0	0
Thompson	*continued*	n/r	n/r	63	47	0	110	313	0	0	0
Late Run		n/r	n/r	34	26	0	60	373	0	0	0
continued		n/r	n/r	40	19	0	59	432	0	0	0
		n/r	n/r	226	218	0	444	876	25	7	186
		n/r	n/r	36	21	0	57	933	1	5	15
		n/r	n/r	16	14	0	30	963	0	0	14
		n/r	n/r	89	84	0	173	1,136	0	0	84
		n/r	n/r	18	7	0	25	1,161	0	0	7
		n/r	n/r	22	18	0	40	1,201	0	2	16
		n/r	n/r	6	9	0	15	1,216	1	1	7
		n/r	n/r	12	16	0	28	1,244	0	1	15
		n/r	n/r	8	8	0	16	1,260	0	1	7
		n/r	111	86	53	0	139	1,399	7	1	45
	Adams Lake	12-Oct	2	0	1	0	1	1	1	0	0
		23-Oct	65	0	0	0	0	1	0	0	0
	Adams R., upper	12-Oct	0	0	0	0	0	0	0	0	0
		30-Oct	0	0	0	0	0	0	0	0	0
	Anstey River	15-Oct	34	0	0	0	0	0	0	0	0
		22-Oct	52	0	0	0	0	0	0	0	0
		1-Nov	5	0	0	0	0	313	0	0	0
	Bush Creek	12-Oct	0	0	0	0	0	0	0	0	0
	Canoe Creek	24-Oct	0	0	0	0	0	0	0	0	0
		7-Nov	0	1	0	0	1	1	0	0	0
	Cayenne Creek	12-Oct	0	0	0	0	0	0	0	0	0
	Celista Creek	19-Oct	0	0	0	0	0	0	0	0	0
		28-Oct	0	0	0	0	0	0	0	0	0
	Eagle River	21-Oct	476 [D]	0	0	0	0	0	0	0	0
	Hiuihill Creek	12-Oct	12	0	0	0	0	0	0	0	0
		19-Oct	211	1	0	0	1	1	0	0	0
		24-Oct	217	15	3	0	18	19	0	0	3
		29-Oct	112	11	14	0	25	44	0	0	12
		8-Nov	20	7	13	0	20	64	0	0	13
	Hunakwa Creek	15-Oct	14	1	0	0	1	1	0	0	0
		22-Oct	13	0	1	0	1	2	0	0	0
		1-Nov	0	0	0	0	0	2	0	0	0
	Little River	4-Oct	n/r	5	5	0	10	10	4	0	1
		6-Oct	n/r	2	4	0	6	16	0	0	0
		8-Oct	n/r	4	1	0	5	21	0	0	1
		10-Oct	n/r	9	8	0	17	38	0	0	0
		12-Oct	n/r	4	4	0	8	46	0	0	0
		14-Oct	4,900 [D]	30	20	0	50	96	0	0	0
		16-Oct	n/r	11	7	0	18	114	0	0	0
		18-Oct	n/r	77	67	0	144	258	0	0	2
		20-Oct	n/r	62	62	0	124	382	0	0	0
		22-Oct	n/r	62	102	0	164	546	0	0	0
		24-Oct	n/r	148	115	0	263	809	1	0	0
		26-Oct	n/r	126	89	0	215	1,024	0	0	1
		28-Oct	n/r	54	64	0	118	1,142	0	0	0
		30-Oct	n/r	79	56	0	135	1,277	0	0	0
		1-Nov	n/r	103	122	0	225	1,502	0	0	1
		3-Nov	n/r	92	73	0	165	1,667	0	0	0
		5-Nov	n/r	53	44	0	97	1,764	0	0	0
		7-Nov	n/r	30	16	0	46	1,810	0	0	0
		9-Nov	n/r	59	29	0	88	1,898	0	0	1

Continued

Appendix 4. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by population group, population and date, for Fraser River sockeye salmon assessed using visual surveys, 1995 continued.

Stock group	Stock	Date	Live count	Carcasses recovered Male	Female	Jack	Total	Cum.	% spawned 0%	50%	100%
South	Momich River	12-Oct	1	0	0	0	0	0	0	0	0
Thompson		25-Oct	0	0	0	0	0	0	0	0	0
Late Run		30-Oct	0	0	0	0	0	0	0	0	0
continued	Nikwikwaia Creek	12-Oct	13	0	0	0	0	0	0	0	2
		19-Oct	369	1	0	0	1	1	0	0	0
		24-Oct	266	2	4	0	6	7	3	0	1
		29-Oct	142	1	5	0	6	13	5	0	0
		8-Nov	12	0	22	0	22	35	21	0	0
	Onyx Creek	14-Oct	0	0	0	0	0	0	0	0	0
		21-Oct	0	0	0	0	0	0	0	0	0
	Pass Creek	12-Oct	6	0	0	0	0	0	0	0	0
		23-Oct	21	0	0	0	0	0	0	0	0
		25-Oct	16	1	1	0	2	2	0	0	1
		30-Oct	8	1	5	0	6	8	0	1	4
		5-Nov	0	2	3	0	5	13	0	0	3
	Perry River	21-Oct	0	0	0	0	0	0	0	0	0
	Ross Creek	14-Oct	0	0	0	0	0	0	0	0	0
		21-Oct	0	0	0	0	0	0	0	0	0
	Salmon River	21-Oct	0	0	0	0	0	0	0	0	0
	(below fence)	31-Oct	0	0	0	0	0	0	0	0	0
		7-Nov	0	0	0	0	0	0	0	0	0
	Scotch Creek	11-Oct	258	7	5	0	12	12	2	0	3
		15-Oct	435	12	14	0	26	38	4	1	9
		22-Oct	1,115	34	27	0	61	99	13	2	12
		25-Oct	1,224	90	91	0	181	280	43	1	47
		30-Oct	510	51	69	0	120	400	44	0	25
		9-Nov	53	25	37	0	62	462	4	0	33
	Seymour River	19-Oct	0	0	0	0	0	0	0	0	0
		28-Oct	0	0	0	0	0	0	0	0	0
	S. Thompson River	14-Oct	150	0	0	0	0	0	0	0	0
		31-Oct	0	10	5	0	15	15	0	0	5
	Tappen Creek	16-Oct	0	0	0	0	0	0	0	0	0
		24-Oct	0	0	0	0	0	0	0	0	0
		7-Nov	0	0	0	0	0	0	0	0	0
	Shuswap Lake										
	Anstey Arm	15-Oct	414	0	0	0	0	0	0	0	0
		22-Oct	107	0	0	0	0	0	0	0	0
		1-Nov	18	0	0	0	13 [c]	13	0	0	0
	Main Arm	13-Oct	1,812	0	0	0	0	0	0	0	0
		20-Oct	1,544	0	0	0	0	0	0	0	0
		6-Nov	102	0	0	0	0	0	0	0	0
	Salmon Arm	14-Oct	246	0	0	0	0	0	0	0	0
		21-Oct	321	0	0	0	0	0	0	0	0
		24-Oct	0	1	5	0	6	6	2	0	3
		2-Nov	55	0	0	0	36 [c]	36	0	0	0
	Seymour Arm	19-Oct	0	0	0	0	0	0	0	0	0
		28-Oct	1	0	1	0	1	1	0	0	0
	Shuswap River										
	Shuswap R., lower	9-Oct	6,845	0	0	0	5 [c]	5	0	0	0
		17-Oct	6,403	0	0	0	0	5	0	0	0
		26-Oct	0	120	120	0	240	245	0	0	120
		4-Nov	38	0	0	0	0	245	0	0	0
	Shuswap R., middle	18-Oct	86	0	0	0	0	0	0	0	0
		29-Oct	75	1	20	0	21	21	0	0	20
		3-Nov	8	1	4	0	5	26	0	0	4
	Tsuius Creek	17-Oct	0	0	0	0	0	0	0	0	0

Continued

Appendix 4. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by population group, population and date, for Fraser River sockeye salmon assessed using visual surveys, 1995 continued.

Stock group	Stock	Date	Live count	Carcasses recovered Male	Female	Jack	Total	Cum.	% spawned 0%	50%	100%
	Wap Creek	17-Oct	0	0	0	0	0	0	0	0	0
North Thompson	Barriere River	4-Sep	63	0	0	0	0	0	0	0	0
	Fennell Creek	15-Aug	284	0	0	0	0	0	0	0	0
	(above fence)	24-Aug	4,305	19	19	0	38	38	12	0	4
		2-Sep	3,370	186	193	0	379	417	1	0	179
		9-Sep	407	190	283	0	473	890	1	1	272
	Fennell Creek	15-Aug	118	0	1	0	1	1	1	0	0
	(below fence)	2-Sep	65	0	0	0	0	1	0	0	0
		9-Sep	7	0	0	0	0	1	0	0	0
	Harper Creek	24-Aug	2	0	0	0	0	0	0	0	0
	North Thompson R.	17-Sep	2	0	0	0	0	0	0	0	0
	Raft River	18-Aug	0	0	0	0	0	0	0	0	0
		26-Aug	404	0	0	0	0	0	0	0	0
		4-Sep	568	8	5	0	13	13	1	0	4
		10-Sep	306	37	59	1	97	110	0	0	59
		17-Sep	29	10	47	0	57	167	1	0	46
Chilcotin	Taseko Lake	21-Sep	0	71	98	0	184 [C]	184	0	0	98
Quesnel	**Horsefly River**										
	Little Horsefly River	10-Sep	0	0	0	0	0	0	0	0	0
	McKinley Cr., lower	16-Sep	46	49	116	0	165	165	0	0	115
	McKinley Cr., upper	13-Sep	0	0	0	0	0	0	0	0	0
	Mitchell River										
	Mitchell River	1-Sep	13,710 [D]	0	0	0	50 [C]	50	0	0	0
		18-Sep	15,700 [D]	28	60	0	3,800 [C]	3,850	0	0	0
Stuart	**Driftwood River**										
Early Runs	Blackwater Creek	4-Aug	0 [D]	0	0	0	0	0	0	0	0
		10-Aug	83	11	3	0	14	14	0	1	2
	Driftwood River	4-Aug	1,993 [D]	0	0	0	10 [C]	10	0	0	0
	Kastberg Creek	4-Aug	0 [D]	0	0	0	0	0	0	0	0
	Kotsine River	4-Aug	0 [D]	0	0	0	0	0	0	0	0
	Lion Creek	4-Aug	50 [D]	0	0	0	0	0	0	0	0
	Porter Creek	10-Aug	360	69	61	0	284	284	3	0	58
	Takla Lake, N.E. Arm										
	Ankwill Creek	19-Jul	0	0	0	0	0	0	0	0	0
		27-Jul	303	0	0	0	2 [C]	2	0	0	0
		2-Aug	809	2	5	0	7	9	2	2	1
		8-Aug	808	8	7	0	15	24	3	0	4
		14-Aug	239	22	21	0	43	67	0	0	21
	Bates Creek	4-Aug	0	0	0	0	0	0	0	0	0
	Blanchette Creek	19-Jul	0	0	0	0	0	0	0	0	0
		27-Jul	0	0	0	0	0	0	0	0	0
		2-Aug	29	0	0	0	0	0	0	0	0
		8-Aug	86	2	0	0	2	2	0	0	0
		14-Aug	66	0	5	0	5	7	2	0	3
	Forsythe Creek	19-Jul	0	0	0	0	0	0	0	0	0
		27-Jul	17	0	0	0	0	0	0	0	0
		2-Aug	181	0	0	0	0	0	0	0	0
		8-Aug	340	12	3	0	15	15	1	0	2
		14-Aug	81	13	14	0	27	42	1	2	11
	French Creek	19-Jul	0	0	0	0	0	0	0	0	0
		27-Jul	0	0	0	0	0	0	0	0	0
		2-Aug	48	1	0	0	1	1	0	0	0
		8-Aug	51	3	0	0	3	4	0	0	0
		14-Aug	3	0	0	0	0	4	0	0	0

Continued

Appendix 4. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by population group, population and date, for Fraser River sockeye salmon assessed using visual surveys, 1995 continued.

Stock group	Stock	Date	Live count	Carcasses recovered Male	Female	Jack	Total	Cum.	% spawned 0%	50%	100%
Stuart	Frypan Creek	19-Jul	4	0	0	0	0	0	0	0	0
Early Runs		27-Jul	519	1	0	0	1	1	0	0	0
Continued		2-Aug	1,035	6	8	0	14	15	0	2	0
		8-Aug	956	52	55	0	107	122	17	0	38
		14-Aug	97	33	31	0	64	186	4	1	26
	Hudson's Bay Cr.	19-Jul	0	0	0	0	0	0	0	0	0
		27-Jul	0	0	0	0	0	0	0	0	0
		2-Aug	1	0	0	0	0	0	0	0	0
		8-Aug	0	0	0	0	0	0	0	0	0
		14-Aug	0	0	0	0	0	0	0	0	0
	Shale Creek	19-Jul	0	0	0	0	0	0	0	0	0
		27-Jul	109	0	0	0	0	0	0	0	0
		2-Aug	547	1	0	0	1	1	0	0	0
		8-Aug	731	12	12	0	24	25	2	0	10
		14-Aug	480	75	66	0	141	166	3	2	61
	Five Mile Creek	19-Jul	0	0	0	0	0	0	0	0	0
		27-Jul	0	0	0	0	0	0	0	0	0
		2-Aug	0	0	1	0	1	1	0	0	0
		8-Aug	91	8	4	0	12	13	2	0	2
		14-Aug	46	10	16	0	26	39	3	0	13
	Fifteen Mile Creek	19-Jul	0	0	0	0	0	0	0	0	0
		27-Jul	0	0	0	0	0	0	0	0	0
		2-Aug	6	0	0	0	0	0	0	0	0
		8-Aug	41	0	2	0	2	2	2	0	0
		14-Aug	42	1	3	0	4	6	0	1	2
	Twenty-five Mile Cr.	19-Jul	0	0	0	0	0	0	0	0	0
		27-Jul	7	0	0	0	0	0	0	0	0
		2-Aug	29	0	0	0	0	0	0	0	0
		8-Aug	306	2	0	0	2	2	0	0	0
		14-Aug	103	5	7	0	12	14	1	0	6
	Takla Lake, NW										
	Crow Creek	22-Jul	78	0	0	0	0	0	0	0	0
		29-Sep	317	2	2	0	4	4	2	0	0
		4-Aug	534	18	17	0	35	39	6	1	6
		10-Aug	283	124	155	0	279	318	8	1	146
		16-Aug	115	54	102	0	156	474	4	0	98
	Dust Creek	22-Jul	0	0	0	0	0	0	0	0	0
		29-Jul	608	2	2	0	4	4	2	0	0
		4-Aug	570	0	0	0	0	4	0	0	0
		10-Aug	433	161	165	0	326	330	4	2	159
		16-Aug	88	19	39	0	58	388	0	0	39
	Hooker Creek	22-Jul	0	0	0	0	0	0	0	0	0
		29-Jul	0	0	0	0	0	0	0	0	0
		4-Aug	83	0	0	0	0	0	0	0	0
		10-Aug	31	0	5	0	5	5	0	0	5
		16-Aug	5	0	3	0	3	8	0	0	3
	McDougall Creek	22-Jul	0	0	0	0	0	0	0	0	0
		29-Jul	0	0	0	0	0	0	0	0	0
		4-Aug	0	0	0	0	0	0	0	0	0
		10-Aug	0	0	0	0	0	0	0	0	0
	Point Creek	22-Jul	0	0	0	0	0	0	0	0	0
		29-Jul	83	0	0	0	0	0	0	0	0
		4-Sep	247	4	2	0	6	6	0	0	2
		10-Aug	233	8	6	0	14	20	1	0	5
		16-Aug	118	31	51	0	82	102	0	0	51

Continued

Appendix 4. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by population group, population and date, for Fraser River sockeye salmon assessed using visual surveys, 1995 continued.

Stock group	Stock	Date	Live count	Carcasses recovered: Male	Female	Jack	Total	Cum.	% spawned: 0%	50%	100%
Stuart	Sinta Creek	22-Jul	0	0	0	0	0	0	0	0	0
Early Runs		29-Jul	0	0	0	0	0	0	0	0	0
Continued		4-Aug	0	0	0	0	0	0	0	0	0
		10-Aug	0	0	0	0	0	0	0	0	0
	Takla Lake, S										
	Bivouac Creek	23-Jul	265	0	0	0	0	0	0	0	0
		26-Jul	784	2	1	0	3	3	0	0	1
		29-Jul	830	4	3	0	7	10	2	0	1
		4-Aug	1,409	74	77	0	151	161	24	0	50
		9-Sep	1,231	222	312	0	534	695	14	1	297
		14-Aug	452	356	552	0	908	1,603	0	0	552
	Gluske Creek	21-Jul	2,643	2	0	0	2	2	0	0	0
	(above fence)	24-Jul	3,215	8	6	0	14	16	5	1	0
		26-Jul	6,945	7	11	0	18	34	9	0	2
		28-Jul	8,826	54	58	0	112	146	32	4	21
		30-Jul	8,114	70	40	0	110	256	18	8	14
		1-Aug	6,989	112	79	0	191	447	37	6	36
		3-Aug	5,766	317	231	0	548	995	42	6	185
		5-Aug	8,580	623	475	0	1,098	2,093	141	22	312
		7-Aug	8,560	427	385	0	812	2,905	21	187	177
		9-Aug	4,933	1,104	1,190	0	2,294	5,199	227	4	959
		11-Aug	3,902	816	784	0	1,600	6,799	20	46	718
		13-Aug	3,113	997	1,314	0	2,311	9,110	22	5	1,287
		15-Aug	1,161	659	827	0	1,486	10,596	168	17	642
		17-Aug	189	217	410	0	627	11,223	0	0	410
	Gluske Creek	21-Jul	0	0	0	0	0	0	0	0	0
	(below fence)	24-Jul	300	0	1	0	1	1	1	0	0
		26-Jul	350	2	1	0	3	4	1	0	0
		1-Aug	972	0	0	0	0	4	0	0	0
		3-Aug	744	8	9	0	17	21	1	0	8
		5-Aug	790	12	11	0	23	44	7	0	4
		7-Aug	1,040	170	153	0	323	367	13	65	75
		9-Aug	582	31	48	0	79	446	5	0	43
		11-Aug	446	73	102	0	175	621	0	2	100
		13-Aug	674	56	58	0	114	735	1	0	57
		15-Aug	430	34	54	0	88	823	28	3	23
		17-Aug	284	40	42	0	82	905	0	0	42
	Leo Creek [E]	23-Jul	0	0	0	0	0	0	0	0	0
		2-Aug	0	0	0	0	0	0	0	0	0
		12-Aug	0	0	0	0	0	0	0	0	0
	Narrows Creek	23-Jul	96	0	0	0	0	0	0	0	0
		28-Jul	1,021	0	0	0	0	0	0	0	0
		2-Aug	1,614	15	13	0	28	28	13	0	0
		8-Aug	1,353	185	171	0	356	384	45	3	123
		12-Aug	342	194	191	0	385	769	10	15	166
		18-Aug	1,134	52	61	0	113	882	3	0	58
	Sakeniche Creek	22-Jul	0	0	0	0	0	0	0	0	0
		29-Jul	0	0	0	0	0	0	0	0	0
		4-Aug	1	3	0	0	3	3	0	0	0
		10-Aug	212	27	50	0	77	80	19	0	31
		11-Aug	550	89	111	0	200	280	7	1	103
		18-Aug	48	5	12	0	17	297	2	0	10
	Sandpoint Creek	22-Jul	112	0	1	0	1	1	1	0	0
		28-Jul	821	4	3	0	7	8	3	0	0
		2-Aug	907	7	19	0	26	34	17	0	2
		8-Aug	690	25	40	0	65	99	8	4	28

Continued

Appendix 4. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by population group, population and date, for Fraser River sockeye salmon assessed using visual surveys, 1995 continued.

Stock group	Stock	Date	Live count	Carcasses recovered Male	Female	Jack	Total	Cum.	% spawned 0%	50%	100%
Stuart	Sandpoint Creek	12-Aug	70	74	123	0	197	296	3	3	117
Early Runs	*continued*	18-Aug	2	6	11	0	17	313	0	0	11
Continued	**Middle River**										
	Baptiste Creek	5-Aug	0	0	0	0	0	0	0	0	0
	Forfar Creek	27-Jul	446	0	0	0	0	0	0	0	0
	(above fence)	24-Jul	2,743	2	3	0	5	5	3	0	0
		26-Jul	4,834	0	4	0	4	9	4	0	0
		28-Jul	4,590	11	13	0	24	33	12	0	1
		30-Jul	8,990	41	26	0	67	100	23	0	3
		1-Aug	4,620	20	22	0	44 [c]	144	9	0	13
		3-Aug	6,710	129	119	0	248	392	25	0	85
		5-Aug	11,234	422	295	0	717	1,109	17	30	257
		7-Aug	7,710	472	376	0	848	1,957	82	3	291
		9-Aug	6,978	607	678	1	1,286	3,243	89	3	583
		11-Aug	5,149	919	1,073	0	1,992	5,235	141	20	912
		13-Aug	3,001	760	828	0	1,588	6,823	54	36	738
		15-Aug	1,360	586	625	0	1,211	8,034	16	6	603
		17-Aug	726	404	502	0	906	8,940	0	0	502
	Forfar Creek	24-Jul	273	0	0	0	0	0	0	0	0
	(below fence)	30-Jul	3,000	0	11	0	11	11	11	0	0
		1-Aug	980	3	1	0	4	15	1	0	0
		3-Aug	1,187	12	11	0	23	38	1	0	10
		5-Aug	1,048	15	25	0	40	78	0	0	0
		7-Aug	1,210	32	26	0	58	136	9	0	17
		9-Aug	720	25	27	0	52	188	10	0	17
		11-Aug	550	46	45	0	91	279	6	2	37
		13-Aug	336	50	69	0	119	398	12	10	47
		15-Aug	440	16	33	0	49	447	2	0	31
		17-Aug	399	41	60	0	101	548	0	0	60
	Kynoch Creek	21-Jul	579	0	0	0	0	0	0	0	0
	(above fence)	24-Jul	6,742	2	0	0	2	2	0	0	0
		26-Jul	11,000	5	4	0	9	11	1	0	3
		28-Jul	6,915	15	12	0	27	38	11	0	1
		30-Jul	11,460	47	51	0	98	136	44	3	4
		1-Aug	11,110	132	85	0	217	353	43	8	28
		3-Aug	11,259	131	85	0	216	569	26	26	13
		5-Aug	12,257	500	346	0	846	1,415	162	5	177
		7-Aug	13,217	1,137	1,015	0	2,152	3,567	59	10	946
		9-Aug	12,702	1,439	1,773	0	3,212	6,779	54	18	1,641
		11-Aug	10,050	1,706	1,801	0	3,507	10,286	66	6	1,729
		13-Aug	7,538	1,441	1,592	0	3,033	13,319	109	6	1,477
		15-Aug	3,238	1,114	1,216	0	2,330	15,649	0	0	1,216
		17-Aug	2,454	651	756	0	1,407	17,056	57	3	696
	Kynoch Creek	21-Jul	600	1	0	0	1	1	0	0	0
	(below fence)	24-Jul	1,880	2	6	0	8	9	4	1	1
		26-Jul	1,240	3	2	0	5	14	2	0	0
		28-Jul	1,740	2	3	0	5	19	3	0	0
		30-Jul	900	2	3	0	5	24	3	0	0
		1-Aug	840	4	3	0	7	31	3	0	0
		3-Aug	600	0	0	0	0	31	0	0	0
		5-Aug	1,410	6	8	0	14	45	6	0	2
		7-Aug	1,527	7	12	0	19	64	2	0	10
		9-Sep	1,480	21	44	0	65	129	2	0	42
		11-Aug	1,500	93	89	0	182	311	3	0	86
		13-Aug	1,440	48	52	0	100	411	4	0	48

Continued

Appendix 4. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by population group, population and date, for Fraser River sockeye salmon assessed using visual surveys, 1995 continued.

				Carcasses recovered					% spawned		
Stock group	Stock	Date	Live count	Male	Female	Jack	Total	Cum.	0%	50%	100%
Stuart	Kynoch Creek	15-Aug	700	143	228	0	371	782	0	0	228
Early Runs	*continued*	17-Aug	570	70	112	0	182	964	10	0	102
Continued	Middle River	7-Aug	90	0	0	0	0	0	0	0	0
	Rossette Creek	21-Jul	1,391	0	0	0	5 [C]	5	0	0	0
		24-Jul	5,870	1	0	0	4 [C]	9	0	0	0
		26-Jul	4,994	22	21	0	43	52	11	0	10
		28-Jul	5,470	27	60	0	108 [C]	160	60	0	0
		30-Jul	4,763	100	133	0	263 [C]	423	86	0	47
		1-Aug	7,500	125	115	0	246 [C]	669	20	2	93
		3-Aug	6,900	518	505	0	1,023	1,692	174	8	323
		5-Aug	6,036	523	616	0	1,139	2,831	128	65	419
		7-Aug	4,810	1,429	1,077	1	2,507	5,338	53	0	1024
		9-Aug	6,311	611	726	0	1,337	6,675	32	25	669
		11-Aug	3,196	838	1,072	0	1,925 [C]	8,600	33	10	1029
		13-Aug	1,730	769	1,026	0	1,795	10,395	0	3	1023
		15-Aug	1,562	344	201	0	545	10,940	0	0	204
		17-Aug	1,176	233	438	0	671	11,611	52	6	380
	Trembleur Lake										
	Felix Creek	20-Jul	81	0	0	0	0	0	0	0	0
		25-Jul	4,258	1	4	0	5	5	4	0	0
		31-Jul	4,960	60	48	0	108	113	33	0	15
		6-Aug	6,301	738	487	0	1,225	1,338	28	3	456
		12-Aug	1,590	696	740	0	1,436	2,774	11	0	729
	Fleming Creek	4-Aug	3,464 [D]	0	0	0	12 [C]	12	0	0	0
	Paula Creek	20-Jul	361	1	0	0	7 [C]	7	0	0	0
		25-Jul	5,202	14	15	0	29	36	9	1	5
		31-Jul	6,480	157	152	0	309	345	32	33	87
		6-Aug	4,004	1,200	1,183	0	2,383	2,728	206	248	729
		12-Aug	1,072	915	1,099	0	2,014	4,742	72	0	1,027
Stuart	Kazchek Creek	23-Sep	34 [D]	0	0	0	24 [C]	24	0	0	0
Summer Runs	Kuzkwa Creek	23-Sep	1,333 [D]	0	0	0	492 [C]	492	0	0	0
	Middle River	23-Sep	2,340 [D]	0	0	0	1,805 [C]	1,805	0	0	0
	Pinchi Creek	23-Sep	340 [D]	0	0	0	294 [C]	294	0	0	0
	Sakeniche River	23-Sep	0 [D]	0	0	0	0	0	0	0	0
	Sowchea Creek	23-Sep	0 [D]	0	0	0	0	0	0	0	0
	Tachie River	23-Sep	11,050 [D]	0	0	0	1,377 [C]	0	0	0	0
Nechako	Nadina River	[B]	2,500	0	0	0	0	0	0	0	0
Upper Fraser	Bowron R, upper	20-Jul	0	0	0	0	0	0	0	0	0
		27-Jul	-	0	1	0	1	1	1	0	0
		29-Jul	-	0	1	0	1	2	1	0	0
		30-Jul	-	0	1	0	1	3	1	0	0
		4-Aug	58	0	1	0	1	4	1	0	0
		7-Aug	24	0	0	0	0	4	0	0	0
		10-Aug	209	1	0	0	1	5	0	0	0
		12-Aug	-	2	0	0	2	7	0	0	0
		15-Aug	414	1	2	0	3	10	2	0	0
		19-Aug	833	7	8	0	15	25	0	0	0
		21-Aug	-	0	2	0	2	27	0	0	0
		22-Aug	2,370	45	45	0	90	117	2	0	0
		23-Aug	3,652	13	12	0	25	142	0	0	2
		25-Aug	-	69	73	0	142	284	9	1	5
		26-Aug	3,222	36	44	0	80	364	0	0	2
		27-Aug	-	100	82	0	182	546	1	0	8
		28-Aug	3,099	29	42	0	71	617	1	0	3
		29-Aug	-	149	143	0	292	909	0	0	13

Continued

Appendix 4. Daily live counts, male, female and jack carcass recoveries, and female spawning success, by population group, population and date, for Fraser River sockeye salmon assessed using visual surveys, 1995 continued.

Stock group	Stock	Date	Live count	Carcasses recovered: Male	Female	Jack	Total	Cum.	% spawned: 0%	50%	100%
Upper Fraser	Bowron R, upper	30-Aug	3,461	71	79	0	150	1,059	0	0	2
continued	*continued*	31-Aug	-	105	116	0	221	1,280	3	0	13
		1-Sep	10,493 [D]	0	0	0	0	1,280	0	0	0
		2-Sep	-	165	172	0	337	1,617	1	0	10

[A.] Includes recoveries field identified as jacks which scale evaluation confirmed as an adult.
[B.] Dates of recoveries not available (data supplied by SEP).
[C.] Includes unsexed dead recorded but not sampled during a live enumeration survey.
[D.] Observation from helicopter overflight.
[E.] Fish passage into stream blocked by numerous beaver dams.

Appendix 5. Number of surveys, peak live counts, cumulative dead counts, expansion factors, spawning success, and escapement of sockeye adults (by sex) and jacks, by population group and population, for Fraser River sockeye salmon assessed using visual surveys, 1995.

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
Lower Fraser	Chilliwack Lake	5	30	246	3.6	88.3%	-	576	392	20
	Nahatlatch Lake	5	8	123	3.8	73.6%	-	272	213	8
	Nahatlatch River	4	994	26	1.8	87.8%	-	906	906	24
	Widgeon Slough	3	61	5	1.8	89.7%	-	50	69	0
Harrison-Lillooet	Big Silver Creek	3	782	86	1.8	86.9%	-	769	744	49
	Harrison River	5	9,311	0	1.8	99.0%	- [B]	9,795	6,823	142
	Samson Creek	2	60	18	1.8	94.4%	-	62	70	8
	Weaver Creek [C]	10	n/a	5,157	1.8	56.0%	-	5,425	3,779	79
Seton-Anderson	Gates Creek	7	9,888	0	1.8	98.3%	-	2,570	4,611	10,617
	Portage Creek	3	4,589	104	1.8	92.6%	-	3,209	4,666	572
South Thompson *Early Sum-mer Runs*	Adams Channel	1	0	0	-	-	-	0	0	0
	Adams River, lower	1	0	0	-	-	-	0	0	0
	Adams River, upper	4	50	0	1.8	100.0%	-	36	54	0
	Anstey River	4	1,971	8	1.8	100.0%	-	2,346	1,216	0
	Cayenne Creek	4	25	1	1.8	100.0%	-	9	38	0
	Celista Creek	4	116	0	1.8	100.0%	- [D]	101	108	0
	Eagle River	4	1,050	0	1.8	100.0%	-	711	1,179	0
	Hiuihill Creek	1	0	0	-	-	-	0	0	0
	Hunakwa Creek	2	0	7	1.8	100.0%	-	7	6	0
	McNomee Creek	9	4,330	147	1.8	99.8%	-	4,239	3,820	0
	Nikwikwaia Creek	1	0	0	-	-	-	0	0	0
	Onyx Creek	1	0	0	-	-	-	0	0	0
	Perry River	4	131	0	1.8	100.0%	- [E]	89	147	0
	Salmon River	1	0	0	-	-	-	0	0	0
	Scotch, above fence	5	9,592	572	1.4	98.1%	-	6,746	7,878	1
	Scotch, below fence	4	58 [F]	48	1.4	100.0%	-	68	80	0
	Yard Creek	4	854	9	1.8	100.0%	-	691	862	0
South Thompson *Late Runs*	Adams Channel [G]	21	111	1,399	1.0	89.4%	-	832	678	0
	Adams Lake	2	65	1	1.8	93.7%	- [H]	59	60	0
	Adams River, upper	2	0	0	-	-	-	0	0	0
	Anstey River	3	52	0	1.8	93.7%	- [H]	46	48	0
	Bush Creek	1	0	0	-	-	-	0	0	0
	Canoe Creek	2	0	1	1.8	93.7%	- [H]	1	1	0
	Cayenne Creek	1	0	0	-	-	-	0	0	0
	Celista Creek	2	0	0	-	-	-	0	0	0
	Eagle River	1	476	0	1.8	93.7%	- [H]	411	446	0
	Hiuihill Creek	5	217	19	1.8	100.0%	-	226	199	0
	Hunakwa Creek	3	14	1	1.8	93.7%	- [H]	14	14	0
	Little River	19	4,900	96	1.8	82.6%	-	5,284	3,840	0
	Momich River	3	1	0	1.8	93.7%	- [H]	1	1	0
	Nikwikwaia Creek	5	369	1	1.8	95.2%	- [H]	328	338	0
	Onyx Creek	2	0	0	-	-	-	0	0	0
	Pass Creek	5	21	0	1.8	94.4%	-	12	26	0
	Perry River	1	0	0	-	-	-	0	0	0
	Ross Creek	2	0	0	-	-	-	0	0	0
	Salmon R, blw. fence	3	0	0	-	-	-	0	0	0
	Scotch Creek	6	1,224	280	1.8	53.9%	-	1,283	1,424	0
	Seymour River	2	0	0	-	-	-	0	0	0
	S. Thompson R.	2	150	0	1.8	100.0%	-	156	114	0
	Tappen Creek	3	0	0	-	-	-	0	0	0

Continued

Appendix 5. Number of surveys, peak live counts, cumulative dead counts, expansion factors, spawning success, and escapement of sockeye adults (by sex) and jacks, by population group and population, 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	**Shuswap Lake**									
Thompson	Anstey Arm	3	414	0	1.8	93.7%	- [H]	357	388	0
Late Runs	Main Arm	3	1,812	0	1.8	93.7%	- [H]	1,503	1,759	0
Continued	Salmon Arm	4	321	0	1.8	60.0%	- [H]	277	301	0
	Seymour Arm	2	1	1	1.8	93.7%	- [H]	2	2	0
	Shuswap River									
	Shuswap R., lower	4	6,845	5	1.8	100.0%	- [H]	5,911	6,419	0
	Shuswap R., middle	3	86	0	1.8	100.0%	- [H]	74	81	0
	Tsuius Creek	1	0	0	-	-	-	0	0	0
	Wap Creek	1	0	0	-	-	-	0	0	0
North	Barriere River	1	63	0	1.8	96.6%	- [I]	51	62	0
Thompson	Fennell, above fence	4	4,305	38	2.6	96.6%	-	5,048	6,194	14
	Fennell, below fence	3	0 [F]	1	2.6	0.0%	-	0	3	0
	Harper Creek	1	2	0	1.8	96.6%	- [I]	2	2	0
	North Thompson R.	1	2	0	1.8	98.2%	- [J]	1	3	0
	Raft River	5	568	13	1.8	98.2%	-	345	695	6
Chilcotin	Taseko Lake [K]	1	n/a	184	10.0	100.0%	-	773	1,067	0
Quesnel	**Horsefly River**									
	Little Horsefly River	1	0	0	-	-	-	0	0	0
	McKinley Cr., lower	1	46	165	1.8	100.0%	-	113	267	0
	McKinley Cr., upper	1	0	0	-	-	-	0	0	0
	Mitchell River									
	Mitchell River	2	15,700	3,850	1.8	97.3%	- [L]	15,693	19,497	0
Stuart	**Driftwood River**									
Early Runs	Blackwater Creek	2	83	14	1.5	83.3%	- [M]	77	69	0
	Driftwood River	1	1,993	10	1.5	95.1%	- [M]	1,595	1,410	0
	Kastberg Creek	1	0	0	-	-	-	0	0	0
	Kotsine River	1	0	0	-	-	-	0	0	0
	Lion Creek	1	50	0	1.5	95.1%	- [M]	40	35	0
	Porter Creek	1	360	284	1.5	95.1%	-	513	453	0
	Takla Lake, N.E. Arm									
	Ankwill Creek	5	809	9	1.5	81.8%	- [N]	588	639	0
	Bates Creek	1	0	0	-	-	-	0	0	0
	Blanchette Creek	5	86	2	1.5	87.7%	- [N]	63	69	0
	Forsythe Creek	5	340	15	1.5	82.4%	- [N]	256	277	0
	French Creek	5	51	4	1.5	87.7%	- [N]	40	43	0
	Frypan Creek	5	1,035	15	1.5	72.9%	-	779	796	0
	Hudson's Bay Cr.	5	1	0	1.5	87.7%	- [N]	1	1	0
	Shale Creek	5	731	25	1.5	92.3%	-	601	533	0
	Five Mile Creek	5	91	13	1.5	71.4%	-	72	84	0
	Fifteen Mile Creek	5	42	6	1.5	87.7%	- [N]	35	37	0
	Twenty-five Mile Cr.	5	306	2	1.5	87.7%	- [N]	222	240	0
	Takla Lake, N.W. Arm									
	Crow Creek	5	534	39	1.5	91.7%	-	359	501	0
	Dust Creek	5	608	4	1.5	96.6%	-	431	487	0
	Hooker Creek	5	83	0	1.5	100.0%	- [N]	60	65	0
	McDougall Creek	4	0	0	-	-	-	0	0	0
	Point Creek	5	247	6	1.5	98.3%	-	160	220	0
	Sinta Creek	4	0	0	-	-	-	0	0	0

Continued

Appendix 5. Number of surveys, peak live counts, cumulative dead counts, expansion factors, spawning success, and escapement of sockeye adults (by sex) and jacks, by population group and population, 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	**Takla Lake, S. Arm**									
Early Runs	Bivouac Creek	6	1,409	161	1.5	95.4%	-	967	1,388	0
Continued	Gluske Cr., above	14	8,826	146	1.7	84.6%	-	6,826	8,217	1
	Gluske Cr., below	12	430	823	1.7	80.8%	-	1,003	1,127	0
	Leo Creek	3	0	0	-	-	-	0	0	0
	Narrows Creek	6	1,614	28	1.5	81.7%	-	1,245	1,218	0
	Sakeniche River	6	550	280	1.5	83.5%	-	520	725	0
	Sandpoint Creek	6	907	34	1.5	82.0%	-	523	889	0
	Middle River									
	Baptiste Creek	1	0	0	-	-	-	0	0	0
	Forfar Cr., above	14	11,234	1,109	1.3	88.5%	-	7,144	9,332	2
	Forfar Cr., below	11	440	447	1.3	73.1%	-	505	648	0
	Kynock Cr., above	14	13,217	3,567	1.6	92.1%	-	12,454	14,529	2
	Kynoch Cr., below	14	700	782	1.6	92.4%	-	989	1,382	0
	Middle River	1	90	0	1.5	88.2% [O]	- [O]	65	70	0
	Rossette Creek	14	7,500	669	1.5	88.2%	-	5,887	6,366	1
	Trembleur Lake									
	Felix Creek	5	6,301	1,338	1.5	93.9%	-	6,176	5,283	0
	Fleming Creek	1	3,464	12	1.5	81.2% [P]	- [P]	2,518	2,696	0
	Paula Creek	5	6,480	345	1.5	81.2%	-	4,944	5,294	0
Stuart	Kazchek Creek	1	34	24	1.8	100.0% [Q]	- [Q]	52	52	0
Summer Runs	Kuzkwa River	1	1,333	492	1.8	100.0% [Q]	- [Q]	1,643	1,643	0
	Middle River	1	2,340	1,805	1.8	100.0% [Q]	- [Q]	3,731	3,731	0
	Pinchi Creek	1	340	294	1.8	100.0% [Q]	- [Q]	571	571	0
	Sakeniche River.	1	0	0	-	-	-	0	0	0
	Sowchea Creek	1	0	0	-	-	-	0	0	0
	Tachie River	1	11,050	1,377	1.8	100.0% [Q]	- [Q]	11,184	11,184	0
Nechako	Nadina River	n/a	2,500	0	1.0	69.4% [R]	- [R]	1,230	1,269	1
Upper Fraser	Bowron River	22	10,285	1,280	2.9	80.1%	-	17,598	16,819	14

A. Noted only when insufficient survey data were available for that stock.
B. Weaver Creek estimate.
C. Estimated from total dead count; live count included non-local migrants.
D. Seymour River estimate.
E. Eagle River estimate.
F. Live count (Appendix 4) minus subsequent fence count (Appendix 3).
G. Estimate is cum. dead plus live count (111) on last survey.
H. Adams River estimate.
I. Fennell Creek estimate
J. Raft River estimate
K. Turbidity prevented live counts.
L. Horsefly River estimate.
M. Porter Creek estimate.
N. Takla Lake stocks composite estimate.
O. Rossette Creek estimate.
P. Paula Creek estimate.
Q. Sex ratio and success of spawn assumed.
R. Nadina Channel estimate, data provided by HEB.

Appendix 6. Period of peak spawning, adult and jack escapement, spawning success, and the number of females that spawned successfully, by population group, population and estimation method, for Fraser River sockeye salmon, 1995. [A]

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	988	968	20	576	392	88.3%	346	Visual
	Cultus Lake	Early Dec	10,349	10,316	33	4,744	5,572	76.8%	4,279	Fence
	Nahatlatch Lake	06-Sep to 13-Sep	493	485	8	272	213	73.6%	157	Visual
	Nahatlatch River	06-Sep to 13-Sep	1,836	1,812	24	906	906	87.8%	796	Visual
	Pitt River, upper	-	5,500	5,500	0	2,887	2,613	90.0%	2,352	Visual
	Widgeon Slough	10-Nov to 16-Nov	119	119	0	50	69	89.7%	62	Visual
	Total	**-**	**19,285**	**19,200**	**85**	**9,435**	**9,765**	**81.8%**	**7,992**	**-**
Harrison-Lillooet	Big Silver Creek	25-Sep to 01-Oct	1,562	1,513	49	769	744	86.9%	646	Visual
	Birkenhead River	20-Sep to 26-Sep	42,985	39,846	3,139	19,838	20,008	93.1%	18,604	M.R.
	Harrison River	01-Nov to 10-Nov	16,760	16,618	142	9,795	6,823	99.0%	6,757	Visual
	Samson Creek	-	140	132	8	62	70	94.4%	66	Visual
	Weaver Channel	12-Oct to 16-Oct	20,499	20,262	237	8,637	11,625	69.5%	8,077	Census
	Weaver Creek	12-Oct to 16-Oct	12,942	12,863	79	7,820	5,043	56.0%	2,826	Visual
	Total	**-**	**94,888**	**91,234**	**3,654**	**46,921**	**44,313**	**83.4%**	**36,976**	**-**
Seton-Anderson	Gates Creek	31-Aug to 06-Sep	17,798	7,181	10,617	2,570	4,611	98.3%	4,533	Visual
	Portage Creek	03-Nov to 09-Nov	8,447	7,875	572	3,209	4,666	92.6%	4,319	Visual
	Total	**-**	**26,245**	**15,056**	**11,189**	**5,779**	**9,277**	**95.4%**	**8,852**	**-**
South Thompson *Early Summer Runs*	Adams Channel	-	0	0	0	0	0	-	0	Visual
	Adams R., lower	-	0	0	0	0	0	-	0	Visual
	Adams R., upper	02-Sep to 07-Sep	90	90	0	36	54	100.0%	54	Visual
	Anstey River	29-Aug to 05-Sep	3,562	3,562	0	2,346	1,216	100.0%	1,216	Visual
	Cayenne Creek	28-Aug to 07-Sep	47	47	0	9	38	100.0%	38	Visual
	Celista Creek	02-Sep to 07-Sep	209	209	0	101	108	100.0%	108	Visual
	Eagle River	30-Aug to 06-Sep	1,890	1,890	0	711	1,179	100.0%	1,179	Visual
	Hiuihill Creek	-	0	0	0	0	0	-	0	Visual
	Hunakwa Creek	-	13	13	0	7	6	100.0%	6	Visual
	McNomee Creek	03-Sep to 07-Sep	8,059	8,059	0	4,239	3,820	99.8%	3,810	Visual
	Nikwikwaia Creek	-	0	0	0	0	0	-	0	Visual
	Onyx Creek	-	0	0	0	0	0	-	0	Visual
	Perry River	01-Sep to 06-Sep	236	236	0	89	147	100.0%	147	Visual
	Salmon River	-	0	0	0	0	0	-	0	Visual
	Scotch Creek	29-Aug to 03-Sep	14,773	14,772	1	6,814	7,958	98.1%	7,810	Fence
	Seymour River	06-Sep to 12-Sep	40,687	40,687	0	20,224	20,463	98.3%	20,091	M.R.
	Yard Creek	30-Aug to 06-Sep	1,553	1,553	0	691	862	100.0%	862	Visual
	Total	**-**	**71,119**	**71,118**	**1**	**35,267**	**35,851**	**98.6%**	**35,321**	**-**
South Thompson *Late Runs*	Adams Channel	07-Oct to 16-Oct	1,510	1,510	0	832	678	89.4%	606	Visual
	Adams Lake	-	119	119	0	58	61	94.4%	58	Visual
	Adams R., lower	07-Oct to 16-Oct	394,250	394,250	0	191,690	202,560	94.5%	191,372	M.R.
	Adams R., upper	-	0	0	0	0	0	-	0	Visual
	Anstey River	20-Oct to 25-Oct	94	94	0	46	48	93.7%	45	Visual
	Bush Creek	-	0	0	0	0	0	-	0	Visual
	Canoe Creek	-	2	2	0	1	1	93.7%	1	Visual
	Cayenne Creek	-	0	0	0	0	0	-	0	Visual
	Celista Creek	-	0	0	0	0	0	-	0	Visual
	Eagle River	-	857	857	0	411	446	93.7%	418	Visual
	Hiuihill Creek	16-Oct to 24-Oct	425	425	0	226	199	100.0%	199	Visual
	Hunakwa Creek	-	28	28	0	14	14	93.7%	13	Visual
	Little River	07-Oct to 16-Oct	9,124	9,124	0	5,284	3,840	77.7%	2,984	Visual
	Momich River	-	2	2	0	1	1	94.4%	1	Visual
	Nikwikwaia Creek	16-Oct to 24-Oct	666	666	0	325	341	95.2%	324	Visual
	Onyx Creek	-	0	0	0	0	0	-	0	Visual
	Pass Creek	-	38	38	0	12	26	94.4%	25	Visual
	Perry River	-	0	0	0	0	0	-	0	Visual
	Ross Creek	-	0	0	0	0	0	-	0	Visual
	Salmon River	-	8	8	0	5	3	100.0%	3	Fence
	Scotch Creek	20-Oct to 25-Oct	2,707	2,707	0	1,283	1,424	60.3%	859	Visual
	Seymour River	-	0	0	0	0	0	-	0	Visual
	S. Thompson R.	-	270	270	0	156	114	100.0%	114	Visual
	Tappen Creek	-	0	0	0	0	0	-	0	Visual

Continued

Appendix 6. Period of peak spawning, adult and jack escapement, spawning success, and the number of females that spawned successfully, by population group, population and estimation method, for Fraser River sockeye salmon, 1995 continued. [A]

Stock Group	Stock	Period of peak spawning	Escapement Total	Adults	Jacks	Males	Females	Percent spawning success	Effective females	Estimation method
South	**Shuswap Lake**									
Thompson	Anstey Arm	10-Oct to 18-Oct	745	745	0	357	388	93.7%	363	Visual
Late Runs	Main Arm	20-Oct to 25-Oct	3,262	3,262	0	1,503	1,759	93.7%	1,648	Visual
continued	Salmon Arm	20-Oct to 25-Oct	578	578	0	277	301	60.0%	181	Visual
	Seymour Arm	-	4	4	0	2	2	93.7%	2	Visual
	Shuswap River									
	Shuswap R., lower	10-Oct to 18-Oct	12,330	12,330	0	5,911	6,419	100.0%	6,419	Visual
	Shuswap R., middle	-	155	155	0	74	81	100.0%	81	Visual
	Tsuius Creek	-	0	0	0	0	0	-	0	Visual
	Wap Creek	-	0	0	0	0	0	-	0	Visual
	Total	**-**	**427,174**	**427,174**	**0**	**208,468**	**218,706**	**94.1%**	**205,716**	**-**
North	Barriere River	**-**	113	113	0	51	62	96.6%	60	Visual
Thompson	Fennell Creek	24-Aug to 02-Sep	11,259	11,245	14	5,048	6,197	96.6%	5,986	Fence
	Harper Creek	**-**	4	4	0	2	2	96.6%	2	Visual
	North Thompson River	**-**	4	4	0	1	3	98.2%	3	Visual
	Raft River	01-Sep to 09-Sep	1,046	1,040	6	345	695	98.2%	682	Visual
	Total	**-**	**12,426**	**12,406**	**20**	**5,447**	**6,959**	**96.8%**	**6,733**	**-**
Chilcotin	Chilko Channel	18-Sep to 24-Sep	8,486	8,316	170	3,892	4,424	80.4%	3,558	Census
	Chilko River and Lake	18-Sep to 24-Sep	539,269	536,048	3,221	221,058	314,990	93.5%	294,469	M.R.
	Taseko Lake	-	1,840	1,840	0	773	1,067	100.0%	1,067	Visual
	Total	**-**	**549,595**	**546,204**	**3,391**	**225,723**	**320,481**	**93.3%**	**299,094**	**-**
Quesnel	**Horsefly River**									
	Horsefly Channel	07-Sep to 11-Sep	16,263	16,263	0	6,655	9,608	97.3%	9,349	Census
	Horsefly River	07-Sep to 11-Sep	164,230	164,229	1	73,519	90,710	97.3%	88,212	M.R.
	Little Horsefly River	-	0	0	0	0	0	-	0	Visual
	McKinley Creek, lower	-	380	380	0	113	267	100.0%	267	Visual
	McKinley Creek, upper	-	0	0	0	0	0	-	0	Visual
	Moffat Creek	-	0	0	0	0	0	-	0	Visual
	Mitchell River									
	Mitchell River	-	35,190	35,190	0	15,693	19,497	97.4%	18,990	Visual
	Total	**-**	**216,063**	**216,062**	**1**	**95,980**	**120,082**	**97.3%**	**116,818**	**-**
Stuart	**Driftwood River**									
Early Runs	Blackwater River	Early August	146	146	0	77	69	83.3%	57	Visual
	Driftwood River	Early August	3,005	3,005	0	1,595	1,410	95.1%	1,341	Visual
	Kastberg Creek	-	0	0	0	0	0	-	0	Visual
	Kotsine River	-	0	0	0	0	0	-	0	Visual
	Lion Creek	Early August	75	75	0	40	35	95.1%	33	Visual
	Porter Creek	Early August	966	966	0	513	453	95.1%	431	Visual
	Takla Lake, N.E. Arm									
	Ankwill Creek	02-Aug to 08-Aug	1,227	1,227	0	588	639	81.8%	523	Visual
	Bates Creek	-	0	0	0	0	0	-	0	Visual
	Blanchette Creek	05-Aug to 11-Aug	132	132	0	63	69	87.7%	61	Visual
	Forsythe Creek	05-Aug to 11-Aug	533	533	0	256	277	82.4%	228	Visual
	French Creek	-	83	83	0	40	43	87.7%	38	Visual
	Frypan Creek	02-Aug to 08-Aug	1,575	1,575	0	779	796	72.9%	580	Visual
	Hudson's Bay Cr.	-	2	2	0	1	1	87.7%	1	Visual
	Shale Creek	05-Aug to 11-Aug	1,134	1,134	0	601	533	92.3%	492	Visual
	Five Mile Creek	05-Aug to 11-Aug	156	156	0	72	84	71.4%	60	Visual
	Fifteen Mile Creek	08-Aug to 15-Aug	72	72	0	35	37	87.7%	32	Visual
	Twenty-five Mile Cr.	08-Aug to 15-Aug	462	462	0	222	240	87.7%	211	Visual
	Takla Lake, N.W. Arm									
	Crow Creek	04-Aug to 10-Aug	860	860	0	359	501	91.7%	459	Visual
	Dust Creek	04-Aug to 10-Aug	918	918	0	431	487	96.6%	470	Visual
	Hooker Creek	04-Aug to 10-Aug	125	125	0	60	65	100.0%	65	Visual
	McDougall Creek	-	0	0	0	0	0	-	0	Visual
	Point Creek	10-Aug to 14-Aug	380	380	0	160	220	98.3%	216	Visual
	Sinta Creek	-	0	0	0	0	0	-	0	Visual
	Takla Lake, S. Arm									
	Bivouac Creek	01-Aug to 07-Aug	2,355	2,355	0	967	1,388	95.4%	1,324	Visual
	Gluske Creek	01-Aug to 07-Aug	17,199	17,198	1	7,829	9,369	84.3%	7,877	Fence

Continued

Appendix 6. Period of peak spawning, adult and jack escapement, spawning success, and the number of females that spawned successfully, by population group, population and estimation method, for Fraser River sockeye salmon, 1995 continued. [A]

Stock Group	Stock	Period of peak spawning	Escapement Total	Adults	Jacks	Males	Females	Percent spawning success	Effective females	Estimation method
Stuart	Leo Creek	-	0	0	0	0	0	-	0	Visual
Early Runs	Narrows Creek	02-Aug to 08-Aug	2,463	2,463	0	1,245	1,218	81.7%	995	Visual
cont'd	Sakeniche River	02-Aug to 08-Aug	1,245	1,245	0	520	725	83.5%	606	Visual
	Sandpoint Creek	02-Aug to 08-Aug	1,412	1,412	0	523	889	82.0%	729	Visual
	Middle River									
	Baptiste Creek	-	0	0	0	0	0	-	0	Visual
	Forfar Creek	03-Aug to 09-Aug	17,656	17,654	2	7,649	10,005	87.5%	8,733	Fence
	Kynock Creek	03-Aug to 09-Aug	29,381	29,379	2	13,443	15,936	92.1%	14,652	Fence
	Middle River	-	135	135	0	65	70	88.2%	62	Visual
	Rossette Creek	01-Aug to 05-Aug	12,254	12,253	1	5,887	6,366	88.2%	5,612	Visual
	Trembleur Lake									
	Felix Creek	31-Jul to 05-Aug	11,459	11,459	0	6,176	5,283	93.9%	4,963	Visual
	Fleming Creek	-	5,214	5,214	0	2,518	2,696	81.2%	2,190	Visual
	Paula Creek	28-Jul to 03-Aug	10,238	10,238	0	4,944	5,294	81.2%	4,300	Visual
	Total	**-**	**122,862**	**122,856**	**6**	**57,658**	**65,198**	**88.1%**	**57,341**	**-**
Stuart	Kazchek Creek	Late Sep	104	104	0	52	52	100.0%	52	Visual
Summer	Kuzkwa River	Late Sep	3,286	3,286	0	1,643	1,643	100.0%	1,643	Visual
Runs	Middle River	Late Sep	7,462	7,462	0	3,731	3,731	100.0%	3,731	Visual
	Pinchi Creek	Late Sep	1,142	1,142	0	571	571	100.0%	571	Visual
	Sakeniche River.	**-**	0	0	0	0	0	-	0	Visual
	Sowchea Creek	**-**	0	0	0	0	0	-	0	Visual
	Tachie River	Late Sep	22,368	22,368	0	11,184	11,184	100.0%	11,184	Visual
	Total	**-**	**34,362**	**34,362**	**0**	**17,181**	**17,181**	**100.0%**	**17,181**	**-**
Nechako	Nadina Channel	19-Sep to 23-Sep	21,506	21,499	7	10,583	10,916	69.4%	7,572	Census
	Nadina River	19-Sep to 23-Sep	2,500	2,499	1	1,230	1,269	69.4%	880	Visual
	Stellako River	22-Sep to 27-Sep	122,780	122,676	104	65,167	57,509	71.6%	41,135	Fence
	Total	**-**	**146,786**	**146,674**	**112**	**76,980**	**69,694**	**71.1%**	**49,587**	**-**
Upper Fraser	Bowron River	Early Sep	34,431	34,417	14	17,598	16,819	80.1%	13,467	Fence
	Total		**34,431**	**34,417**	**14**	**17,598**	**16,819**	**80.1%**	**13,467**	
Total	**Early Runs**	**-**	**122,862**	**122,856**	**6**	**57,658**	**65,198**	**87.9%**	**57,341**	**-**
	Early Summer Runs	**-**	**170,437**	**159,725**	**10,712**	**78,109**	**81,616**	**89.7%**	**73,224**	**-**
	Summer Runs	**-**	**920,960**	**917,464**	**3,496**	**403,278**	**514,186**	**92.0%**	**473,161**	**-**
	Late Runs	**-**	**540,977**	**536,718**	**4,259**	**263,392**	**273,326**	**92.0%**	**251,352**	**-**
	Total	**-**	**1,755,236**	**1,736,763**	**18,473**	**802,437**	**934,326**	**91.5%**	**855,078**	**-**

[A] Escapement estimates do not include fish sold as surplus to channel requirements or females taken for fecundity sampling.