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Enumeration of the 1988-1992 Squamish River Chinook Salmon Escapement

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ABSTRACT

Schubert, N.D. 1993. Enumeration of the 1988-1992 Squamish River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2187: 96 p.

The Department of Fisheries and Oceans committed, through the 1985 Pacific Salmon Treaty and the 1988 southern Strait of Georgia conservation initiative, to rebuild the southern Strait of Georgia chinook salmon (*Oncorhynchus tshawytscha*) stocks, including the Squamish River stock, to escapement goal levels by 1998. Due to the unreliability of Squamish River escapement estimates generated by the visual techniques in current use, new estimation methods were required to monitor rebuilding progress. Four were investigated: a system-wide mark-recapture study using adipose fin clipped hatchery fish as marks and the existing Indian fishery to recover the marks; a system-wide mark-recapture study where marks were applied to live fish in Howe Sound and recovered from carcasses on the spawning grounds; mark-recapture studies in the Cheakamus and Mamquam rivers where marks were applied to live fish and recovered from carcasses; and a mark-recapture study in Ashlu Creek where marks were applied to and recovered from carcasses.

This report describes the field methods, analytic techniques and study results, including adult age, length, sex, adipose fin clip incidence and, when possible, chinook adult escapement estimates. Population estimates could not be generated from the Indian fishery sampling and the Ashlu Creek carcass tagging studies because of violations of the assumptions underlying these techniques. The Howe Sound tagging study estimate of total return to the Squamish River system ranged from 7,323 to 9,348 adults. The Cheakamus River live tagging study estimate of escapement to the Cheakamus River ranged from 727 to 928 adults. These estimates were an average 4.2 times larger than those based on visual techniques.

Four changes in the biology of Squamish River chinook were noted during the study, all resulting from an increased return of cultured fish: the predominant life history pattern shifted from stream-type to ocean-type fish, and the average age at maturity declined by a year; first generation enhanced chinook exceeded 50% of the annual escapement of several major stocks; there has been an intermixing of previously discrete stocks; and spawners have been redistributed to areas where subsequent production may be limited. A review of the status of this stock, including the role of enhancement in rebuilding, was recommended.

Low tag recoveries limited the ability to test for bias and reduced the reliability of the stratified population estimates. The tributary mark-recapture studies did not provide a reliable time series of escapement data primarily due to the small population sizes; it was recommended that tributary marking studies be terminated. The Howe Sound study was identified as the most promising population estimation technique provided that modifications are implemented to increase the tag recoveries and to make the application and recovery samples more representative.

RÉSUMÉ

Schubert, N.D. 1993. Enumeration of the 1988-1992 Squamish River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2187: 96 p.

Le ministère des Pêches et des Océans s'est engagé, dans le cadre du Traité de 1985 sur le saumon du Pacifique et de l'initiative de conservation de 1988 pour le sud du détroit de Géorgie, à rétablir les stocks de saumon quinnat *(Oncorhynchus tshawytscha)* du sud du détroit de Géorgie, y compris celui de las rivière Squamish, pour leur faire retrouver d'ici 1998 un niveau correspondant aux objectifs fixés pour les échappées. Les estimations sur les échappées de la rivière Squamish n' étant pas fiables du fait qu'elles ont été obtenues par des méthodes visuelles, il était nécessaire d'avoir recours à de nouvelles méthodes d'estimation pour surveiller les progrès du rétablissement. Quatre méthodes ont été examinées : une étude de marquage et recapture, portant sur l'ensemble du réseau, avec ablation de la nageoire adipeuse chez les poissons d'élevage, la pêches indienne actuelle permettant de récupérer les marques; une étude de marquage et recapture à l'échelle du réseau, dans laquelle des marques étaient implantées sur des poissons vivants dans la baie Howe, puis récupérées sur les carcasses dans les frayères; des études de marquage et recapture dans les rivières Cheakamus et Mamquam, dans lesquelles les marques étaient implantées sur des poissons vivants puis récupérées sur les carcasses; enfin, une étude de marquage et recapture menée dans les ruisseau Ashlu, dans laquelle les marques étaient implantées et récupérées sur les carcasses.

Le présent rapport décrit les méthodes utilisées sur le terrain, les techniques d'analyse et les résultats de études, notamment l'âge des adultes, leur longueur, leur sexe, l'absence de la nageoire adipeuse et, autant que possible, les estimations sur les échappées des quinnats adultes. Il n'a pas été possible de calculer de estimations des populations à partir de l'échantillonnage sur la pêches indienne et du marquage des carcasses du ruisseau Ashlu à cause du non-respect des postulats sur lesquels se fondaient ces techniques. L'estimation des remontes totales dans le réseau de la rivière Squamish à partir des travaux de marquage dans la baie Howe était de l'ordre de 7 323 à 9 348 adultes. L'estimation des échappées de la rivière Cheakamus obtenue grâce au marquage de poissons vivants dans cette même rivière était de l'ordre de 727 à 928 adultes. Ces estimations étaient en moyenne 4,2 fois plus élevées que celles obtenues par les méthodes visuelles.

Quatre modifications ont été observées pendant l'étude dans la biologie du quinnat de la rivière Squamish, qui proviennent toutes d'un accroissement de la remonte de poissons d'élevage : on notait la prédominance nouvelle des poissons de type océanique sur le type dulcicole, et l'âge moyen à la maturité baissait d'un an; les quinnats d'élevage de première génération dépassaient 50 % des échappées annuelles dan plusieurs grands stocks; on notait un mélanges de stocks jusque-là séparés; enfin, des géniteurs se retrouvaient dans des régions où la production ultérieure peut être limitée. Il est recommandé d'examiner la situation de ce stock, et notamment le rôle des activités piscicoles dans le rétablissement.

Le nombre de marques récupérées est faible, ce qui limite la possibilité de mesurer le biais et réduit la fiabilité des estimations de la population stratifiée. Les études de marquage et recapture dans les affluents n'ont pas fourni de séries chronologiques fiables de données sur les échappées, ce qui est dû principalement à la faible taille des populations; il a été recommandé de mettre fin aux études de marquage dans les affluents. C'est la méthode utilisée pour l'étude de la baie Howe qui est apparue la plus prometteuse pour l'estimation des populations, à condition d'y apporter certaines modifications visant à augmenter les récupérations de marques et à rendre plus représentatifs les échantillons prélevés pour le marquage et la récupération.

INTRODUCTION

The 1985 Pacific Salmon Treaty committed management agencies in Canada and the United States of America to halt the decline of chinook salmon (*Oncorhynchus tshawytscha*) spawning escapements and to attain, by 1998, escapement goals established by each nation (Anon. 1985). Stock rebuilding was to be achieved by reducing brood year exploitation rates by 15 percentage points through management actions in ocean troll, sport and net fisheries. By 1987, it was apparent that these actions would be insufficient to rebuild chinook stocks in the Squamish and other rivers draining into the southern Strait of Georgia (Pacific Salmon Commission 1987). Consequently, additional measures were developed by the Department of Fisheries and Oceans (DFO) with the objective of rebuilding these stocks through a combination of enhancement and an additional 20% reduction in harvest rates in the major southern British Columbia ocean and freshwater fisheries.

Glacial run-off and frequent fall floods make unreliable Squamish River chinook escapements estimated from visual observations. Consequently, the evaluation of the response of this stock to the rebuilding programs required the development of alternate estimation techniques. In 1988, DFO's Fisheries and Biological Sciences branches began the joint development of programs to improve the accuracy and precision of these estimates. Initially, efforts focussed on estimating the system-wide escapement through an evaluation of harvest rates in the river Indian fishery (Schubert and Starr MS 1988). When this approach proved untenable, systematic surveys were implemented in selected tributaries, and marks were applied in the tributaries and in Howe Sound in an attempt to estimate escapement through mark-recapture techniques.

This report documents the 1988-1992 chinook spawner sampling and enumeration studies in the Squamish River system. The report describes field methods, analytic techniques and study results, including adult age, length, sex, adipose fin clip (AFC) incidence and chinook adult escapement estimates; the study did not estimate the escapement of precocious males (jacks). The report concludes with a discussion of data limitations and recommendations for the design of future studies.

STUDY AREA

The Squamish River flows southeast for 108 km, entering the head of Howe Sound 45 km north of Vancouver (Fig. 1). The river and principle tributaries, Ashlu Creek and the Elaho, Cheakamus and Mamquam rivers, drain a mountainous, glaciated watershed of 3,636 km^2. Annual mean daily flows averaged 238 $m^3 \cdot s^{-1}$ during 1922-1990, with monthly maximum and minimum mean daily flows of 493 $m^3 \cdot s^{-1}$ (July) and 90 $m^3 \cdot s^{-1}$ (January), respectively (Environment Canada 1991). Fall flash floods from heavy rain and rapid snow melt, a common hydrological phenomenon in the Squamish River system (Hoos and Vold 1975), have frequently damaged chinook spawning habitats (Hancock and Marshall 1986).

The Squamish River flows for much of its length through a broad valley bounded by steep, glaciated mountains. In the lower 35 km, the river flows largely in a single channel and is characterized by fast runs and rapids separated by lower gradient sections with smooth, sinuous meanders (Hoos and Vold 1975). Between kms 35 and 63, the river is shallower and flows in a shifting, gravel bed channel with numerous side channels and islands. Clark (1988) described habitat suitable for salmonid spawning in this section; however, turbid glacial water has prevented the identification of mainstem chinook spawning except near tributary mouths or in clear, peripheral areas (A. Ionson, Squamish Subdistrict Fishery Officer, pers. comm.). A falls at km 69 forms the upstream limit of the chinook distribution (Hancock and Marshall 1986).

This study focused on three tributaries, Ashlu Creek and the Cheakamus and Mamquam rivers, and on Britannia Beach, a site in Howe Sound where Squamish River chinook are vulnerable to capture. These areas are described below. A fourth tributary, Shovelnose Creek, was also surveyed, but on a less structured basis.

ASHLU CREEK

Ashlu Creek flows southeast for 36 km, entering the Squamish River 34 km from its mouth (Fig.1). The creek flows from the mountains 2.5 km upstream from the Squamish River; a falls at km 3 is impassable to chinook salmon. Anecdotal records (Hancock and Marshall 1986)

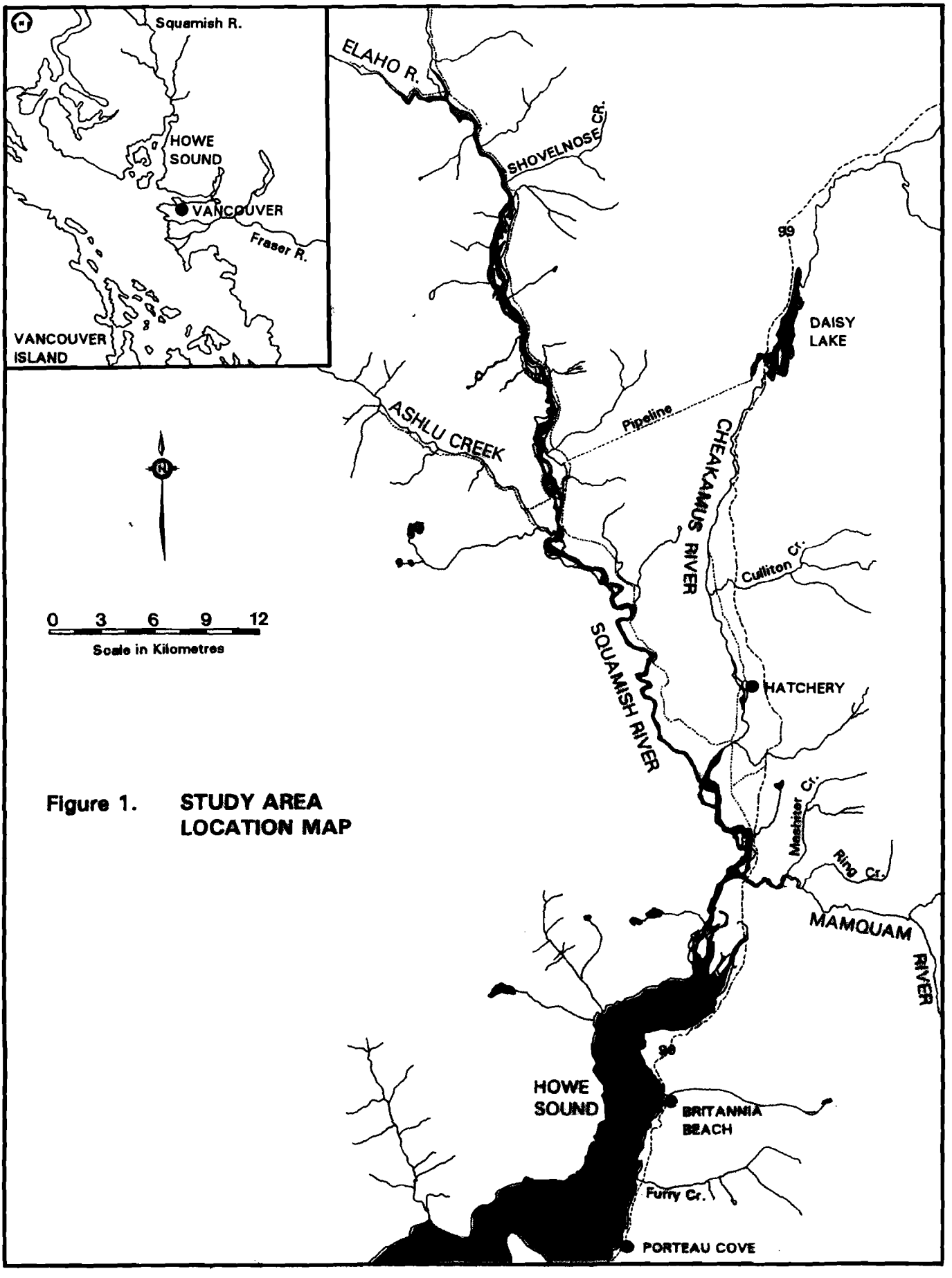

Figure 1. STUDY AREA LOCATION MAP

suggest that logging over the last 50 years has increased the intensity and frequency of freshets in this stream; however, Environment Canada has not monitored stream flow.

We divided the accessible portion of the creek into four reaches. Reach 1, from the falls (km 3.0) to the logging road bridge (km 2.1), is characterized by a single channel with rapids, a few deep pools, and a substrate of boulders and patchy gravel. Reach 2, from the bridge downstream to a large log jam (km 0.5), is characterized by a shifting, braided channel with rapids, runs, a few deep pools and a gravel substrate. Reach 3, from the log jam to the river mouth, is characterized by long runs, deep pools, frequent log jams and a gravel substrate. Reach 4 is a 0.8 km long side channel on the west side beginning at the logging road bridge. It was cut off by the main river in 1991, leaving a deep back eddy.

CHEAKAMUS RIVER

The Cheakamus River flows southwest for 72 km, entering the Squamish River 13 km from its mouth (Fig. 1). The hydrograph reflects a dominant summer glacial melt, with the 1957-1990 monthly maximum and minimum daily flows averaging 82 $m^3 \cdot s^{-1}$ (June) and 16 $m^3 \cdot s^{-1}$ (March), respectively (Environment Canada 1991). The annual mean daily flow averaged 32 $m^3 \cdot s^{-1}$. In 1957, a dam was constructed at the Daisy Lake outlet (km 20) to divert water to a power house on the Squamish River. Mean and minimum flows were reduced by over 50%; flow maxima remained unchanged (Hirst 1991). Other developments include the logging of portions of the watershed, and the discharge by the resort community of Whistler of treated sewage into the upper reaches of the river (Lucey *et al.* 1992).

The Tenderfoot Creek Hatchery was constructed in 1981 on a small tributary of the lower Cheakamus River to increase the production of Squamish system chinook, coho (*O. kisutch*) and steelhead (*O. gairdneri*). In 1984, the hatchery production capacity for chinook fry was expanded from 208,000 to 1.25 million (MacKinlay MS 1985). In 1988, capacity was further expanded by the construction of pens at Porteau Cove in Howe Sound. Up to 1.5 million chinook smolts are transported to the pens where they are held for two weeks before release. The remainder are released directly into the Squamish River system.

The Cheakamus River is passable to chinook spawners up to a falls at km 14. We divided this portion of the creek into five reaches. Reach 1, from the canyon (km 14; locally termed *Road's End*) to Culliton Creek (km 11.5), is characterized by riffles and runs, several deep pools and a gravel substrate; turbidity is low during normal flows. Reach 2, from Culliton Creek to the Paradise Valley Road Bailey bridge (km 6.2), has a steeper gradient and a predominately boulder substrate except at scattered riffles in the lower section. The water in reaches 2-5 is turbid (visibility of a few centimeters) due to heavy silt loads carried by Culliton Creek. Reach 3, from the bridge to the North Vancouver Outdoor School (km 4.8), is characterized by long, slow runs and a few riffles; many sections are dyked. The substrate is shifting sand and silt; gravel is confined to the riffles. Reach 4, from the school to the Upper Squamish Road bridge (km 2.5), is similar to Reach 3 except there are deep pools in the lower section. Reach 5, from the highway bridge to the Squamish River, is a dyked channel with rapids and riffles and a boulder substrate. Only the upper 0.5 km of this reach was surveyed on a regular basis.

MAMQUAM RIVER

The Mamquam River flows west for 33 km, entering the Squamish River 6 km from its mouth (Fig. 1). The hydrographs in the Cheakamus and Mamquam rivers were similar; the 1966-1986 Mamquam River monthly maximum and minimum daily flows averaged 50 $m^3 \cdot s^{-1}$ (June) and 16 $m^3 \cdot s^{-1}$ (February), respectively. The annual mean daily flow averaged 26 $m^3 \cdot s^{-1}$ (Environment Canada 1991). The river is passable to chinook spawners up to a falls at km 6.8. Most of the accessible river has been severely impacted by floods which were exacerbated by logging, and by dyking and other flood control activities (Hancock and Marshall 1986).

We divided the accessible portion of Mamquam River into four reaches. In Reach 1, from the falls (km 6.8) to Ring Creek (km 5.1), the river flows in a narrow valley and is characterized by rapids and pools and a boulder substrate. Reach 2, between Ring and Mashiter (km 3.7) creeks, is characterized by long runs and a coarse gravel substrate. At the midpoint of this reach, the narrow valley ends as the river flows across the flood plain in a broad, dyked

channel. In Reach 3, from Mashiter Creek to the Highway 99 bridge (km 0.8), the channel meanders from dyke to dyke and is characterized by long, deep runs. Reach 4, from the bridge to the Squamish River, is characterized by shallow, fast runs and a gravel and sand substrate.

BRITANNIA BEACH

Britannia Beach in located in upper Howe Sound on the east side of the Britannia Basin, 7 km south of the Squamish River (Fig. 1). Water circulation patterns along the beach are influenced by a sill, which rises to within 70 m of the surface, separating the basin from southern Howe Sound. The sill inhibits deep water circulation, sometimes resulting in hypoxia (Drysdale and Pedersen 1992). Surface water patterns are influenced by Squamish River runoff and prevailing wind patterns, producing a counterclockwise gyre which runs north along the beach; however, the waters adjacent to the beach tend to be stagnant (Hoos and Vold 1975).

A copper and zinc mine operated at Britannia from 1905 to 1974. Acid rock leachate continues to enter Britannia Creek, and mine tailings completely cover the bottom to a depth of 35 m, reducing or eliminating the benthic fauna and invertebrate communities (McDaniel 1973; Levings and McDaniel 1973). Britannia Bay contains elevated levels of dissolved copper and zinc; local fish and invertebrates contain high tissue concentrations of these metals (van Aggelen and Moore 1986, *in* Drysdale and Pedersen 1992).

STUDY DESIGN

The approach taken to the development of more reliable escapement estimates was experimental; therefore, the study design changed annually in response to the results of previous years' studies. The study design used in each year is described below.

1988-1989

Five factors were considered in the initial design of the Squamish River study: a) the chinook distribution was extensive, with spawning recorded in over 12 discrete areas; b) the 1980-1987 reported escapements were small, averaging only 2,600; c) two-thirds of the reported escapement spawned in the mainstem where turbid, glacial water makes study difficult; d) in 1988-1990, most adults with coded wire tags (CWT's) would return to the Cheakamus River release site; and e) an Indian fishery harvests chinook adults in the lower Squamish River.

A system-wide mark-recapture study was initially rejected because costs would be high, low abundance would limit estimation precision, and the return of AFC chinook to a single site would bias the estimated AFC escapement. Instead, the system-wide chinook escapement was to be estimated from a representative sample of the Indian fishery and from the escapement (total and AFC) to the Cheakamus River (i.e. the calculated chinook escapement would be the product of the Cheakamus River escapement estimate and the ratio of the mark incidence in the Cheakamus River and Indian fishery samples). AFC incidence was assessed during regular fishery monitoring patrols, and a technician sampled the catch. A mark-recapture study was conducted in the Cheakamus River to estimate the AFC incidence, sex and age structure and total escapement. Because Cheakamus River chinook escapements were low (1980-1987 mean of 206), the twice-weekly carcass recovery survey was augmented by a carcass weir installed below the main spawning areas of Reach 3.

1990-1991

Four changes were implemented in 1990. First, the Indian fishery evaluation was discontinued because two study design assumptions were violated: the fishery did not representatively sample the Squamish River chinook return; and not all AFC chinook returned to the Cheakamus River. The latter was aggravated in 1990 because 1987-brood hatchery chinook were released in Ashlu Creek and the Squamish River as well as from the hatchery. Second, the hatchery program expanded in 1988 to include the use of sea pens in Howe Sound. Because jacks and adults were expected to return to the sea pen site before entering the Squamish River, it provided an opportunity to capture and tag Squamish River chinook in Howe Sound. In 1990, males (jacks and adults) in excess of hatchery brood stock needs were released with tags. In subsequent years, both males and females were released with tags. Third, the Cheakamus River mark-recapture study became the primary method to estimate escapement in that river.

Table 1. Study duration, by year, location and activity type, in the 1988-1992 Squamish River chinook adult enumeration study.

Year	Location	Study type	Study period
1988	Cheakamus River	a Disk tag application	13-Sep to 15-Sep
		Stream survey	02-Sep to 12-Oct
	Squamish River	Indian fishery sampling	03-Jul to 14-Oct
1989	Cheakamus River	Spaghetti tag application	25-Aug to 14-Sep
		Stream survey	28-Aug to 16-Oct
	Squamish River	Indian fishery sampling	09-Jul to 15-Oct
1990	Ashlu Creek	Stream survey	06-Sep to 01-Oct
	Cheakamus River	Spaghetti tag application	23-Aug to 14-Sep
		Stream survey	26-Aug to 05-Oct
	Howe Sound	a Strap tag application	21-Aug to 30-Aug
1991	Ashlu Creek	Stream survey	06-Sep to 10-Oct
	Cheakamus River	Spaghetti tag application	20-Aug to 24-Sep
		Stream survey	05-Sep to 09-Oct
	Mamquam River	Stream survey	09-Sep to 11-Oct
	Howe Sound	Strap tag application	17-Jul to 05-Sep
1992	Ashlu Creek	a Spaghetti tag application (carcasses)	02-Sep to 29-Sep
		Stream survey	02-Sep to 06-Oct
	Cheakamus River	Spaghetti tag application	18-Aug to 10-Sep
		Stream survey	19-Aug to 08-Oct
	Mamquam River	a Spaghetti tag application	19-Aug to 11-Sep
		Stream survey	31-Aug to 28-Sep
	Howe Sound	Strap tag application	27-Jul to 17-Aug

a. Preliminary study designed to evaluate the applicability of the technique.

Fourth, stream surveys were implemented in Ashlu Creek in 1990 and Mamquam River in 1991 to provide a more representative sample of the Squamish River system escapement.

1992

Two further changes occurred in 1992. First, an experimental mark-recapture study was conducted in Mamquam River. Second, a carcass tagging program was conducted in Ashlu Creek. Both were attempts to improve the precision of escapement estimates for two of the larger Squamish River chinook stocks.

FIELD METHODS

HOWE SOUND TAG APPLICATION

Tenderfoot Creek Hatchery staff applied strap tags (Nielsen and Johnson 1983) and secondary marks to chinook adults and jacks not required as hatchery brood stock in 1990 (Table 1). The chinook were captured using a 61.0 m x 7.3 m x 5.1 cm-mesh knotless nylon net set from a 7.3 m boat with an hydraulic power drum. Because initial efforts at Porteau Cove were unsuccessful, all tags were released at Britannia Beach. The strap tags consisted of an alumin-

ium band, bent into an open horseshoe shape, which was inserted over the right operculum and crimped into place with pliers. Date and location of capture, tag number, sex and adipose fin status were recorded for each fish released with a tag. Length and condition at release was not recorded. Each tagged fish received a secondary mark to allow the assessment of tag loss. A 0.7 cm diameter hole was punched through the right operculum of both males and females using a single hole paper punch.

Similar procedures were used in 1991 except: a) chinook were also captured at Porteau Cove and a small cove 0.5 km north of Britannia Beach; b) females were released with tags; however, none were released until late in the program when hatchery brood stock needs had been met; and c) capture effort occurred more regularly and over a longer time frame (Table 1). In 1992, there were two changes: a) females, adult males and jacks were released with tags through the entire study period; and b) the study terminated early because of a health risk caused by sewage entering Britannia Creek.

TRIBUTARY TAG APPLICATION

Ashlu Creek

Spaghetti tags and secondary marks were applied to all chinook carcasses recovered in Ashlu Creek during the weekly stream surveys in 1992 (described below) (Table 1). The tags consisted of a 50 cm long, 2 mm diameter hollow plastic tube numbered with a unique code. The tag was inserted with a 13 cm long stainless steel needle through the musculature and pterygiophore bones approximately 1.2 cm below the anterior portion of the dorsal fin insertion. It was tied tightly over the dorsal surface with a square knot. Each tagged fish received a secondary mark to allow the assessment of tag loss. One or two 0.7 cm diameter holes were punched through the left operculum of males and females, respectively, using a single hole paper punch. Date and location of capture, tag number, post-orbital-hypural plate (POH) length (±0.5 cm), sex, and adipose fin status were recorded for each fish released with a tag. Carcass condition was recorded as 1 (fresh - gills red or mottled), 2 (moderately fresh - gills white, body firm), 3 (moderately rotten - body intact, flesh soft) or 4 (rotten - skin and bones).

Cheakamus River

Cheakamus River chinook were marked by Tenderfoot Creek Hatchery staff by applying Petersen disk tags to jacks and spawned out adults not required as hatchery brood stock in 1988 (Table 1). The tags consisted of two 2.2 cm diameter laminated cellulose acetate disks and one 0.7 cm diameter transparent plastic buffer disk threaded through centrally punched holes onto a 7.7 cm long nickel pin. The pin was inserted, as above, with the tags arranged one on each side of the fish with the buffer disk on the pin head side; they were secured by twisting the pin into a double knot. One disk per pair was numbered with a unique code. Date and location of capture, tag number, sex and adipose fin status were recorded for each fish released with a tag. Length and condition at release were not recorded. Disk tagged fish did not receive a secondary mark; however, some chinook were released with a 0.7 cm diameter hole punched through the right operculum. The date and location of tagging, however, were not recorded.

An independent crew captured and applied spaghetti tags and secondary marks to Cheakamus River chinook in 1989-1992 (Table 1). The chinook were captured by a two or three person crew using a 9-18 m x 3.7 m x 16.5 cm-mesh tangle net set by hand from a 4.4 m inflatable rubber boat. Capture occurred primarily in reaches 3 and 4; however, all reaches were sampled weekly. Chinook adults were tagged in a wooden tray (10 cm x 10 cm x 100 cm) constructed with a flexible plastic bottom and a meter stick recessed in one side. Jacks, defined as a male with a nose-fork (NF) length of 50 cm or less, were released untagged. The spaghetti tags and secondary marks were applied as described for Ashlu Creek. Care was taken to avoid gill tissue damage. Date and location of capture, tag number, NF length (±0.5 cm), sex and adipose fin status were recorded for each fish released with a tag. Release condition was recorded as 1 (swam away vigorously), 2 (swam away sluggishly) or 3 (required ventilation).

Mamquam River

Spaghetti tags and secondary marks were applied to Mamquam River chinook adults in 1992 (Table 1) using the procedures described for the 1989-1992 Cheakamus River program.

STREAM SURVEYS

Weekly stream surveys were conducted in Ashlu Creek in 1990-1992, in Cheakamus River in 1988-1992, and in Mamquam River in 1991-1992 (Table 1). Complete surveys were conducted in Ashlu Creek by one person on foot, and in Cheakamus and Mamquam rivers by a two person crew using an inflatable rubber raft.

Carcasses were recorded by date, reach, sex (confirmed by abdominal incision) and mark type (disk, spaghetti or strap tag; one or two hole secondary mark on the left or right operculum; or AFC). All carcasses were sampled, then cut in two with a machete and returned to the river. Sample data, recorded by date and reach, included POH length (±0.5 cm), sex, female spawning success (0%, 50% or 100% spawned), adipose fin and carcass condition, and scale samples; flesh colour was recorded in 1991-1992. The head of each AFC chinook was removed posterior to the eye orbit for later CWT identification. Adipose fin condition was recorded as unclipped, complete (flush with dorsal surface), partial (nub present) or questionable (appeared clipped but fungus or decomposition obscured the area). The condition of AFC carcasses was recorded as reported for Ashlu Creek, except the absence of one or both eyes was also noted.

CARCASS WEIR

A carcass weir was constructed at the bottom of Cheakamus Reach 3 to catch carcasses drifting out of the system. The weir, consisting of 45.7 m x 4.9 m x 10.5 cm-mesh net constructed from seine bunt web, was hung across the river on a 1.6 cm diameter steel cable. The weir was cleaned and carcasses were enumerated and sampled, as above, each morning.

INDIAN FISHERY SAMPLING

The Squamish Indian Band fishes for chinook salmon in the lower 30 km of the Squamish River. In 1988-1989, the fishery occurred one day per week using 18 m long set gill nets. The fishery was patrolled by Squamish Subdistrict enforcement staff on most open days. In general, patrols were conducted in a boat which traversed the fishing area near dawn. On each patrol, nets were enumerated and recorded by location, and most nets were inspected for catch. Net location, time checked and catch by species were recorded for each net; chinook were recorded as adult or jack, and AFC status was noted.

In 1988-1989, the chinook catch was sampled for POH length (±0.5 cm), sex, adipose fin condition, flesh colour and scales; when possible, heads were recovered from chinook with an AFC. The samples were obtained from net sites and households by a sampler hired from the Squamish Indian Band.

ANALYTIC PROCEDURES

TESTS FOR SAMPLING SELECTIVITY

Period

Temporal bias was assessed using a chi-square test (Sokal and Rohlf 1981). Application bias was examined by comparing between periods the mark incidence in the recovery sample, where mark incidence was the proportion of the chinook adults marked with either a primary tag (disk, spaghetti or strap) or the secondary mark specific to that tag. Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered.

Location

Spatial bias was similarly assessed in the application sample by comparing between sections the mark incidence in the recovery sample. Recovery bias was examined by stratifying the application sample by section and comparing the proportions recovered.

Fish Size

Size related bias was assessed through the Kolmogorov-Smirnov two-sample test (Sokal and Rohlf 1981). Application bias was examined by comparing the POH length-frequency distributions of marked and unmarked spawning ground recoveries. Recovery bias was examined by partitioning the application sample into recovered and nonrecovered components and comparing the NF length-frequency distributions of each.

Fish Sex

Sex related bias was assessed through chi-square tests. Application bias was examined

by comparing the sex ratio of the marked and unmarked spawning ground recoveries. Recovery bias was examined by partitioning the application sample into recovered and non-recovered components and comparing the sex composition in each.

Recovery Method

Bias in the stream survey recovery technique was assessed by comparing stream survey and carcass weir recoveries in the Cheakamus River. Size and sex biases were examined as described above.

Other Tests

Bias resulting from tagging stress was also assessed using chi-square tests as above. The application sample was partitioned into two groups, those which required ventilation at release and those which did not, and recovery rates were examined in each group. As well, differential spawning success was examined in carcasses with primary tags or secondary marks and those without.

POPULATION ESTIMATION

Petersen Mark-Recapture

The chinook adult population in the Cheakamus and Mamquam rivers and the entire Squamish River system was calculated from the mark-recapture data using the Petersen formula (Chapman modification) (Ricker 1975). When biases were identified, stratified estimates were also calculated, using Schaefer's (Ricker 1975) and Darroch's (1961) methods. The total estimate was the sum of the estimates by sex:

1) Estimated chinook adult population (N_t):

$$N_t = N_m + N_f$$

where:

N_m = estimated adult male population;

$$= \frac{(M_m + 1)(C_m + 1)}{(R_m + 1)}$$

N_f = estimated female population, analogous to above.

2) Ninety-five percent confidence limits of N_t:

$$N_t \pm 1.96\sqrt{V_t}$$

where:

N_t = total population estimate;
V_t = variance of the population estimate;
$= V_m + V_f$
V_m = variance of the adult male population estimate;

$$= \frac{(N_m^2)(C_m - R_m)}{(C_m + 1)(R_m + 2)}$$

N_m = adult male population estimate;
C_m = number of adult male carcasses examined for primary tags;
R_m = number of adult males recovered with a primary tag or secondary mark;
V_f = variance of female population estimate, analogous to above.

Sex Identification Correction: The tag application data were corrected for sex identification error. Error occurred because the development of sexually dimorphic traits was often not advanced and internal examinations could not be made. Correction of recovery data was unnecessary because all carcasses were incised and examined internally. Sex identification error was corrected as described by Staley (1990):

3) Estimated true number of males released with primary tags and secondary marks (M_m):

$$M_m = \frac{M^*_m - (M_t R_{m,f})/R_f}{1 - (R_{m,f}/R_f) - (R_{f,m}/R_m)}$$

where:

M^*_m = field estimate of number of males released with primary tags and secondary marks;
M_t = total number of chinook adults released with primary tags and secondary marks;

$R_{m,f}$ = number of females recovered with primary tags which were released as males;

$R_{f,m}$ = number of males recovered with primary tags which were released as females;

R_f = number of females recovered with primary tags;

R_m = number of males recovered with primary tags.

4) Estimated true number of females released with primary tags and secondary marks (M_f):

$$M_f = M_t - M_m$$

Adipose Fin Clipped Population: The estimate of Cheakamus River chinook adults with an AFC was calculated, by sex, as the product of the AFC incidence in the carcass recovery sample, the largest of the two available samples, and the mark-recapture population estimate. Ninety-five percent confidence limits were calculated from the respective upper and lower confidence limits of the AFC incidence and the population estimate. For example, the upper 95% confidence limit of the AFC population estimate was the product of the upper limit of the AFC incidence and the upper limit of the total mark-recapture estimate. The mathematical relationships are reported below (Cochran 1977):

5) Estimated AFC population (N_a):

$$N_a = p(N_t)$$

6) Estimated 95% confidence limits for p:

$$p \pm 1.96 (se + fpc)$$

where:

p = proportion of the sample with an AFC;

se = standard error;

$= (1-f)pq/(n-1)$

fpc = finite population correction;

$= \frac{1}{2n}$

n = sample size;

$q = 1-p$

$f = \frac{n}{N_t}$

Other Methods

Indian Fishery AFC Incidence: The 1988-1989 Squamish River system chinook population was to be calculated as the product of the Cheakamus River escapement estimate and the ratio of the chinook adult AFC incidence in the Cheakamus River and Indian fishery samples. Analytic procedures were based on those developed by Hankin (1982); however, because of assumption violation, no estimates were calculated and analytic procedures are not reported.

Jolly-Seber Mark-Recapture: The 1992 Ashlu Creek chinook carcass recovery data were analyzed using the Jolly-Seber technique as reported by Ricker (1975). Because of assumption violations, escapement was not estimated and analytic procedures are not reported.

RESULTS

HOWE SOUND TAG APPLICATION

In 1990, 58 adult males and 290 jacks were released with a strap tag and secondary mark at Britannia Beach during August 21-30, (Table 2a; Appendix 1a). Of that total, 3 (5.2%) adults and 29 (10.0%) jacks had an AFC. Release condition was not recorded, and because only one strap tagged fish was later recovered (Appendix 2a), the release data could not be corrected for sex identification error.

In 1991, 581 adults and 108 jacks were released with a strap tag and secondary mark at three Howe Sound sites from July 17 to September 5 (Table 2a; Appendix 1b). Of the adults and jacks, 85% and 53%, respectively, were captured at Britannia Beach, 7% and 30% at Porteau Cove and 8% and 17% at a small cove north of Britannia Beach. Eighty-two (14.1%) adults and 26 (24.1%) jacks had an AFC. Release condition was not recorded. None of the males and 2 (66.7%) of the females had been misidentified at the time of tagging (Appendix 2a). After adjustment for sex identification error, an estimated 434

Table 2a. Strap tag application, carcass examination and mark recovery, by sex, of chinook adults and jacks tagged in Howe Sound and recovered in the Squamish River system, 1990-1992.

Year	Sex	Strap tags applied	Carcasses examined a	Marks recovered: Strap tag and secondary mark	Marks recovered: Secondary mark only	Marks recovered: Strap tag only	Marks recovered: Total	Percent recovered
1990	Male	58	109	0	0	0	0	0.0%
	Female	0	182	0	0	0	0	-
	Adult total	58	302 b	0	0	0	0	0.0%
	Jacks	290	86	1	0	0	1	0.3%
1991	Male	434 c	231	16	7	0	23	5.3%
	Female	147 c	277	3	4	0	7	4.8%
	Adult total	581	511 b	19	11	0	30	5.2%
	Jacks	108	14	0	0	0	0	0.0%
1992	Male	169 c	128	3	3	1	7	4.1%
	Female	429 c	308	24	2	2	28	6.5%
	Adult total	598	457 b	27	5	3	35	5.9%
	Jacks	95	51	1	0	0	1	1.1%

a. Ashlu Creek and Cheakamus and Mamquam rivers only.

b. Includes carcasses for which sex could not be reliably determined.

c. Corrected for sex identification error at release.

(74.7%) adult males and 147 (25.3%) females were released with a strap tag and secondary mark (Table 2a). No females were released with tags until August 27; until that time, all were taken for hatchery brood stock.

In 1992, 598 adults and 95 jacks were released with a strap tag and secondary mark at Britannia Beach from July 27 to August 17 (Table 2a; Appendix 1c); 154 (25.8%) adults and 39 (41.1%) jacks had an AFC. Trapping was terminated more than two weeks early because of a health risk from raw sewage entering Britannia Creek. Release condition was not recorded. None of the males and 1 (4.2%) female had been misidentified at the time of tagging (Appendix 2b). After adjustment for sex identification error, an estimated 169 (28.3%) adult males and 429 (71.7%) females were released with a strap tag and secondary mark (Table 2a).

TRIBUTARY TAG APPLICATION

Ashlu Creek

In 1992, 37 male and 64 female carcasses were released with a spaghetti tag and secondary mark during September 2-29 (Appendix 3). Of the males, carcass condition at release was 89% and 11% in classes 1-2 and 3-4, respectively; 24.3% were recovered once and none were recovered more than once (Appendices 3 and 4). Of the females, carcass condition at release was 86% and 14% in classes 1-2 and 3-4, respectively; 46.9%, 7.8% and 3.1% were later recovered once, twice and three times, respectively.

Cheakamus River

In 1988, disk tags were applied to 13 spawned out chinook adults and 10 jacks on

Table 2b. Spaghetti tag application, carcass examination and mark recovery, by sex, of chinook adults in the Cheakamus and Mamquam rivers, 1988-1992.

Location	Year	Sex	Spaghetti tags applied	Carcasses examined	Marks recovered: Spaghetti tag and secondary mark	Marks recovered: Secondary mark only	Marks recovered: Spaghetti tag only	Marks recovered: Total	Percent recovered
Cheakamus River	1988 [a]	Male	6	49	2	0	0	2	33.3%
		Female	7	94	4	0	0	4	57.1%
		Total	13	145 [b]	6	0	0	6	46.2%
	1989	Male	34	120	6	4	0	10	29.4%
		Female	18	107	5	0	0	5	27.8%
		Total	52	236 [b]	11	4	0	15	28.8%
	1990	Male	40 [c]	80	1	4	0	5	12.5%
		Female	16 [c]	153	6	0	0	6	37.5%
		Total	56	244 [b]	7	4	0	11	19.6%
	1991	Male	29	44	1	3	0	4	13.8%
		Female	11	50	0	1 [d]	0	1	9.1%
		Total	40	97 [b]	1	4	0	5	12.5%
	1992	Male	22	65	0	2	0	2	9.1%
		Female	36	188	6	3	0	9	25.0%
		Total	58	257 [b]	6	5	0	11	19.0%
Mamquam River	1992	Male	3	31	1	0	0	1	33.3%
		Female	2	56	2	0	0	2	100.0%
		Total	5	92 [b]	3	0	0	3	60.0%

a. Spawned out fish disk tagged during hatchery brood stock acquisition.
b. Includes carcasses for which sex could not be reliably determined.
c. Adjusted for sex identification error.
d. Recovered in Ashlu Creek.

September 13 and 15, (Table 2b; Appendix 5a); 38 adults and 63 jacks were released with a secondary mark only. All tagging was ancillary to hatchery brood stock collection; condition at release was not recorded. None of the carcasses recovered with disk tags had been misidentified by sex at release (Appendix 6a). Disk tag releases totalled 6 (46.2%) males and 7 (53.8) females; most (61.5%) were released in Reach 1 (above Culliton Creek).

In 1989, 52 chinook adults were released with a spaghetti tag and secondary mark from August 25 to September 14 (Table 2b; Appendix 5b). One fish (1.9%) required ventilation at release; however, the proportion of this group recovered (100%) was not significantly different ($p > 0.05$; chi-square) from the group not requiring ventilation (19.6%). Consequently, this fish was not removed from the application sample. None of the carcasses recovered with a spaghetti

tag had been misidentified by sex at release (Appendix 6a). Spaghetti tag releases totalled 34 (65.4%) males and 18 (34.6%) females; most (86.5%) were released in Reach 4, with 7 (13.5%) released in Reach 1.

In 1990, 56 chinook adults were released with a spaghetti tag and secondary mark from August 23 to September 14 (Table 2b; Appendix 5c). Three (5.4%) required ventilation at release; however, the proportion of this group recovered (0.0%) was not significantly different ($p > 0.05$; chi-square) from the group not requiring ventilation (13.2%). One (20.0%) male and no females had been misidentified by sex at release (Appendix 6b). When adjusted for this error, an estimated 40 (71.4%) males and 16 (28.6%) females were released with a spaghetti tag and secondary mark; most (83.9%) were released in Reach 4, with 7 (12.5%) released in Reach 1.

In 1991, 40 chinook adults were released with a spaghetti tag and secondary mark from August 20 to September 24 (Table 2b; Appendix 5c); 32 of these fish were tagged before a severe flood beginning on August 29. None of the tagged adults required ventilation at release, and none of the carcasses recovered with a spaghetti tag or secondary mark had been misidentified by sex at release (Appendix 6b). Spaghetti tag releases, therefore, totalled 29 (72.5%) males and 11 (27.5%) females; all were released in Reach 3.

In 1992, 58 chinook adults were released with a spaghetti tag and secondary mark from August 18 to September 10 (Table 2b; Appendix 5c). Three fish (5.2%) required ventilation at release; however, the proportion of this group recovered (0.0%) was not significantly different ($p > 0.05$; chi-square) from the group not requiring ventilation (10.9%). None of the carcasses recovered with a spaghetti tag or secondary mark had been misidentified by sex at release (Appendix 6b). Spaghetti tag releases, therefore, totalled 22 (37.9%) males and 36 (62.1%) females; most (65.5%) were released in Reach 4, with none released in Reach 1.

Mamquam River

In 1992, 5 chinook adults were released with a spaghetti tag and secondary mark from August 19 to September 11 (Table 2b; Appendix 7a). None of the tagged adults required ventilation at release, and none of the carcasses recovered with a spaghetti tag or secondary mark had been misidentified by sex at release (Appendix 7b). Spaghetti tag releases, therefore, totalled 3 (60.0%) males and 2 (40.0%) females.

SPAWNING GROUND RECOVERY

Ashlu Creek

In 1990, 58 adults and 14 jacks were recovered from September 6 to October 1 (Appendix 8a). Of the adults, 29 (50.0%) were male, 29 (50%) were female, and 1 (1.7%) had an AFC. One (7.1%) of the jacks had an AFC. None of the recoveries had a primary tag or a secondary mark.

In 1991, 142 adults and 2 jacks were recovered from September 6 to October 10 (Appendix 8b). Of the adults, 54 (38.0%) were male and 88 (62.0%) were female, 1 (0.7%) had a spaghetti tag or secondary mark, 3 (2.1%) had a strap tag or secondary mark and 7 (5.0%) had an AFC. None of the jacks had a tag, a secondary mark or an AFC.

In 1992, 108 adults and 3 jacks were recovered from September 2 to October 6 (Appendix 8c). Of the adults identified to sex, 32 (33.3%) were male and 64 (66.7%) were female; none of the adults had a spaghetti tag or secondary mark, 2 (1.9%) had a strap tag or secondary mark, and 11 (11.3%) had an AFC. None of the jacks had a tag, mark or AFC.

Cheakamus River

In 1988, 145 chinook adults and 52 jacks were recovered from September 2 to October 12 (Table 2b; Appendix 9a). Of the adults identified to sex, 49 (34.3%) were male and 94 (65.7%) were female; 18 (12.4%) of the adults had an AFC, 6 (4.1%) had a disk tag and 4 (2.8%) had a secondary mark. Of the jacks, 5 (9.6%) had an AFC, 2 (3.8%) had a disk tag and 6 (11.5%) had a secondary mark. Most adults (77.2%) were recovered in Reach 1; the carcass weir recovered 4 (8.2%) adult males, 4 (4.3%) females and 12 (23.1%) jacks.

In 1989, 236 chinook adults and 43 jacks were recovered from August 28 to October 16

(Table 2b; Appendix 9b). Of the adults identified to sex, 120 (52.9%) were male and 107 (47.1%) were female; 15 (6.4%) of the adults had a spaghetti tag or secondary mark and 20 (8.5%) had an AFC. The difference in spaghetti tag loss between males (40.0%) and females (0.0%) was significant ($p < 0.05$; chi-square). Most adults were recovered in reaches 4 (36.4%) and 1 (36.9%); the carcass weirs trapped 6 (5.0%) adult males, 7 (6.5%) females and 5 (11.6%) jacks.

In 1990, 244 chinook adults and 72 jacks were recovered from August 26 to October 5 (Table 2b; Appendix 9c). Of the adults identified to sex, 80 (34.3%) were male and 153 (65.7%) were female; 11 (4.5%) of the adults had a spaghetti tag or secondary mark and 30 (12.3%) had an AFC. The difference in spaghetti tag loss between males (80.0%) and females (0.0%) was significant ($p < 0.05$; chi-square). Of the jacks, 1 (1.4%) had a strap tag and 8 (11.1%) had an AFC. Most adults were recovered in reaches 1 (37.7%) and 4 (32.4%); the carcass weir trapped 12 (15.0%) adult males, 14 (9.2%) females and 27 (37.5%) jacks.

In 1991, the survey was delayed by a freshet until September 5, then continued until October 9; 97 chinook adults and 2 jacks were recovered (Table 2b; Appendix 9d). Of the adults identified to sex, 44 (46.8%) were male and 50 (53.2%) were female; 4 (4.1%) of the adults had a spaghetti tag or secondary mark, 2 (2.1%) had a strap tag or secondary mark, and 14 (14.4%) had an AFC. Only males were recovered with a spaghetti or strap tag (or secondary mark); tag loss was 75.0% and 50.0%, respectively. None of the jacks had a tag, secondary mark or AFC. Most of the adults were recovered in reaches 1 (38.1%) and 4 (23.7%), although there was also an unusually large recovery in Tenderfoot Creek (19.6%), a small tributary where chinook spawners had not been previously documented. The majority of the spaghetti tags were also recovered in Tenderfoot Creek. The carcass weir was not installed because the freshet prevented tag application during the normal peak period, and also forced many spawners from the river. Because the latter would have compromised the study design, the expense of weir installation was unwarranted.

In 1992, 257 chinook adults and 38 jacks were recovered from August 19 to October 8 (Table 2b; Appendix 9e). Of the adults identified to sex, 65 (25.7%) were male and 188 (74.3%) were female; 11 (4.3%) of the adults had a spaghetti tag or secondary mark, 23 (8.9%) had a strap tag or secondary mark and 46 (17.9%) had an AFC. Three of the carcasses with a strap tag (13.6%) did not have a secondary mark. Spaghetti tag loss was 100.0% in males and 33.3% in females; strap tag loss was 33.3% in males and 0.0% in females. Neither difference was significant ($p > 0.05$; chi-square). Of the jacks, 1 (2.6%) had a strap tag and 15 (39.5%) had an AFC. Most of the adults were recovered in Reach 1 (68.1%); the carcass weir trapped 9 (13.8%) adult males, 18 (9.6%) females and 11 (28.9%) jacks.

Mamquam River

In 1991, 272 chinook adults and 10 jacks were recovered from September 9 to October 11 (Appendix 10a). Of the adults identified to sex, 133 (48.9%) were male and 139 (51.1%) were female; 25 (9.2%) of the adults had a strap tag or secondary mark and 48 (17.6%) had an AFC. The difference in strap tag loss between sexes was not significant ($p > 0.05$; chi-square). Four (40.0%) of the jacks had an AFC.

In 1992, 92 chinook adults and 10 jacks were recovered from August 31 to September 28 (Appendix 10b). Of the adults identified to sex, 31 (35.6%) were male and 56 (64.4%) were female; 3 (3.3%) of the adults had a spaghetti tag, 10 (10.9%) had a strap tag or secondary mark and 24 (26.1%) had an AFC. The difference in strap tag loss between males (66.7%) and females (16.7%) was not significant ($p > 0.05$; chi-square). Five (50.0%) jacks had an AFC.

Shovelnose Creek

In 1991, 171 chinook adults and 22 jacks were recovered on September 11 and 17 (Appendix 11). Of the adults, 96 (56.1%) were male and 75 (43.9%) were female; none had a primary tag or secondary mark, and 17 (9.9%) had an AFC. Four (18.2%) of the jacks had an AFC. An additional 12 adults were taken for hatchery brood stock (Appendix 12).

In 1992, 10 chinook adults were recovered on September 9 and 22 (Appendix 11). Of the adults, 1 (10.0%) was male and 9 (90.0%)

were female; none had a primary tag or secondary mark, and 4 (40.0%) had an AFC. An additional 123 adults and 3 jacks were taken for hatchery brood stock (Appendix 12). None had a primary tag or secondary mark; 12 (9.8%) adults and 1 (33.3%) jack had an AFC.

AGE, LENGTH AND SEX

Ashlu Creek

The age, length and sex of the 1990-1992 Ashlu Creek spawning ground recoveries are reported in Appendix 13; ages are summarized by sex in Table 3. Most males matured at ages 3 and 4, females at ages 4 and 5. Three changes during the study period resulted from enhancement: a) the adult AFC incidence, which includes adults of hatchery origin but excludes unmarked hatchery fish, increased from 1.7% to 11.3% (Table 4). All AFC adults were aged 3_1 and 4_1, and none had overwintered as juveniles in freshwater (Appendix 13); b) the proportion of adults which had overwintered in freshwater progressively declined, from 48% to 39% in males and from 71% to 39% in females; and c) the dominant age class changed, in males from 4_2 (31%) to 4_1 (43%), and in females from 5_2 (38%) and 4_2 (33%) to 4_1 (57%). The mean annual POH length of males and females ranged from 60.3 cm to 70.5 cm, and from 72.4 cm to 75.5 cm, respectively (Appendix 13). Females comprised 40%-65% of the annual chinook adult sample; 99.2% had white flesh.

Cheakamus River

The age, length and sex of the 1988-1992 Cheakamus River spawning ground recoveries are reported in Appendix 14; ages are summarized by sex in Table 3. Most males matured at ages 3 and 4. Females matured at ages 4 and 5 in 1988-1990; however, in 1991-1992, age-3 replaced age-5 as a dominant class. Enhancement effects were similar to those in Ashlu Creek: a) the adult AFC incidence increased from 12.4% to 17.9% (Table 4). Ages 3_1, 4_1 and 5_1 accounted for 76.1% of the AFC adults and few (6.4%) had overwintered in freshwater (Appendix 14); b) the proportion of adults which had overwintered in freshwater progressively declined, from 61% to 4% in males and from 75% to 2% in females; and c) the dominant age classes changed, in males from 5_2 (28%), 4_2 (9%) and 3_2 (21%) to 4_1 (33%) and 3_1 (28%), and in females from 5_2 (63%) to 4_1 (83%). The mean annual POH length of males and females ranged from 55.3 cm to 66.8 cm, and from 69.8 cm to 76.0 cm, respectively (Appendix 14). Females comprised 39%-65% of the annual chinook adult sample; 99.7% had white flesh.

Mamquam River

The age, length and sex of the 1991-1992 Mamquam River spawning ground recoveries are reported in Appendix 15; ages are summarized by sex in Table 3. Hatchery fish released at sea pens in Howe Sound comprised most of the 1991-1992 escapement; 20.1% of the adults had an AFC (Table 4). Males returned at age-3 in 1991 and ages 2, 3 and 4 in 1992; females returned at age-3 in 1991 and at ages 3 and 4 in 1992. The proportion of adults which overwintered in freshwater was low in both years, averaging 8.2% in males and 3.9% in females. The mean annual POH length of males and females ranged from 62.7 cm to 63.3 cm and from 68.5 cm to 73.0 cm, respectively (Appendix 15). Females comprised 49%-58% of the annual chinook adult sample; 98.9% had white flesh.

CODED WIRE TAG RECOVERIES

In 1988, 18 adults and 5 jacks were recovered with an AFC in the Cheakamus River, an AFC incidence of 12.4% and 9.6%, respectively (Table 4). CWT's were recovered from 9 adults and 4 jacks; when corrected for predator and processing losses, the long term CWT loss averaged 28.6% and 0.0%, respectively. Of those with a CWT, all were from mixed stock or Cheakamus groups released in the Cheakamus River; most were 1984-brood (Appendix 16a).

In 1989, 20 adults and no jacks were recovered with an AFC in the Cheakamus River, an AFC incidence of 8.5% (Table 4). CWT's were recovered from 17 adults; when corrected for predator and processing losses, the long term CWT loss averaged 0.0%. Of those with a CWT, all were from mixed stock, Cheakamus, Squamish or Ashlu groups released in the Cheakamus River; most were 1986-brood (Appendix 16b).

In 1990, 31 adults and 9 jacks were recovered with an AFC, 1 adult and 1 jack in Ashlu Creek and the remainder in the Cheaka-

Table 3. Percent at age, by sex and location, of Squamish River system chinook spawning ground recoveries, 1988-1992. a

		Female					Male				
Location	Age	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992
Ashlu Creek	6/2	-	-	0%	0%	0%	-	-	0%	3%	0%
	5/2	-	-	38%	24%	28%	-	-	7%	16%	14%
	5/1	-	-	0%	0%	0%	-	-	3%	0%	0%
	4/2	-	-	33%	30%	11%	-	-	31%	22%	18%
	4/1	-	-	24%	21%	57%	-	-	0%	16%	43%
	3/2	-	-	0%	0%	0%	-	-	10%	3%	7%
	3/1	-	-	0%	25%	4%	-	-	21%	41%	14%
	2/1	-	-	5%	0%	0%	-	-	28%	0%	4%
	Sub-1	-	-	29%	46%	61%	-	-	52%	56%	61%
	Sub-2	-	-	71%	54%	39%	-	-	48%	44%	39%
	Sample size:	-	-	29	81	64	-	-	43	44	35
Cheakamus River	6/2	2%	0%	1%	0%	0%	0%	1%	0%	0%	0%
	5/2	63%	11%	16%	5%	2%	28%	8%	3%	0%	1%
	5/1	6%	2%	1%	5%	0%	2%	0%	0%	0%	0%
	4/2	9%	42%	6%	16%	1%	9%	9%	7%	9%	1%
	4/1	17%	14%	71%	40%	83%	4%	6%	21%	33%	33%
	3/2	2%	0%	0%	0%	0%	21%	11%	4%	3%	2%
	3/1	0%	32%	6%	34%	15%	8%	52%	17%	52%	28%
	2/2	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%
	2/1	2%	0%	0%	0%	0%	28%	13%	48%	3%	34%
	Sub-1	25%	47%	78%	79%	98%	39%	71%	86%	88%	96%
	Sub-2	75%	53%	22%	21%	2%	61%	29%	14%	12%	4%
	Sample size:	91	102	153	49	188	95	157	152	46	103
Mamquam River	5/2	-	-	-	0%	3%	-	-	-	0%	3%
	5/1	-	-	-	1%	3%	-	-	-	1%	0%
	4/2	-	-	-	4%	0%	-	-	-	4%	6%
	4/1	-	-	-	15%	80%	-	-	-	3%	27%
	3/2	-	-	-	0%	0%	-	-	-	2%	6%
	3/1	-	-	-	80%	15%	-	-	-	84%	33%
	2/1	-	-	-	0%	0%	-	-	-	6%	24%
	Sub-1	-	-	-	96%	97%	-	-	-	94%	85%
	Sub-2	-	-	-	4%	3%	-	-	-	6%	15%
	Sample size:	-	-	-	139	56	-	-	-	143	41

a. Data are from Appendices 13-15.

Table 4. AFC and CWT sampling, by location, year and sex, of Squamish River system chinook adults and jacks, 1988-1992. a

		Ashlu Creek			Cheakamus River					Mamquam River	
		1990	1991	1992	1988	1989	1990	1991	1992	1991	1992
Sample size	Male adult	29	54	32	49	120	80	44	65	133	31
	Female	29	88	64	94	107	153	50	188	139	56
	Jack	14	2	3	52	43	72	2	38	10	10
Number with AFC's	Male adult	1	1	2	5	8	11	9	17	19	12
	Female	0	6	9	13	12	19	5	29	29	12
	Jack	1	0	0	5	0	8	0	15	4	5
- AFC but no head	Male adult	0	0	0	2	1	1	1	1	0	1
	Female	0	2	0	2	1	2	2	0	0	1
	Jack	0	0	0	1	0	0	0	1	0	0
- CWT lost during processing	Male adult	0	0	0	0	0	0	0	0	0	0
	Female	0	0	0	1	1	0	0	0	0	0
	Jack	0	0	0	0	0	0	0	0	0	0
- AFC but no CWT	Male adult	1	0	1	1	0	0	2	1	0	0
	Female	0	1	1	3	0	2	0	1	3	1
	Jack	0	0	0	0	0	1	0	1	0	0
- CWT recovered	Male adult	0	1	1	2	7	10	6	15	19	11
	Female	0	3	8	7	10	15	3	28	26	10
	Jack	1	0	0	4	0	7	0	13	4	5
AFC incidence (%) b	Adults	1.7%	5.0%	11.3%	12.4%	8.5%	12.3%	14.4%	17.9%	17.6%	26.1%
	Jacks	7.1%	0.0%	0.0%	9.6%	0.0%	11.1%	0.0%	39.5%	40.0%	50.0%
CWT loss (%)	Adults	100.0%	20.0%	18.2%	28.6%	0.0%	7.4%	18.2%	4.4%	6.3%	4.5%
	Jacks	0.0%	-	-	0.0%	-	12.5%	-	7.1%	0.0%	0.0%

a. Carcass recovery data are from Appendices 8-10; CWT data are from Appendix 16.

b. Calculation includes recoveries with known AFC status but unknown sex; excludes carcasses with known sex but unknown AFC status.

mus River. Adult AFC incidence was significantly ($p < 0.05$; chi-square) higher in the Cheakamus River (Table 4). CWT's were recovered from 25 adults and 8 jacks; when corrected for predator and processing losses, the long term CWT loss averaged 10.7% and 11.1%, respectively. The Cheakamus River CWT recoveries were from a mixed stock group released in the Cheakamus River (21), Cheakamus or Squamish chinook released at Porteau Cove (10) and Squamish River chinook released in the Squamish River (1); most were 1986-brood (Appendix 16c). The Ashlu Creek recovery was a 1988-brood Squamish chinook released in the Squamish River.

In 1991, 69 adults and 4 jacks were recovered with an AFC, 7 adults in Ashlu Creek, 14 adults in the Cheakamus River and 48 adults and 4 jacks in the Mamquam River. Adult AFC incidence was significantly different ($p < 0.05$; chi-square) between areas, with high incidence in the Mamquam and Cheakamus rivers (Table 4). CWT's were recovered from 58 adults and 4 jacks; when corrected for predator and processing losses, the long term CWT loss averaged 9.4% and 0.0%, respectively. The Ashlu Creek CWT recoveries were from Ashlu Creek chinook released in Ashlu Creek (3) and a mixed stock group released at Porteau Cove (1) (Appendix 16d). The Cheakamus River system CWT recoveries were from Cheakamus chinook released in the Cheakamus River (4) or at Porteau Cove (1), Cheakamus or Squamish chinook released at Porteau Cove (1) and Squamish chinook released at Porteau Cove (3). The Mamquam River system CWT recoveries were from Cheakamus chinook released in the Cheakamus River (1) or at Porteau Cove (5), Cheakamus or Squamish chinook released at Porteau Cove (27), Squamish chinook released in the Mamquam River (5) or at Porteau Cove (7), and mixed stock groups released at Porteau Cove (4). Most recoveries were from the 1988-brood.

In 1992, 81 adults and 20 jacks were recovered with an AFC, 11 adults and no jacks in Ashlu Creek, 46 adults and 15 jacks in the Cheakamus River and 24 adults and 5 jacks in the Mamquam River. Adult AFC incidence was significantly ($p < 0.05$; chi-square) higher in the Mamquam River; differences between Ashlu Creek and the Cheakamus River were not significant ($p > 0.05$) (Table 4). CWT's were recovered from 73 adults and 18 jacks; when corrected for predator and processing losses, the long term CWT loss averaged 6.4% and 5.3%, respectively. The Ashlu Creek CWT recoveries were from Ashlu Creek chinook released in Ashlu Creek (4), Squamish chinook released at Porteau Cove (2), Cheakamus or Squamish chinook released at Porteau Cove (1), Squamish chinook released in the Squamish River (1) and a mixed stock group released at Porteau Cove (1) (Appendix 16d). The Cheakamus River CWT recoveries were from Cheakamus chinook released in the Cheakamus River (13) or at Porteau Cove (3), Cheakamus or Squamish chinook released at Porteau Cove (11), Squamish chinook released at Porteau Cove (9) or in the Mamquam River (3) and mixed stock groups released at Porteau Cove (14) or in the Mamquam River (3). The Mamquam River CWT recoveries were from Cheakamus chinook released in the Cheakamus River (2) or at Porteau Cove (1), Cheakamus or Squamish chinook released at Porteau Cove (5), Squamish chinook released in the Mamquam River (3) or at Porteau Cove (6) and mixed stock groups released at Porteau Cove (7) or in the Mamquam River (2). Most recoveries were from the 1988-brood.

Scale Ageing Accuracy

Scale ageing accuracy was evaluated in 183 samples for which both ageable scales and CWT's were available. Only 8.2% of the scale ages were incorrect, with some variability by age (Table 5).

INDIAN FISHERY SAMPLING

In 1988, the Indian fishery was surveyed on 16 days between July 3 and October 14 (Appendix 17a). Thirty-eight chinook adults and 22 jacks were examined for an AFC; 10 (26.3%) and 0 (0.0%) were noted. There was no difference in the adult AFC incidence above (26.7%) and below (26.1%) the Cheakamus River ($p > 0.05$; chi-square); neither were significantly different from the Cheakamus River AFC incidence (12.4%) (Table 4). Females in the catch (1) were all age 5_2; male ages were 16% (3) 5_2, 16% (3) 4_2, 32% (6) 3_2 and 37% (7) 2_1 (Appendix 17b).

In 1989, the Indian fishery was surveyed on 11 days between July 9 and October 15 (Appendix 17c). Thirty-seven chinook adults and 10 jacks were examined for an AFC; 4 (10.8%) and 1 (10.0%) were noted. There was no difference in the adult AFC incidence above (11.8%) and below (10.0%) the Cheakamus River ($p > 0.05$; chi-square). Both were higher than in the Cheakamus River (8.5%), but the difference was not significant ($p > 0.05$). Chinook were not sampled nor were heads recovered in 1989.

SAMPLING SELECTIVITY

Howe Sound

Period: Temporal bias in the application sample was examined by comparing the mark incidence in the recovery sample during three

Table 5. Comparison of Squamish River chinook scale-ages with known ages from coded wire tags recovered on the spawning grounds, 1988-1992. a

Total age estimated from scale sample	Known total age from coded wire tag			
	2-years	3-years	4-years	5-years
2-years	24	1	3	0
3-years	2	71	3	0
4-years	0	5	71	0
5-years	0	0	1	2
Total	26	77	78	2
% aged correctly	92.3%	92.2%	91.0%	100.0%

a. Data are reported by year in Appendix 16.

periods (Table 6). Mark incidence ranged from 3.5% to 8.9% and was highest during September 14-23, possibly reflecting temporal differences in application effort. The difference, however, was not significant ($p > 0.05$; chi-square) either by sex or in the total recovery. Recovery bias was examined by stratifying the application sample into three periods and comparing the proportions recovered (Table 7). The overall proportion varied from 1.7% to 9.4%; however, the difference was not significant ($p > 0.05$).

Location: Spatial bias in the application sample was examined by comparing among tributaries the mark incidence in the recovery sample (Table 8). Mark incidence varied from 0.0% to 10.9%, with the highest occurring in Mamquam River; no marks were recovered in Shovelnose Creek in 1990-1992. Mark incidences were significantly different ($p < 0.05$) in males and total recoveries in 1991, and in females and total recoveries in 1992. The results were similar when Shovelnose Creek was excluded, except the 1992 difference among females was not significant. Recovery bias was examined by stratifying the application sample by location and comparing the proportions recovered (Table 9). Although a higher proportion of the tags applied at Britannia Beach was recovered, the difference was not significant ($p > 0.05$) by sex or in total.

Fish Size: Size related bias in the application sample was assessed by comparing POH length-frequency distributions of marked and unmarked spawning ground recoveries. No significant differences ($p > 0.05$; Kolmogorov-Smirnov two-sample test) were noted in jacks, adult males and females in either year. When annual data were grouped, however, a significant ($p < 0.05$) bias toward smaller adult males was noted. Recovery bias could not be assessed because lengths were not recorded at application.

Fish Sex: Sex related bias in the application sample was assessed by comparing the sex ratio of the marked and unmarked carcasses (Table 10). Biases were not detected, except a significant ($p < 0.05$; chi-square) bias toward males in 1991. Recovery bias was assessed by partitioning the application sample into recovered and nonrecovered components and comparing the sex composition in each (Table 10). No difference was noted ($p > 0.05$).

Spawning Success: Differential behaviour related to capture and tagging stress was examined by comparing the spawning success of marked and unmarked females (Appendix 18). No significant difference ($p > 0.05$) was noted in 1991 or 1992.

Cheakamus River

Period: Temporal bias in the application sample was significant ($p < 0.05$; chi-square) in 1988 and 1991 (Table 11). The higher mark incidences late in 1988 and early in 1991 reflected the unstructured study design, and a late

Table 6. Incidence of strap tags or secondary marks in chinook adults tagged in Howe Sound and recovered on the Squamish River system spawning grounds, by recovery period and sex, 1991-1992. a

		Recovered with a strap tag or secondary mark			Total recovery			Mark incidence		
Year	Recovery period	Male	Female	Total	Male	Female	Total	Male	Female	Total
1991	26-Aug to 13-Sep	0	3	3	37	48	85	0.0%	6.3%	3.5%
	14-Sep to 23-Sep	13	1	14	103	100	203	12.6%	1.0%	6.9%
	24-Sep to 12-Oct	10	3	13	91	129	223 b	11.0%	2.3%	5.8%
	Total	23	7	30	231	277	511 b	10.0%	2.5%	5.9%
1992	26-Aug to 13-Sep	2	12	14	66	130	203 b	3.0%	9.2%	6.9%
	14-Sep to 23-Sep	5	15	20	56	158	225 b	8.9%	9.5%	8.9%
	24-Sep to 12-Oct	0	1	1	6	20	29 b	0.0%	5.0%	3.4%
	Total	7	28	35	128	308	457 b	5.5%	9.1%	7.7%

a. Ashlu Creek and Cheakamus and Mamquam rivers only.

b. Includes carcasses for which sex could not be reliably determined.

Table 7. Proportion of the Howe Sound chinook adult strap tag application sample recovered on the Squamish River system spawning grounds, by application period and sex, 1991-1992.

		Strap tags and secondary marks applied a			Carcasses recovered with strap tags			Percent recovered		
Year	Application period	Male	Female	Total	Male	Female	Total	Male	Female	Total
1991	17-Jul to 31-Jul	47	11	58	0	1	1	0.0%	9.1%	1.7%
	01-Aug to 15-Aug	154	35	189	7	0	7	4.5%	0.0%	3.7%
	16-Aug to 05-Sep	233	101	334	9	2	11	3.9%	2.0%	3.3%
	Total b	434	147	581	23	7	30	5.3%	4.8%	5.2%
1992	17-Jul to 31-Jul	54	123	177	0	11	11	0.0%	8.9%	6.2%
	01-Aug to 15-Aug	108	281	389	4	12	16	3.7%	4.3%	4.1%
	16-Aug to 05-Sep	7	25	32	0	3	3	0.0%	12.0%	9.4%
	Total b	169	429	598	7	28	35	4.1%	6.5%	5.9%

a. Corrected for sex identification error.

b. Includes carcasses with secondary marks only.

Table 8. Proportion of the Squamish River system chinook adult spawning ground recovery sample marked with strap tags or secondary marks, by location and sex, 1991-1992.

		Chinook adult carcasses examined			Carcasses recovered with strap tags or secondary marks			Mark incidence		
Year	Recovery location	Male	Female	Total	Male	Female	Total	Male	Female	Total
1991	Ashlu Creek	54	88	142	1	2	3	1.9%	2.3%	2.1%
	Cheakamus River	44	50	97 b	2	0	2	4.5%	0.0%	2.1%
	Mamquam River	133	139	272	20	5	25	15.0%	3.6%	9.2%
	Shovelnose Creek a	104	79	183	0	0	0	0.0%	0.0%	0.0%
	Total	335	356	694	23	7	30	6.9%	2.0%	4.3%
1992	Ashlu Creek	32	64	108 b	1	1	2	3.1%	1.6%	1.9%
	Cheakamus River	65	188	257 b	3	20	23	4.6%	10.6%	8.9%
	Mamquam River	31	56	92 b	3	7	10	9.7%	12.5%	10.9%
	Shovelnose Creek a	56	77	133	0	0	0	0.0%	0.0%	0.0%
	Total	184	385	590	7	28	35	3.8%	7.3%	5.9%

a. Because the stream survey was unstructured, includes stream survey and brood stock recoveries.

b. Includes carcasses for which sex could not be reliably determined.

Table 9. Proportion of the Howe Sound chinook adult strap tag application sample recovered on the Squamish River system spawning grounds, by application location and sex, 1991-1992.

		Strap tags and secondary marks applied a			Carcasses recovered with strap tags			Percent recovered		
Year	Application location	Male	Female	Total	Male	Female	Total	Male	Female	Total
1991	Porteau Cove	33	8	41	1	0	1	3.0%	0.0%	2.4%
	Britannia Beach	363	131	494	14	3	17	3.9%	2.3%	3.4%
	N. of Britannia	38	8	46	1	0	1	2.6%	0.0%	2.2%
	Total	434	147	581	23 b	7 b	30 b	5.3%	4.8%	5.2%
1992	Britannia Beach	169	429	598	7 b	28 b	35 b	4.1%	6.5%	5.9%

a. Corrected for sex identification error.

b. Includes carcasses with secondary marks only.

Table 10. Sex composition of chinook adults in the Howe Sound tag application and Squamish River system spawning ground recovery samples, 1991-1992. a

		Application sample sex ratio, by recovery status				Recovery sample sex ratio, by mark status a			
Year	Sex	Sample size	Recovered	Not recovered	Total	Sample size	Marked	Unmarked	Total
1991	Male	434	76.7%	74.6%	74.7%	231	76.7%	43.5%	45.5%
	Female	147	23.3%	25.4%	25.3%	277	23.3%	56.5%	54.5%
1992	Male	169	20.6%	28.7%	28.3%	128	20.6%	30.1%	29.4%
	Female	429	79.4%	71.3%	71.7%	308	79.4%	69.9%	70.6%

a. Ashlu Creek and Cheakamus and Mamquam rivers only; excludes carcasses for which sex was not reliably determined.

Table 11. Incidence of spaghetti tags or secondary marks in chinook adults tagged and recovered on the Cheakamus River spawning grounds, by recovery period and sex, 1988-1992.

		Recovered with a spaghetti tag or secondary mark			Total recovery			Mark incidence		
Year	Recovery period	Male	Female	Total	Male	Female	Total	Male	Female	Total
1988 a	26-Aug to 13-Sep	0	0	0	18	41	59	0.0%	0.0%	0.0%
	14-Sep to 23-Sep	1	1	2	12	25	39 b	8.3%	4.0%	5.1%
	24-Sep to 12-Oct	1	3	4	19	28	47	5.3%	10.7%	8.5%
1989	26-Aug to 13-Sep	1	1	2	24	17	42 b	4.2%	5.9%	4.8%
	14-Sep to 23-Sep	7	2	9	67	40	111 b	10.4%	5.0%	8.1%
	24-Sep to 12-Oct	2	2	4	29	50	83 b	6.9%	4.0%	4.8%
1990	26-Aug to 13-Sep	3	4	7	36	85	125 b	8.3%	4.7%	5.6%
	14-Sep to 23-Sep	0	1	1	24	44	71 b	0.0%	2.3%	1.4%
	24-Sep to 12-Oct	2	1	3	20	24	48 b	10.0%	4.2%	6.3%
1991	26-Aug to 13-Sep	2	0	2	11	7	18	18.2%	0.0%	11.1%
	14-Sep to 23-Sep	2	0	2	17	16	33	11.8%	0.0%	6.1%
	24-Sep to 12-Oct	0	0	0	16	27	46 b	0.0%	0.0%	0.0%
1992	26-Aug to 13-Sep	2	4	6	43	99	144 b	4.7%	4.0%	4.2%
	14-Sep to 23-Sep	0	5	5	19	72	92 b	0.0%	6.9%	5.4%
	24-Sep to 12-Oct	0	0	0	3	17	21 b	0.0%	0.0%	0.0%

a. Primary (disk) tags only.

b. Includes carcasses for which sex could not be reliably determined.

Table 12. Proportion of the Cheakamus River chinook adult spaghtetti tag application sample recovered on the Cheakamus River spawning grounds, by application period and sex, 1988-1992.

Year	Application period	Spaghetti tags and secondary marks applied			Carcasses recovered with spaghetti tags			Percent recovered		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
1988 a	18-Aug to 25-Aug	0	0	0	0	0	0	-	-	-
	26-Aug to 15-Sep	6	7	13	2	4	6	33.3%	57.1%	46.2%
1989	18-Aug to 31-Aug	13	8	21	2	2	4	15.4%	25.0%	19.0%
	01-Sep to 15-Sep	21	10	31	4	3	7	19.0%	30.0%	22.6%
1990 b	18-Aug to 25-Aug	15	5	20	0	3	3	0.0%	60.0%	15.0%
	26-Aug to 15-Sep	25	11	36	1	3	4	4.0%	27.3%	11.1%
1991	18-Aug to 25-Aug	16	5	21	0	0	0	0.0%	0.0%	0.0%
	26-Aug to 15-Sep	13	6	19	1	0	1	7.7%	0.0%	5.3%
1992	18-Aug to 19-Aug	13	17	30	0	4	4	0.0%	23.5%	13.3%
	20-Aug to 15-Sep	9	19	28	0	2	2	0.0%	10.5%	7.1%

a. Disk tagged during hatchery brood stock acquisition.

b. Corrected for sex identification error.

August flood, respectively. Recovery bias was examined by stratifying the application sample into two periods and comparing proportions recovered (Table 12). Temporal differences were not significant ($p > 0.05$; chi-square).

Location: Spatial bias in the application sample was examined by comparing the recovery sample mark incidence in the lower, turbid water section (reaches 2-5) and the upper, clear water section (Reach 1) (Table 13). Differences were significant ($p < 0.05$; chi-square) only in the 1989 and 1992 total recoveries, with the highest incidence in the upper section (11.5%) in 1989 and in the lower section (8.5%) in 1992. Recovery bias was examined by stratifying the application sample by section and comparing the proportions recovered (Table 14). Significant differences ($p < 0.05$) were noted only in 1989.

Fish Size: Application bias was not detected in males or females ($p > 0.05$; Kolmogorov-Smirnov two sample test) in the annual data or when the annual data were pooled. Recovery bias, assessed by partitioning the application sample into recovered and nonrecovered components and comparing the NF length-frequency distributions, was not detected in the annual data. Significant differences ($p < 0.05$) were noted, however, in adult males and females when the annual data were pooled; small and large males and small females were recovered at a lower rate (Table 15).

Fish Sex: Bias was not noted ($p > 0.05$; chi-square) in any year (Table 16).

Spawning Success: Differential behaviour related to capture and tagging stress was examined by comparing the spawning success of marked and unmarked females (Appendix 18). No differences ($p > 0.05$; chi-square) were noted.

Recovery Method: Biases were examined by comparing stream survey and carcass weir recovery data. Size related biases in females, adult males and jacks were not noted ($p > 0.05$; Kolmogorov-Smirnov two-sample test) in any year

Table 13. Incidence of spaghetti tags and secondary marks, by section and sex, in the Cheakamus River chinook adult spawning ground recovery sample, 1988-1992.

Year	Recovery section a	Chinook adult carcasses examined			Carcasses recovered with spaghetti tags or secondary marks			Mark incidence		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
1988 b	Lower	14	17	33 c	1	1	2	7.1%	5.9%	6.1%
	Upper	35	77	112	1	3	4	2.9%	3.9%	3.6%
1989	Lower	82	60	149 c	4	1	5	4.9%	1.7%	3.4%
	Upper	38	47	87 c	6	4	10	15.8%	8.5%	11.5%
1990	Lower	55	88	152 c	4	5	9	7.3%	5.7%	5.9%
	Upper	25	65	92 c	1	1	2	4.0%	1.5%	2.2%
1991	Lower	29	29	60 c	4	0	4	13.8%	0.0%	6.7%
	Upper	15	21	37 c	0	0	0	0.0%	0.0%	0.0%
1992	Lower	23	56	82 c	2	5	7	8.7%	8.9%	8.5%
	Upper	42	132	175 c	0	4	4	0.0%	3.0%	2.3%

a. Lower section includes reaches 2-5; upper section includes Reach 1.

b. Disk tagged during hatchery brood stock acquisition; no secondary marks applied.

c. Includes carcasses for which sex could not be reliably determined.

Table 14. Proportion of the Cheakamus River chinook adult spaghetti tag application sample recovered on the Cheakamus River spawning grounds, by application section and sex, 1988-1992.

Year	Application section a	Spaghetti tags applied			Carcasses recovered with spaghetti tags			Percent recovered		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
1988 b	Lower	4	1	5	2	1	3	50.0%	100.0%	60.0%
	Upper	2	6	8	0	3	3	0.0%	50.0%	37.5%
1989	Lower	29	16	45	3	3	6	10.3%	18.8%	13.3%
	Upper	5	2	7	3	2	5	60.0%	100.0%	71.4%
1990 c	Lower	33	16	49	0	6	6	0.0%	37.5%	12.2%
	Upper	7	0	7	1	0	1	14.3%	-	14.3%
1991	Lower d	29	11	40	4	1 e	5	13.8%	9.1%	12.5%
1992	Lower d	22	36	58	2	9	11	9.1%	25.0%	19.0%

a. Lower section includes reaches 2-5; upper section is Reach 1.

b. Disk tagged during hatchery brood stock acquisition.

c. Application data corrected for sex identification error.

d. Includes recoveries with secondary marks only.

e. Recovered in Ashlu Creek.

Table 15. Proportion of the Cheakamus River chinook adult spaghetti tag application sample recovered on the Cheakamus River spawning grounds, by sex and 5 cm increments of nose-fork length, 1989-1992.

Year	Nose-fork length (cm)	Spaghetti tags applied			Carcasses recovered with spaghetti tags or secondary marks			Percent recovered		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
1989-1992	50-59	8	0	8	0	0	0	0.0%	-	0.0%
	60-69	4	0	4	1	0	1	25.0%	-	25.0%
	70-79	34	4	38	4	0	4	11.8%	0.0%	10.5%
	80-89	32	25	57	3	4	7	9.4%	16.0%	12.3%
	90-99	24	45	69	0	11	11	0.0%	24.4%	15.9%
	100-109	13	15	28	0	2	2	0.0%	13.3%	7.1%
	110-119	1	0	1	0	0	0	0.0%	-	0.0%
	120-129	1	0	1	0	0	0	0.0%	-	0.0%
	Total	117	89	206	8	17	25	6.8%	19.1%	12.1%

Table 16. Sex composition of Cheakamus River chinook adults in the spaghetti tag application and spawning ground recovery samples, 1988-1992.

Year	Sex	Application sample sex ratio, by recovery status				Recovery sample sex ratio, by mark status			
		Sample size	Recovered	Not recovered	Total	Sample size	Marked	Unmarked	Total
1988	Male	6	33.3%	57.1%	46.2%	49	33.3%	34.3%	34.3%
	Female	7	66.7%	42.9%	53.8%	94	66.7%	65.7%	65.7%
1989	Male	34	66.7%	64.9%	65.4%	120	66.7%	51.9%	52.9%
	Female	18	33.3%	35.1%	34.6%	107	33.3%	48.1%	47.1%
1990	Male	40	45.5%	77.8%	71.4%	80	45.5%	33.8%	34.3%
	Female	16	54.5%	22.2%	28.6%	153	54.5%	66.2%	65.7%
1991	Male	29	80.0%	71.4%	72.5%	44	80.0%	44.9%	46.8%
	Female	11	20.0%	28.6%	27.5%	50	20.0%	55.1%	53.2%
1992	Male	22	18.2%	42.6%	37.9%	65	18.2%	26.0%	25.7%
	Female	36	81.8%	57.4%	62.1%	188	81.8%	74.0%	74.3%

Table 17. Sex composition of Cheakamus River chinook adults in the stream survey and carcass weir recovery samples, 1988-1990 and 1992.

		Stream survey recoveries		Carcass weir recoveries	
Year	Sex	Sample size	Percent	Sample size	Percent
1988	Male	45	33.3%	4	50.0%
	Female	90	66.7%	4	50.0%
1989	Male	114	53.3%	6	46.2%
	Female	100	46.7%	7	53.8%
1990	Male	68	32.9%	12	46.2%
	Female	139	67.1%	14	53.8%
1992	Male	56	24.8%	9	33.3%
	Female	170	75.2%	18	66.7%

or when the annual data were pooled. When jacks and adult males were grouped, however, a significant bias toward jacks was noted in the weir sample in all years except 1989. Further, the proportion jacks was significantly ($p < 0.05$; chi-square) higher in the weir sample when all years were pooled.

Sex related bias was examined by comparing the adult sex ratios in each sample (Table 17). No biases were noted ($p > 0.05$; chi-square), either in annual or pooled data.

POPULATION ESTIMATION

Squamish River System

Indian Fishery AFC Incidence: Two observations were inconsistent with the assumption that all chinook with an AFC would return to the Cheakamus River release site in 1988-1989: a) there was no difference in the AFC incidence in the Indian fisheries above and below the Cheakamus River mouth (Appendix 17); and b) the AFC incidence in the Indian fishery was not significantly higher ($p > 0.05$) than in the Cheakamus River (Appendix 17; Table 4). This procedure, therefore, could not be used to estimate the 1988-1989 Squamish River system chinook escapement.

Howe Sound Tagging: Population estimates were calculated in three steps. First, data sets prone to statistical bias, a concern when the recovery of primary tags and secondary marks is four or less (Ricker 1975), were discarded; this did not occur in 1991-1992 (Table 18). Second, because primary tags or secondary marks were not recovered above Ashlu Creek, it was concluded that this group was not vulnerable to tag application. The Shovelnose Creek recoveries, therefore, were excluded and population estimates were calculated using the simple Petersen single census estimator. Third, when spatial or temporal sampling biases where identified, stratified estimates were calculated using the Schaefer and Darroch estimators. If both stratified estimates were outside the 95% confidence limits of the simple Petersen estimate, the Petersen was rejected and the Schaefer accepted as the final population estimate.

Estimates of the annual chinook adult return to the Squamish River system, excluding the escapement above Ashlu Creek, are reported by sex in Table 19a. Simple Petersen estimates

Table 18. Results of statistical tests for bias, by location, sample type and year, for the 1988-1992 Squamish River system chinook adult population estimation study. a

Location	Sample	Bias test	Year				
			1988	1989	1990	1991	1992
Howe Sound	Application	Period	n/a	n/a	n/a	-	-
		Location	n/a	n/a	n/a	To Mamquam b	To Mamquam c
		Fish size d	n/a	n/a	n/a	-	-
		Fish sex	n/a	n/a	n/a	To males	-
	Recovery	Period	n/a	n/a	n/a	-	-
		Location	n/a	n/a	n/a	-	n/a
		Fish size	n/a	n/a	n/a	n/a	n/a
		Fish sex	n/a	n/a	n/a	-	-
		Statistical e	n/a	n/a	n/a	-	-
Cheakamus River	Application	Period	To late period	-	-	To early period	-
		Location	-	To upper section	-	-	To lower section
		Fish size	-	-	-	-	-
		Fish sex	-	-	-	-	-
	Recovery	Period	-	-	-	-	-
		Location	-	-	-	-	-
		Fish size f	n/a	-	-	-	-
		Fish sex	-	-	-	-	-
		Statistical e	In males, females	-	-	In males, females	In males

a. Codes were n/a: no study, or appropriate data were not collected; "-": a significant difference was not detected.

b. Bias detected in males and total sample; further, no primary tags or secondary marks were recovered in Shovelnose Creek.

c. Bias detected in females and total sample; further, no primary tags or secondary marks were recovered in Shovelnose Creek.

d. Although no bias was detected in the annual data, when annual data were pooled a bias to small males was noted.

e. Statistical bias is a concern when recoveries total 4 or less.

f. Although no bias was detected in the annual data, when annual data were pooled a bias to intermediate males and large females was noted.

Table 19a. Return to the river estimates and 95% confidence limits, by year, sex and estimation method, from the 1991-1992 Squamish River system chinook adult enumeration study. a

			Single census estimator			Stratified estimators			
							Darroch estimate		
Group	Year	Sex	Simple Petersen estimate	Upper 95% c.l.	Lower 95% c.l.	Schaefer estimate	Estimate	Upper 95% c.l.	Lower 95% c.l.
Total return	1991	Male	4,205	5,766	2,644	4,356	7,624	9,369	5,879
		Female	5,143	8,454	1,832	4,767	9,392 b	13,712	5,072
		Total	9,348	13,009	5,687	9,123	17,016	21,675	12,357
	1992	Male	2,741	4,476	1,007	3,090	2,593	4,244	942
		Female	4,582	6,142	3,021	1,907	4,000	5,235	2,765
		Total	7,323	9,656	4,990	4,997	6,593	8,655	4,531
AFC return	1991	Male	528	753	318	547	957	1,224	708
		Female	743	1,258	256	688	1,356	2,040	710
		Total	1,271	1,798	759	1,235	2,311	2,995	1,649
	1992	Male	664	1,130	233	748	628	1,072	218
		Female	744	1,022	478	310	649	871	438
		Total	1,408	1,822	913	1,058	1,225	1,633	829

a. Estimates are for the Squamish River system below Ashlu Creek; includes the Indian fishery harvest.

b. Estimated by collapsing Ashlu and Cheakamus strata into a single stratum to account for no marked recoveries in Cheakamus River.

were 9,348 (4,205 males and 5,143 females) in 1991 and 7,323 (2,741 males and 4,582 females) in 1992.

In 1991, the Schaefer estimate (9,123) was within 2.4% of the Petersen, and the estimates by sex were within the 95% confidence limits of the Petersen. The Darroch estimate (17,016) was almost double the Petersen, and estimates by sex were above the upper 95% confidence limits of the Petersen estimates. The implications of this observation will be discussed later; however, because only one of the stratified estimates was outside the 95% confidence limits of the Petersen, the Petersen was accepted as the most appropriate population estimate.

In 1992, all stratified estimates were within the 95% confidence limits of the Petersen, with the exception of the Schaefer estimate for females. This estimate was 58% and 52% less than the Petersen and Darroch estimates, respectively. The Petersen estimate, however, was accepted as the most appropriate population estimate.

Ashlu Creek

The number of tags applied and the survey frequency were insufficient to meet the requirement that marked fish be recovered in each sampling period. Even when sexes were combined and the number of recovery periods reduced, marks were not recovered in two strata. The Jolly-Seber technique, therefore, was not used to estimate the 1992 Ashlu Creek escapement.

Cheakamus River

Cheakamus River escapements were estimated using the procedures described for the

Table 19b. Escapement estimates and 95% confidence limits, by year, sex and estimation method, from the 1988-1992 Cheakamus River chinook adult enumeration study.

			Single census estimator			Stratified estimators			
							Darroch estimate		
Group	Year	Sex	Simple Petersen estimate	Upper 95% c.l.	Lower 95% c.l.	Schaefer estimate	Estimate	Upper 95% c.l.	Lower 95% c.l.
Total escapement	1989	Male	385	593	177	626	330	461	199
		Female	342	588	96	469	529	857	201
		Total	727	1,049	405	1,095	859	1,212	506
	1990	Male	554	948	159	629	609	1,076	142
		Female	374	627	121	408	557	875	239
		Total	928	1,396	459	1,037	1,166	1,731	601
	1992	Female	699	1,101	297	752	616	899	333
AFC escapement	1989	Male	26	45	10	42	22	35	11
		Female	38	72	10	53	59	105	20
		Total	64	97	34	96	76	113	42
	1990	Male	76	144	20	86	84	164	17
		Female	46	82	14	51	69	115	28
		Total	123	187	57	134	150	231	74
	1992	Female	108	177	44	116	95	144	49

Howe Sound program. Statistical bias prevented the estimation of all escapements in 1988 and 1991, and the escapement of males in 1992 (Table 18). Spatial biases were noted in 1989 and 1992; therefore, stratified estimates were calculated each year.

Chinook adult escapements are reported by sex in Table 19b. Simple Petersen estimates were 727 (385 males and 342 females) in 1989, 928 (554 males and 374 females) in 1990, and 699 females in 1992.

In 1989, most of the stratified estimates were within the 95% confidence limits of the Petersen (Table 19b), although the Schaefer (1,095) and Darroch (859) estimates of total escapement were 50.6% and 18.2% higher, respectively. The Petersen was accepted as the most appropriate escapement estimate.

In 1990, all stratified estimates were within the 95% confidence limits of the Petersen, although the Schaefer (1,037) and Darroch (1,166) estimates of total escapement were 11.7% and 25.6% higher, respectively. The Petersen was accepted as the most appropriate escapement estimate.

In 1992, both stratified estimates were within the 95% confidence limits of the Petersen. The Schaefer estimate (752) was 7.6% higher than the Petersen, while the Darroch (616) was 11.9% lower. The Petersen was accepted as the most appropriate escapement estimate.

Mamquam River

Statistical bias prevented the estimation of the 1992 Mamquam River chinook adult escapement (Table 18).

DISCUSSION

INDIAN FISHERY AFC INCIDENCE

Hankin (1982) derived estimators for total escapement in rivers where a marked hatchery component of the run returned to a single site. The estimators were developed from three independent programs: lower river monitoring to estimate the AFC proportion of the entering run; release site monitoring to estimate the AFC proportion of the spawners; and enumeration of the total AFC escapement to the hatchery or the spawning area release site. Because hatchery fish were expected to return to the release site, the AFC proportion there would be higher than in the mainstem where untagged stocks were also present. This change in proportion between the lower river and the spawning grounds, combined with estimates of the total AFC escapement, were used to estimate the system-wide escapement. This technique has two advantages: the marks are permanent and easily recognizable; and marking occurs well in advance of the study period. Mortality or emigration from handling stress is avoided, therefore, and tag loss does not occur. We planned to use Hankin's technique in 1988-1989 because returning AFC chinook adults would be vulnerable to the Indian fishery below the Cheakamus River and, since all marked juveniles had been released in the Cheakamus River, all of the marked adults were expected to return there. Two main assumptions were made: a) the Indian fishery would representatively sample the AFC incidence of the entering run, i.e. hatchery and wild fish would be equally vulnerable to the fishery and would have equal probabilities of capture; and b) the AFC adults would not stray to other spawning areas; therefore, AFC incidence on the spawning grounds and the total AFC escapement could be estimated by a mark-recapture study in the Cheakamus River. One or both of these assumptions were violated because the AFC incidence in the Indian fisheries above and below Cheakamus River were identical and the AFC incidence in the Indian fishery was higher than in the Cheakamus River. These observations may have reflected hatchery fish milling near the Cheakamus River mouth (thus increasing their vulnerability to the Indian fishery), substantial straying to other spawning areas, or both. Straying was known to have occurred because the hatchery crews recovered AFC chinook in other areas (Appendix 12). The magnitude of straying could not be substantiated, however, because systematic surveys were not conducted. Regardless of the mechanism, this technique is clearly sensitive to violations in the assumptions of nonstraying and equal vulnerability and could not be used in 1988-1989

HOWE SOUND MARK-RECAPTURE STUDY

Population estimates derived from mark-recapture studies are susceptible to bias from a number of sources, including: tag loss; physiological stress which can induce the emigration of tagged fish from the population and alter recapture vulnerability; and nonrepresentative tag application or recovery resulting from samples which are selective by fish size, sex or spatial and temporal run component. I evaluated tag loss and stress induced mortality and concluded that these biases were successfully avoided. The assumption that the population was closed, however, was less certain. In 1991, a small number of untagged chinook spawned for the first time in Furry Creek, a small Howe Sound tributary. This may have reflected emigration from the Squamish River during the flood rather than a chronic problem with a component of the population potentially vulnerable to tag application but nonvulnerable to recovery. This assumption should be evaluated in future studies. A more serious concern was the 1992 recovery of a tagged chinook in the Strait of Georgia sport fishery at Point Roberts. Although only one tag was returned, it indicated the study population was not completely closed and that the estimate had a positive bias. While most mark-recapture studies are susceptible to bias resulting from the differential emigration of tagged fish from the population, the impact on the population estimates is difficult to quantify. To better evaluate this problem in future studies, posters should be placed at local marinas requesting anglers to report the numbers from any tagged chinook observed in their harvested or released catch.

It was not possible to definitively test the representativeness of the application and recovery samples because the true population parame-

ters were not known. Instead, I examined the samples for four biases, temporal, spatial, fish size and fish sex, as indicators of weakness in the study design. The results of these tests should be interpreted with caution because of three limitations. First, less than 6% of the tags were recovered (only seven females in 1991 and seven males in 1992), resulting in an increased probability of committing a type-II error. An example of the limitation this imposed on the test results was in the evaluation of application sample size bias. Bias was not detected until all data were pooled to increase the sample size. Clearly, more reliable test results depend on recovering more tags through increased application effort, recovery effort, or both. Second, some of the data required to evaluate potential biases were not collected. Size related recovery bias and stress induced changes in recapture vulnerability could not be assessed because size and condition at release were not recorded. These data should be recorded in future studies. Third, tag loss reduced the reliability of the temporal and spatial tests. Without the application date and location, it was necessary to assume that the application distribution of fish recovered with secondary marks was identical to that of fish recovered with numbered tags. This was a structural limitation inherent in the study design. Although the retention of strap tags was relatively poor, their use was necessary because more secure tags, such as Petersen disks, would have increased the vulnerability of tagged fish to the Indian gill net fishery. Such tags would have introduced a serious positive bias to the population estimate.

Biases related to sex, size and location were detected during this study (Table 18). The 1991 sex bias resulted from a failure to tag females until the hatchery brood stock requirements had been met. It was addressed by stratifying by sex, and this hatchery practice was discontinued in 1992. An associated temporal bias in females did not occur because sex identification error during tag application resulted in the inadvertent release of tagged females throughout the run. The assumption of a random temporal distribution of tags, therefore, was not seriously violated.

A size bias to smaller males, noted in the application sample when the annual data were pooled, would be a concern if a similar bias had occurred in the recovery sample. Although recovery bias could not be evaluated because length at release was not recorded, it was considered unlikely because a size related recovery bias did not occur in the Cheakamus River (Table 18), one of the main recovery areas. Other studies have shown that smaller males are recovered at a lower rate because they are less likely to entangle in debris (Cousens *et al.* 1982). For example, Starr and Schubert (1990) reported recovery biases to larger, rather than smaller, chinook in a six year study in the Harrison River.

The most serious bias in this study was a spatial bias detected in the application sample in 1991 and 1992 (Tables 8, 18). The bias had two components: stocks returning to the Squamish River above the Ashlu Creek confluence appeared nonvulnerable to capture in Howe Sound; and Mamquam River chinook had a significantly higher probability of capture. None of the carcasses recovered in the upper Squamish River had a strap tag, and none of the chinook removed from Howe Sound as brood stock were from upper Squamish River CWT groups. This nonvulnerability to capture may have reflected an early migration through Howe Sound before the start of the study or a migratory route along the west shore. The current study addressed this bias by excluding upper Squamish River stocks from the study area population estimates. Future studies should apply tags earlier and explore the feasibility of capture at other upper Howe Sound sites. Of the remaining study area stocks, Mamquam River chinook had a higher probability of capture than Ashlu Creek and Cheakamus River stocks. Capture probability appeared to be related to the level of enhancement. Ashlu Creek had the smallest enhanced component and the lowest proportion with strap tags, while Mamquam River had the largest enhanced component and the highest proportion with strap tags. Enhanced chinook may have homed to the Porteau Cove release site and delayed in the local area, making them more vulnerable to capture at Britannia Beach. The evidence for this hypothesis, however, was not unequivocal. The AFC incidence at Britannia Beach did tend to be higher than on the spawning grounds, although the difference was significant ($p < 0.05$; chi-square) in only one of nine comparisons in males, females and jacks in 1990-1992. These tests may have been relatively insensitive because the spawning ground sample did not include small, untagged,

naturally producing stocks; however, the results are supported by anecdotal information which indicates that wild chinook were also vulnerable at Britannia Beach. Before the closure of the upper Howe Sound sport fishery in the early 1980's, Britannia Beach was known for it's large, white flesh chinook (L. Straight, pers. comm.). Because the Tenderfoot Hatchery did not begin production until 1981 (MacKinlay MS 1985), these must have been wild fish behaving in a manner similar to the fish observed in this study. Further, only 12% of the adults released with strap tags were recaptured in subsequent sets at Britannia Beach, indicating a relatively rapid emigration rather than an extended holding period by hatchery fish near the release site. Regardless of the relative vulnerabilities of hatchery and natural chinook, the spatial bias was addressed by calculating stratified population estimates.

Many authors assume that a stratified estimator which compensates for nonrepresentative sampling will be statistically more robust than a simple estimator and will better approximate the true escapement (e.g. Johnston *et al.* 1986; Tschaplinski and Hyatt 1991). The current study made a similar assumption in that, when sampling selectivity was detected, the simple Petersen estimate was rejected if it differed significantly from both of the stratified estimates. This assumption is central to the analysis of mark-recapture data and deserves further evaluation. The issue was addressed in two ways. First, stratified estimates were calculated using both the Schaefer and Darroch estimators to determine if there was a close correspondence between the two relative to the simple Petersen. The stratified estimators produced similar results in only one case, for males in 1992 (Table 19a). The other stratified estimates differed from each other by 32% to 110%. In each case, however, one of either the Darroch or the Schaefer estimates was similar (within 2% to 15%) to the simple Petersen estimate. Because the stratified estimators did not provide similar results, the assumption that any stratified estimator will be more robust than the simple Petersen was obviously flawed. The selection of an appropriate stratified estimator requires a clear understanding of the behaviour of that estimator under the conditions of sampling selectivity specific to each individual study. Simulation studies are recommended to identify Darroch and Schaefer behaviours under varying conditions of sampling selectivity and at different tag recovery levels. Second, the robustness of the stratified estimators to different spatial stratifications was examined by comparing estimates calculated from a 1 x 3 base matrix (Howe Sound application; Ashlu, Cheakamus, Mamquam recovery areas) and three derivative 1 x 2 matrices which were formed by pooling recovery strata (Appendix 20). The comparison was made only for the Darroch estimator because there is no difference in Schaefer estimates calculated from this base matrix and its derivatives. The pooled matrices produced widely divergent estimates which varied from the base estimate by -52% to +16%. The Darroch estimator, therefore, was highly sensitive to geographic stratification and was especially unstable when there were few tags recovered in one or more strata. Clearly, there is considerable potential for error in studies such as the Squamish where sampling selectivity is identified and few tags are recovered. The future success of this study will depend on increasing the number of tags recovered.

TRIBUTARY MARK-RECAPTURE STUDIES

The tributary mark-recapture studies in many cases suffered from a level of tag recovery which was insufficient to assess statistical and other biases and which may have introduced error in the escapement estimates. This resulted from the small size of the application samples rather than a low recovery rate or a low proportion of the populations with tags (Tables 2b, 19b). Chinook were difficult to capture in large numbers due to the small and dispersed escapements and to the suboptimal trapping conditions in the tributaries. For example, capture efficiency in the Cheakamus River was poor due to net avoidance in the clear water above Culliton Creek and because chinook adults could not be located in the turbid water below Culliton Creek. As a result, less than 60 tags per year were applied and as few as 5 tags per year were recovered. Certain attributes make a stock or species better suited to enumeration using the mark-recapture technique. Ideally, vulnerability to capture should be sufficient to permit the application of a large number of tags to a large proportion of the escapement. Further, spawner distributions should be sufficiently discrete to permit the recovery of a large number of carcasses and a high proportion of the tags. Clearly, mark-recapture was not a reliable technique in the Cheakamus and Mamquam rivers and is unlikely to be in the future

given the current conditions of abundance, trapping techniques and program budgets. Alternate techniques also show limited promise. Visual counts are unreliable due to the silt load carried by Culliton Creek; fences are not feasible due to high costs and the freshets which often occur in the fall. Until conditions change, tributary studies are unlikely to provide a consistent time series of precise escapement estimates. Future enumeration efforts should focus on the estimation of the system-wide escapement and the development of techniques to allocate that escapement to each discrete population.

Statistical bias prevented the estimation of escapement in the Cheakamus River in five of ten attempts (Table 18), and in the Mamquam River in 1992. Escapement estimates were calculated in the remaining five cases; however, small samples continued to be a concern. Other authors have suggested that low tag recoveries may cause the overestimation of escapement. Tschaplinski and Hyatt (1991) reported that population estimates calculated in studies where few tags were recovered were biased high regardless of other problems with sampling selectivity. Although a statistical mechanism was not provided, they concluded that this was a characteristic of the mark-recapture technique. In the Cheakamus River study, it was not possible to evaluate the impact of low recoveries on the population estimates because alternate estimation techniques were unavailable. Small samples also increased the probability of type-II errors in the tests for bias. For example, size bias in the recovery sample was not detected until all of the data were pooled to increase the sample size. These test results, therefore, should be interpreted with caution. The potential for type-II errors in the spatial and temporal bias tests was further exacerbated by high tag loss. Tag loss made necessary the assumption that the application distribution of fish recovered with secondary marks was identical to that of fish recovered with numbered tags. Given the small sample sizes, it was likely that this assumption was incorrect. Tag loss could also introduce error into the stratified population estimates for the same reasons. This was not a serious concern, however, because the stratified estimators were not used to estimate escapement in this study.

As in the Howe Sound study, there was a large difference in escapements estimated using the Schaefer and Darroch stratified estimators (Table 19b). Surprisingly, the difference was greatest in 1989 and 1992, years when spatial selectivity was detected in the application sample. In those years, the sex-specific estimates differed by 13% to 90%, while the estimates for the 1989 total escapement differed by 27%. In 1990, a year when sampling selectivity was not detected, the difference was only 3% in males, 37% in females and 12% in the total escapement. While these differences were generally less than when selectivity was identified, the difference in the female estimates was still substantial. The existence of such differences, especially under the conditions of sampling selectivity where the use of a stratified estimator is most appropriate, is disturbing. Further simulation studies to identify the behaviour of the stratified estimators under the conditions specific to these studies are clearly required.

Tag loss in this study was relatively high. The respective spaghetti and strap tag loss rates were 59.1% and 33.3% in males, and 17.4% and 18.2% in females. The sex-specific difference in tag loss between tag types was not statistically significant ($p > 0.05$; chi-square); however, spaghetti tag loss in males was significantly higher ($p < 0.05$; chi-square) than in females. Spaghetti tag loss is known to be high, especially in males which lose tags while fighting. Similar levels of spaghetti tag loss were reported in the Harrison River (Farwell *et al.* 1990, 1991, 1992). Although high tag loss reduced the value of the bias tests and the stratified estimators, more secure tags such as Petersen disks could not be used because tagged fish would be more vulnerable to the tangle nets used in fish capture. This would introduce bias through increased stress, physical damage and tag loss.

A comparison of carcasses recovered in stream surveys and at the carcass weir in the Cheakamus River showed that chinook jacks were virtually nonvulnerable to the stream survey. Specifically, relative to the weir, the stream surveys had a positive size bias and a significantly lower proportion of jacks (Table 17). Further, the recovery rate for jacks (0.4%) tagged in Howe Sound was an order of magnitude lower than for adults (5.3%)(Table 2a). Jack tagging, therefore, will not provide data useful for population estimation when stream surveys are the main recovery technique.

Table 20. Lower Squamish River system total chinook return and Cheakamus River chinook escapement estimated using mark-recapture and visual techniques, 1989-1992.

Location	Year	Census sample	Mark-recapture estimate a			Visual estimate b		
			Male	Female	Total	Total escape-ment	Indian fishery harvest	Total return
Cheakamus River c	1989	236	385	342	727	350	0	350
	1990	244	554	374	928	400	0	400
	1992	257	n/a	699	n/a	1,000	0	1,000
Squamish River System d	1991	511	4,205	5,143	9,348	1,170	1,095	2,265
	1992	457	2,741	4,582	7,323	1,700	1,507	3,207

a. Simple Petersen estimates.
b. Provided by B. Ionson, Squamish Subdistrict Fishery Officer.
c. Mark-recapture is for escapement only.
d. Mark-recapture is for total return; excludes the upper Squamish.

POPULATION ESTIMATION CONCERNS

When population estimates from all sources (study mark-recapture estimates and visual estimates provided by Subdistrict staff) were evaluated, three issues emerged (Table 20). First, the mark-recapture estimates were an average 4.2 times higher than the corresponding visual estimate. Other authors (e.g. Cousens *et al.* 1982) have reported that escapements estimated from data collected by foot, raft, swims or aircraft normally underestimated the true value. Shardlow *et al.* (1987) attributed this to two factors, fish counts which represented only a small fraction of those present, and the use of conservative expansion factors which did not fully compensate for the small proportion of the population actually observed. Squamish River chinook were especially difficult to enumerate visually due to stock characteristics such as the small population size and the extensive spawning distribution, and to physical conditions such as siltation in the Cheakamus River, glacial runoff in the main river, large pools in the tributaries where fish could avoid detection, and floods which obscured spawners and washed away carcasses. While a positive bias in the mark-recapture estimate cannot be discounted, it is more likely that the reported difference resulted from an inherent negative bias in the visual estimate.

Second, only a small proportion of the Howe Sound mark-recapture estimate of the chinook adult return was accounted for by the available study and visual estimates. For example, the 1992 female return was 4,582 fish (Table 20). If 699 of these fish spawned in the Cheakamus River, 212 fish were removed for the hatchery, the Ashlu Creek and Mamquam River visual estimates were assumed to be correct and half were female (350 fish), and half of the Indian fishery harvest was assumed to be female (754 fish), then an obvious question arises: Where did the other 2,567 fish go? There were several possibilities: a) The Indian fishery harvest may have been underestimated. Surveys of the fishery were relatively infrequent and were conducted among fishers with an attitude of hostility and distrust, conditions which facilitated the concealment of harvest. This was exacerbated by the need to make a number of unsubstantiated analytic assumptions, several of which could have resulted in an underestimate of harvest. Surveys of the lower Fraser River Indian fishery conducted under similar conditions were shown, through the 1993 change to a mandatory landing program, to have almost certainly underestimated harvest (A. Macdonald, Fraser River Indian Fishery Biologist, pers. comm.). The procedures used to estimate harvest in the Squamish River Indian fishery, therefore, should be thoroughly

reviewed. b) Some fish may have been taken by seals in Howe Sound or illegally removed from the river. While seal predation and poaching were known to have occurred (A. Ionson, pers. comm.), losses were unlikely to have been high. These unaccounted losses, however, will continue to be a concern if future population estimates are based on tag application in Howe Sound. c) The Ashlu Creek escapement may have been large relative to the Cheakamus River. While the fishery officer counts and the carcass recoveries recorded by this study suggest that the Cheakamus River supported the system's largest tributary spawning stock, more favourable survey conditions may have biased this view. Recovery rates, for example, were likely higher in the Cheakamus River due to lower discharges and less bear predation. d) The estimated total return may have been biased high. While there were indications of bias, they would likely have been corrected to some extent by similar biases in the Cheakamus River. Regardless, any biases which did occur will be addressed in future Howe Sound studies through the recommendations discussed in the preceding sections.

Third, the exclusion of the upper Squamish River from this study imposed a limitation on the utility of these data for stock assessment purposes. The size of this population is unknown because glacial silt prevents the direct observation of live and dead chinook. There is evidence, however, of a relatively large stock. Although carcasses were rarely recovered, the SEP crews captured several hundred live chinook from these areas. Extensive spawning habitat is known to exist in large sections of the upper mainstem (Clark 1988); therefore, densities would not have to be high and carcasses could easily go undetected. Even when the turbid areas were excluded from the escapement estimation process, escapements in the clear water tributaries (Ionson MS 1988) accounted for 35% of the system total. Extensive mainstem surveys are required to document spawner distributions and to develop appropriate stock assessment procedures.

In summary, it was not possible to reconcile differences between the study and visual data largely because the distribution of Squamish River chinook is not fully understood. A radio tagging study is recommended to determine the relative distribution between the various spawning areas, the Indian fishery and the predators.

ENHANCEMENT IMPACTS

To place in context a discussion of the impacts of enhancement on Squamish River chinook, a review of enhancement's history and its intended role in stock rebuilding is appropriate. Squamish River chinook have been cultured at the Tenderfoot Creek Hatchery since 1981. The original objective was to increase escapements in Ashlu Creek, Cheakamus River and the Squamish River mainstem through the discrete culture of individual stocks and their later release in the streams of origin as 90-day smolts (MacKinlay MS 1985). In the initial years (1981 and 1983-1985 broods), however, the eggs were separated by stock but, because the numbers were small, all of the juveniles were reared in mixed stock groups, marked with the same CWT code and released in Tenderfoot Creek to facilitate capture when they returned as adults (D. Celli, Hatchery Manager, pers. comm.). The 1986-brood stocks were reared separately and marked with unique CWT codes, but again all were released in Tenderfoot Creek. It was not until the 1987-brood that the original strategy was finally implemented in a consistent manner.

By 1988, it was apparent that the survival of the river release groups was much lower than expected. In an attempt to improve survivals, sea pens were constructed in Howe Sound to provide an alternate release site for the hatchery smolts. The subsequent survival of these groups was four to ten times higher than for comparable river releases (Bailey MS 1993). As a result, a substantial part of the hatchery production is now released at Porteau Cove and most of the future enhanced returns are expected to be from these groups.

Enhancement plays a central role in the plan to rebuild southern Strait of Georgia chinook stocks. It was intended to accelerate the process by increasing production at the same time that management actions in the ocean and terminal fisheries would be reducing exploitation rates (Levings and Riddell 1992). Limits were placed on the magnitude of hatchery production to safeguard the genetic integrity of each stock. Enhanced returns were not to exceed 50% of the total adult escapement when the stocks were rebuilt (E. Perry, SEP Biologist, pers. comm.). Rebuilding success was to be assessed using three index stocks, the Nanaimo, Squamish and

Cowichan; however, the plan did not explicitly define the rebuilding or enhancement objectives for the individual stocks within those systems.

Data collected in this study make possible an evaluation of the impact of a decade of Squamish River chinook enhancement. Four changes were noted: a) the predominant juvenile life history pattern shifted from stream-type to ocean-type fish, and the average age at maturity declined by a year; b) first generation enhanced chinook constituted a large proportion of the spawners and, since 1991, have exceeded 50% of the annual escapement in several important stocks; c) there has been an intermixing of previously discrete stocks; and d) while escapements may have increased, spawners have also been redistributed to areas where subsequent production may be limited. The implications of these issues are discussed below.

The strategy used at the Tenderfoot Hatchery tends to constrain the juveniles to an ocean-type (sub-1) strategy, i.e. they migrate to sea during their first year of life. Indeed, over 96% of the chinook recovered with an AFC were ocean-type fish (Appendices 13-15). There is ample evidence, however, that wild Squamish chinook are stream-type (sub-2) fish, i.e. they remain in freshwater for one year. Pitre (MS 1988) presented two lines of evidence for a stream-type strategy. First, pre-enhancement scale samples were almost all from stream-type fish. In 1981-1983, samples from Ashlu Creek, Cheakamus and Squamish rivers were 96% stream-type while, in 1977, samples from Ashlu Creek, Mamquam and Squamish rivers were 100% stream-type (Demontier MS 1978). Second, a study of the juvenile emigration from the Cheakamus River in April and May, 1966 found that virtually all were yearlings (Lister MS 1992). Further, Levy and Levings (1978) reported large smolts but few fry in the estuary in June. Since these data all indicate that the wild chinook are almost entirely stream-type fish, the shift to an ocean-type pattern (Table 3) must have resulted from a dramatic increase in the return of first generation enhanced fish. The impact of this change, on CWT distributions for example, is less certain. Healey (1983) reported that ocean and stream-type chinook had distinct marine distributions, the former remaining onshore throughout their marine life, the latter moving offshore from their first summer at sea. Understanding the cause of this difference is important to the interpretation of the Squamish CWT data. If it represents a phenotypic response produced by freshwater rearing conditions, then enhanced and wild fish would have different marine (and CWT) distributions. If it is genetic, however, the enhanced and wild distributions would be similar and hatchery CWT's would represent both. While Healey was unable to conclude that naturally produced stream and ocean-type chinook constituted separate races, subsequent work by Carl and Healey (1984) and Clarke *et al.* (1992) supports direct genetic control. Hatchery CWT groups, therefore, should be representative of wild production despite different life history strategies. Carl and Healey warned, however, that forcing genetically stream-type juveniles to behave like ocean-type fish could reduce their survival because their inherent behaviour would no longer be appropriate to the new conditions.

The enhanced component of the chinook escapement can be estimated in two ways: a) because the wild and enhanced chinook have different juvenile life history patterns, the percent ocean-type fish is a direct measure of the enhanced component of these stocks; and b) CWT recoveries can be expanded by the proportion of each release group which was represented by a CWT code. The aggregate escapement of all Squamish River system stocks could not be evaluated, however, because the AFC incidence was not sampled in a representative manner: the application sample was biased to stocks with large enhanced components; and the recovery sample was not representative of the entire system and did not include all spawner populations. Instead, the proportion enhanced was examined in individual stocks within the stock aggregate. At the start of this study, ocean-type fish comprised 25% of the Cheakamus chinook. By 1991-1992, the proportion had increased dramatically, to 94% in Cheakamus and Mamquam chinook and 55% in Ashlu chinook (Appendices 13-15; Table 3). Although the ocean-type groups may have included some wild fish, these estimates should closely approximate the true values if the samples were representative. In comparison, the CWT expansion estimates were 59%, 83%, 33% and 56% in Cheakamus, Mamquam, Ashlu and Shovelnose chinook, respectively (Bailey MS 1993). Although these estimates were lower than the life history pattern estimates, two conclusions can be drawn regardless of which

Table 21. Stock origin of coded wire tagged chinook adults recovered on the Squamish River system spawning grounds, by recovery location, 1988-1992.

	Origin of stock									
	Mixed stock release		Ashlu Creek		Cheakamus River		Mamquam River		Squamish River	
Recovery location	No.	% of recovery	No.	% of recovery	No.	% of recovery	No.	% of recovery	No.	% of recovery
Ashlu Creek	3	23.1%	7	53.8%	0	0.0%	0	0.0%	3	23.1%
Cheakamus River	44	42.7%	15	14.6%	23	22.3%	0	0.0%	21	20.4%
Mamquam River	39	59.1%	0	0.0%	6	9.1%	0	0.0%	21	31.8%

method is used. First, Mamquam and Cheakamus chinook had large enhanced components relative to Ashlu chinook. In the Cheakamus, this likely reflected the early enhancement emphasis and straying to the hatchery site. In the Mamquam, it reflected wild escapements which had declined to zero by 1987-1988 and the straying of large numbers of adults returning from the Porteau Cove releases. Second, with only one exception, the enhanced component of these stocks now exceeds 50% of the escapement. While the rebuilding plan specified that enhanced returns would not exceed 50% of the escapement target when the stocks were rebuilt, this guideline was specific to the Squamish River stock aggregate rather than to individual stocks within that aggregate. Because the proportion of enhanced fish in the aggregate could not be accurately estimated, there is a need to reevaluate the role of enhancement in the rebuilding of individual stocks and to develop explicit stock-specific escapement goals and enhancement guidelines.

If there is a concern with the enhanced component of the Squamish River chinook escapement, it is compounded when the intermixing of stocks is considered. Nonnative fish constituted a large proportion of the CWT's recovered in the study streams (Table 21). When this was considered in conjunction with the enhanced proportion estimated from life history patterns, up to 73%, 94% and 25% of the Cheakamus, Mamquam and Ashlu escapements, respectively, could have been of nonnative or mixed stock origin (CWT expansion estimates would be lower). This intermixing had four sources: natural straying; the intentional release of nonnative stocks into the Cheakamus River; the straying back to the hatchery of stocks released as smolts in their natal stream; and the straying throughout the system of stocks released as smolts from the Porteau Cove sea pens. Since nonnative stocks are no longer released into the Cheakamus River, the Porteau Cove fish have become the most serious source of stock intermixing. They were recovered at all of the study sites, and most were of nonnative origin. Because the Porteau Cove smolt releases increased over four-fold between the 1987-1990 and 1991-1992 brood years (Bailey MS 1993), the nonnative components of these stocks will increase from the already high levels reported above. The impact on the Squamish River chinook resource, however, is unclear. It is unknown whether spatial segregation has produced locally adapted stocks within the Squamish River system, or whether natural straying has resulted in extensive hybridization. If locally adapted stocks do exist, the extent to which they have been replaced by or have hybridized with hatchery fish is not understood. Base-line genetic stock identification data should be reevaluated to determine the level of genetic variability in these populations and to provide insights regarding the need to monitor the nature and extent of future genetic change.

This study has not been conducted in its current form for enough years to determine enhancement's role in rebuilding, or if in fact a rebuilding response has occurred. It is clear, however, that enhancement's contribution has not been homogeneous between stocks. For exam-

ple, escapements in the Mamquam River have increased from the functionally extinct level of the late 1980's to a population of several hundred spawners. How these returns should be evaluated, however, remains to be determined. If the decline in the Mamquam stock resulted from a degradation of the habitat's productive capacity, then little subsequent production can be expected and these spawners should be excluded from an evaluation of rebuilding. If an assessment of rebuilding process is to provide meaningful results, there is a need to evaluate how development-induced changes in the riverine and estuarine habitats have influenced the ability of the rebuilding plan to achieve its goals.

ASSESSMENT OF REBUILDING PROGRESS

The objective of this study was to develop escapement estimation techniques which would enable an assessment of the response of this stock to the Pacific Salmon Treaty and southern Strait of Georgia rebuilding programs. It was not until 1990 that tags were first applied in Howe Sound as part of the study which was ultimately identified as the most promising assessment technique. If accepted as an appropriate tool, there are five aspects of the Howe Sound study which should be kept in mind. First, the study estimates the population size at the time of tagging, i.e. the return to the terminal area rather than the escapement. Ancillary studies will be required to quantify other sources of fish loss, such as Indian fishery harvest, and to allocate escapement to specific stocks. Second, the current study cannot provide an unbiased estimate of the AFC incidence in the total return; therefore, other procedures must be developed to evaluate the enhanced component of this stock aggregate. Third, because the study was implemented recently, several years will be required to accumulate the time series of data needed to evaluate population trends and rebuilding progress. Fourth, the existing escapement goal was derived by doubling the average base period (1979-1982) escapement. Because visual techniques were used during the base period, the goal has inherent biases which are different from those of the mark-recapture study. An escapement goal appropriate to this estimation technique must be developed. Fifth, the relationship between the intrasystem distribution of spawners and habitat capacity should be investigated with the objective of identifying stock-specific escapement goals. The role of enhancement should be evaluated relative to those goals.

CONCLUSIONS

Perhaps the greatest challenge in the Squamish River study was in recovering an adequate number of tags. Low tag recoveries limited the reliability of the tests for bias and of the stratified population estimates. This issue must be addressed if future studies are to provide a reliable time series of assessment data.

The tributary mark-recapture studies did not provide a reliable time series of escapement data, primarily because the small populations were not well suited to this technique. Because population sizes will remain relatively small in the foreseeable future, and because alternate trapping techniques are not feasible within the existing budget, the tributary mark-recapture studies should be terminated.

The capture and tagging of chinook adults in Howe Sound is the most promising population estimation technique for the Squamish River system stock. The most serious concern identified in 1991-1992, stock-specific heterogeneous capture vulnerability, can be addressed by stratification if tag recoveries increase and the application and recovery efforts become more representative. This can be achieved through a number of modifications to the Howe Sound tag application and Squamish River system spawning ground recovery studies (discussed below). It should be understood, however, that the proposed study design will estimate the total return of chinook adults to the Squamish River system. If the evaluation of rebuilding progress is to be based on escapement trends, and if the escapement should be distributed between stocks in some desirable way, then two additional study components will be required: the estimation with known precision of the chinook adult harvest in the Squamish River Indian fishery; and the ability to allocate the total estimated escapement among tributaries. Further, because our understanding of spawning distributions is poor, a radio tagging study is needed to provide the data required for the development of an appropriate study design.

RECOMMENDATIONS

1. Tributary mark-recapture studies are unlikely to provide a reliable time series of escapement data under the current conditions of spawner abundance and capture techniques. These studies should be discontinued.

2. The Howe Sound tag application and spawning ground carcass recovery study is the most promising population estimation technique for Squamish River chinook salmon. The study, however, must be modified to address data deficiencies and sampling selectivity concerns, and to increase the number of tags recovered. The required modifications are:

    - Tag application in Howe Sound must begin at least two weeks earlier, in early July;
    - Attempts must be made to capture Squamish River chinook along the west side of upper Howe Sound and in the Squamish River estuary;
    - Application effort must be increased to between three and five days per week;
    - Fish condition and nose-fork length must be recorded for all fish released with tags;
    - Hatchery brood stock must be removed representatively from the application sample if temporal and sex related biases are to be avoided;
    - Posters should be placed at local marinas requesting anglers to report the numbers from any strap tags observed in their harvested or released catch;
    - Jack tagging should be terminated because recovery rates are too low to provide useful assessment information;
    - Spawning ground survey frequency must be increased to two complete passes per week;
    - Spawning ground survey coverage must expand to include Furry Creek and the upper Squamish River and its tributaries.

3. Five ancillary studies are needed to provide the data required to evaluate the reliability of the population estimates generated by this study:

    - A radio tagging study is recommended to provide basic spawner distribution and migratory behaviour data for these stocks;
    - The procedures used to estimate effort and harvest in the Squamish River Indian fishery should be thoroughly reviewed to determine their statistical reliability and to identify potential biases;
    - A Jolly-Seber study on carcasses should be investigated as a means of allocating total escapement to individual stocks;
    - Simulation studies are required to evaluate the behaviour of the stratified population estimators under the conditions of sampling selectivity and tag recovery levels specific to this study;
    - A Jolly-Seber population estimate should be conducted at the Howe Sound tag application site to verify the study population estimates and to test the assumption of equal probability of capture (Krebs 1989) between wild and enhanced fish.

4. The hatchery program should be reviewed to determine if current production levels are consistent with the goals of the southern Strait of Georgia stock rebuilding program. Questions which should be addressed:

    - Given the difficulty in obtaining an unbiased AFC sample of the stock aggregate at application or recovery, should the 50% enhanced guideline be applied to individual stocks rather than to the stock aggregate? If so, how should the escapement goals be established? Are current production levels consistent with the conservation of the genetic diversity within these stocks? What are acceptable enhanced proportions in the final five years of the rebuilding program?
    - Should hatchery procedures be modified to reduce the intermixing of stocks? Base-line genetic stock identification data

should be reevaluated to determine: the level of genetic variability among individual stocks; the need for changes in current enhancement pratices; and the need for annual monitoring of the nature and extent of genetic change;

- Is the current distribution of enhanced returns consistent with the production capacities of those habitats?

5. A review of the status of the Squamish River chinook resource by the Pacific Stock Assessment Review Committee is recommended. This review should include study data and data available from other agencies such as SEP and the provincial government. Issues which must be resolved:

   - Should the mark-recapure study estimates replace the existing visual estimates and, if so, how should the escapement goal be modified?

   - Has the productive capacity of the Squamish River system been degraded by riverine and estuarine developments, and have those developments impaired the ability of these stocks to rebuild?

   - Are Squamish River chinook stock characteristics such as marine distribution, run timing and juvenile life history strategy consistent with its inclusion in the southern Strait of Georgia chinook group?

   - Is the current level and between-stock distribution of enhancement appropriate to the rebuilding of this stock?

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APPENDICES

Appendix 1a. Daily application of strap tags and secondary marks, by adipose fin status and sex, to chinook adults and jacks in Howe Sound, 1990.

		Adipose fin present				Adipose fin absent				Total			
Date	Location a	Male	Female	Jack	Total	Male	Female	Jack	Total	Male	Female	Jack	Total
21-Aug	2	1	0	3	4	0	0	0	0	1	0	3	4
23-Aug	2	11	0	6	17	0	0	3	3	11	0	9	20
25-Aug	2	31	0	154	185	3	0	21	24	34	0	175	209
30-Aug	2	12	0	98	110	0	0	5	5	12	0	103	115
Total	1	0	0	0	0	0	0	0	0	0	0	0	0
	2	55	0	261	316	3	0	29	32	58	0	290	348
	3	0	0	0	0	0	0	0	0	0	0	0	0
	Total	55	0	261	316	3	0	29	32	58	0	290	348

a. Tag application locations were:
1 - Porteau Cove;
2 - Britannia Beach;
3 - Cove approx. 0.5 km north of Britannia Beach.

Appendix 1b. Daily application of strap tags and secondary marks, by adipose fin status and sex, to chinook adults and jacks in Howe Sound, 1991.

		Adipose fin present				Adipose fin absent				Total			
Date	Location a	Male	Female	Jack	Total	Male	Female	Jack	Total	Male	Female	Jack	Total
17-Jul	1	0	0	1	1	0	0	0	0	0	0	1	1
	2	3	0	0	3	0	0	0	0	3	0	0	3
18-Jul	1	0	0	1	1	0	0	0	0	0	0	1	1
	2	1	0	0	1	0	0	0	0	1	0	0	1
22-Jul	1	2	0	23	25	2	0	0	2	4	0	23	27
23-Jul	1	11	0	3	14	0	0	0	0	11	0	3	14
	2	6	0	1	7	0	0	0	0	6	0	1	7
30-Jul	1	0	0	1	1	0	0	0	0	0	0	1	1
	2	16	0	2	18	0	0	0	0	16	0	2	18
31-Jul	2	17	0	4	21	0	0	0	0	17	0	4	21
03-Aug	2	68	0	7	75	0	0	0	0	68	0	7	75
04-Aug	2	1	0	2	3	0	0	0	0	1	0	2	3
05-Aug	2	0	0	7	7	0	0	0	0	0	0	7	7
07-Aug	2	33	0	3	36	8	0	2	10	41	0	5	46
08-Aug	2	22	0	5	27	5	0	2	7	27	0	7	34
09-Aug	2	1	0	0	1	0	0	1	1	1	0	1	2
10-Aug	3	6	0	0	6	2	0	1	3	8	0	1	9
13-Aug	2	30	0	1	31	0	0	0	0	30	0	1	31
	3	9	0	3	12	4	0	4	8	13	0	7	20
16-Aug	2	0	0	1	1	0	0	0	0	0	0	1	1
17-Aug	2	22	0	5	27	0	0	2	2	22	0	7	29
18-Aug	2	61	0	3	64	11	0	0	11	72	0	3	75
	3	16	0	2	18	5	0	8	13	21	0	10	31
22-Aug	1	25	0	1	26	0	0	2	2	25	0	3	28
	2	7	0	1	8	1	0	1	2	8	0	2	10
	3	4	0	0	4	0	0	1	1	4	0	1	5
23-Aug	1	1	0	0	1	0	0	0	0	1	0	0	1
27-Aug	2	48	16	1	65	21	2	0	23	69	18	1	88
28-Aug	2	45	24	4	73	14	6	1	21	59	30	5	94
29-Aug	2	2	0	0	2	1	0	1	2	3	0	1	4
05-Sep	2	1	1	0	2	0	0	0	0	1	1	0	2
Total	1	39	0	30	69	2	0	2	4	41	0	32	73
	2	384	41	47	472	61	8	10	79	445	49	57	551
	3	35	0	5	40	11	0	14	25	46	0	19	65
	Total	458	41	82	581	74	8	26	108	532	49	108	689

a. Tag application locations were:
1 - Porteau Cove;
2 - Britannia Beach;
3 - Cove approx. 0.5 km north of Britannia Beach.

Appendix 1c. Daily application of strap tags and secondary marks, by adipose fin status and sex, to chinook adults and jacks in Howe Sound, 1992.

		Adipose fin present				Adipose fin absent				Total			
Date	Location a	Male	Female	Jack	Total	Male	Female	Jack	Total	Male	Female	Jack	Total
27-Jul	2	1	2	5	8	4	0	0	4	5	2	5	12
31-Jul	2	33	90	11	134	22	25	12	59	55	115	23	193
06-Aug	2	10	57	5	72	9	13	3	25	19	70	8	97
08-Aug	2	4	12	1	17	1	1	3	5	5	13	4	22
10-Aug	2	37	80	15	132	17	15	15	47	54	95	30	179
13-Aug	2	22	72	18	112	20	19	6	45	42	91	24	157
17-Aug	2	6	18	1	25	2	6	0	8	8	24	1	33
Total	1	0	0	0	0	0	0	0	0	0	0	0	0
	2	113	331	56	500	75	79	39	193	188	410	95	693
	3	0	0	0	0	0	0	0	0	0	0	0	0
	Total	113	331	56	500	75	79	39	193	188	410	95	693

a. Tag application locations were:
1 - Porteau Cove;
2 - Britannia Beach;
3 - Cove approx. 0.5 km north of Britannia Beach.

Appendix 2a. Strap tag and secondary mark recoveries, by application and recovery date and location, size, age and sex, of chinook adults and jacks released in Howe Sound, 1990-1991.

	Application sample					Recovery sample a						
Year	Date	Location b	Sex	Strap tag number	Survey type	Date	Location b	POH length (cm)	Sex	Age	Adipose fin	Days out
1990	25-Aug	2	J	5057	Stream	26-Sep	C2	40.1	J	2/1	P	32
1991	31-Jul	2	M	6120	Stream	12-Sep	Mcr	69.0	F c	3/1	P	43
	03-Aug	2	M	7326	survey	23-Sep	M2	58.0	M	3/1	P	51
	07-Aug	2	M	7574		27-Sep	A2	61.0	M	R	P	51
	07-Aug	2	M	6146		19-Sep	M2	60.5	M	3/1	P	43
	07-Aug	2	M	6133		25-Sep	M1	64.5	M	3/1	P	49
	08-Aug	2	M	6176		30-Sep	M3	64.0	M	R	P	53
	10-Aug	3	M	7578		26-Sep	M2	60.0	M	3/1	P	47
	13-Aug	2	M	7595		19-Sep	M2	65.5	M	3/1	P	37
	18-Aug	2	M	6950		16-Sep	Mcr	66.0	F c	3/1	P	29
	18-Aug	2	M	6968		19-Sep	M2	69.0	M	3/1	P	32
	18-Aug	2	M	6954		20-Sep	M3	64.7	M	3/1	A	33
	18-Aug	2	M	6938		23-Sep	C1	67.2	M	3/1	P	36
	22-Aug	1	M	6053		23-Sep	Mchl	n/a	M	n/a	P	32
	27-Aug	2	M	7893		19-Sep	M1	65.5	M	3/1	P	23
	27-Aug	2	M	7826		23-Sep	M3	65.0	M	3/1	P	27
	28-Aug	2	M	7959		19-Sep	M2	55.0	M	3/1	A	22
	28-Aug	2	F	7934		26-Sep	M2	68.0	F	3/1	A	29
	28-Aug	2	M	7952		02-Oct	M3	66.4	M	3/1	A	35
	28-Aug	2	n/a	7996		04-Oct	M2	65.0	M	3/1	P	37
	Primary tag lost; application data unknown					06-Sep	A2	72.0	F	4/1	P	n/a
	Primary tag lost; application data unknown					12-Sep	M3	59.4	F	R	P	n/a
	Primary tag lost; application data unknown					16-Sep	Mcr	58.5	M	3/1	P	n/a
	Primary tag lost; application data unknown					23-Sep	M2	62.0	M	3/1	P	n/a
	Primary tag lost; application data unknown					23-Sep	M3	66.0	M	3/1	P	n/a
	Primary tag lost; application data unknown					25-Sep	M1	62.0	M	4/2	P	n/a
	Primary tag lost; application data unknown					30-Sep	M3	67.0	M	3/1	P	n/a
	Primary tag lost; application data unknown					02-Oct	M3	56.4	M	3/1	P	n/a
	Primary tag lost; application data unknown					04-Oct	C1	72.3	M	R	P	n/a
	Primary tag lost; application data unknown					04-Oct	M3	66.0	F	R	P	n/a
	Primary tag lost; application data unknown					07-Oct	A2	64.0	F	4/1	P	n/a
	23-Jul	1	M	6086	Hatchery brood stock	19-Aug	Mamquam River	n/a	M	n/a	P	27

Females initially identified as male:	2 (66.7%)	Days out until recovery:	Mean:	37
Males initially identified as female:	0 (0.0%)		Maxumum	53
			Minimum:	22

a. Does not include the following 1991 recoveries: 1 at Furry Creek; 3 in the Squamish R. Indian fishery; 1 in the Mamquam R. sport fishery.

b. Strap tags were applied only in Howe Sound; see tag application and daily carcass recovery appendices for location descriptions.

c. Incorrect sex identification during strap tag application.

Appendix 2b. Strap tag and secondary mark recoveries, by application and recovery date and location, size, age and sex, of chinook adults and jacks released in Howe Sound, 1992.

Application sample				Recovery sample							
Date	Location a	Sex	Strap tag number	Survey type	Date	Location	POH length (cm)	Sex	Age	Adipose fin	Days out
31-Jul	2	F	8124	Stream	01-Sep	C1	78.0	F	4/1	P	32
31-Jul	2	F	8048	survey	01-Sep	C1	73.5	F	4/1	P	32
31-Jul	2	F	8166		09-Sep	C1	73.0	F	4/1	P	40
31-Jul	2	F	8170		10-Sep	C1	75.0	F	4/1	P	41
31-Jul	2	F	8187		10-Sep	C1	79.0	F	4/1	P	41
31-Jul	2	F	8176		15-Sep c	C4	69.0	F	4/1	A	46
31-Jul	2	F	8168		15-Sep c	C1	74.5	F	4/1	P	46
31-Jul	2	F	8156		15-Sep	C1	72.0	F	4/1	A	46
31-Jul	2	F	8195		08-Oct	C4	76.0	F	4/1	P	69
31-Jul	2	F	8155		22-Sep	M1	72.0	F	5/1	P	53
31-Jul	2	F	8151		22-Sep	M2	74.5	F	n/a	P	53
06-Aug	2	F	8294		01-Sep	C1	73.5	F	4/1	P	26
06-Aug	2	F	8244		10-Sep	C1	64.5	F	4/1	P	35
06-Aug	2	F	8296		15-Sep	C1	75.5	F	4/1	P	40
06-Aug	2	M	8277		15-Sep	C1	50.0	J	2/1	A	40
06-Aug	2	F	8243		14-Sep	M2	71.2	F	4/1	P	39
06-Aug	2	M	8252		17-Sep	C1	77.0	F	4/1	P	42
08-Aug	2	M	8435		15-Sep c	C3	78.5	M	4/1	P	38
10-Aug	2	M	10439		09-Sep	C1	65.0	M	3/1	P	30
10-Aug	2	F	10468		10-Sep	C1	80.5	F	4/1	P	31
10-Aug	2	F	10433		10-Sep	C1	80.0	F	4/1	P	31
10-Aug	2	F	8472		15-Sep	C1	74.0	F	4/1	P	36
10-Aug	2	F	10519		17-Sep	W2	83.5	F	4/1	P	38
10-Aug	2	F	8450		09-Sep	M3	67.0	F	4/1	A	30
10-Aug	2	M	10507		17-Sep	M3	68.5	M	3/1	A	38
10-Aug	2	M	10515		16-Sep	A2	69.0	M	3/1	P	37
13-Aug	2	M	17359		10-Sep	C1	67.5	F b	3/1	P	28
13-Aug	2	F	17315		14-Sep	M2	73.0	F	4/1	P	32
17-Aug	2	F	17415		15-Sep	C2	86.5	F	n/a	P	29
17-Aug	2	F	17372		17-Sep	M2	n/a	n/a	n/a	P	31
01-Sep	2	F	8082		09-Sep	C1	79.0	F	4/1	P	8
Primary tag lost; application data unknown					15-Sep	C1	71.2	M	4/1	P	n/a
Primary tag lost; application data unknown					09-Sep	M3	71.5	M	3/1	A	n/a
Primary tag lost; application data unknown					14-Sep	M2	56.0	M	3/1	P	n/a
Primary tag lost; application data unknown					14-Sep	M2	72.5	F	4/1	P	n/a
Primary tag lost; application data unknown					16-Sep	A2	78.0	F	4/1	P	n/a

Females initially identified as male:	1 (4.2%)	Days out until recovery:	Mean: 37
Males initially identified as female:	0 (0.0%)		Maxumum 69
			Minimum: 8

a. All strap tags were applied in Howe Sound; see tag application and daily carcass recovery appendicies for location descriptions.

b. Incorrect sex identification during strap tag application.

c. Recovered without a secondary mark.

Appendix 3. Daily application of spaghetti tags and secondary marks to chinook adult carcasses, and the number of subsequent recoveries per tag, by sex, in Ashlu Creek, 1992.

						Number of subsequent recoveries per tag							
			Spaghetti tags applied			Male				Female			
Year	Date	Reach a	Male	Female	Total	0	1	2	3	0	1	2	3
1992	02-Sep	2	1	0	1	1	-	-	-	-	-	-	-
		3	3	2	5	3	-	-	-	2	-	-	-
		4	2	1	3	2	-	-	-	1	-	-	-
	11-Sep	1	3	5	8	3	-	-	-	0	2	2	1
		2	1	8	9	0	1	-	-	1	4	2	1
		3	4	7	11	3	1	-	-	1	6	-	-
	16-Sep	1	3	4	7	1	2	-	-	0	4	-	-
		2	6	7	13	5	1	-	-	4	3	-	-
		3	6	13	19	3	3	-	-	5	7	1	-
		4	0	1	1	-	-	-	-	0	1	-	-
	18-Sep	1	0	2	2	-	-	-	-	1	1	-	-
		2	1	1	2	1	-	-	-	0	1	-	-
		3	1	3	4	0	1	-	-	2	1	-	-
		4	2	2	4	2	-	-	-	2	-	-	-
	22-Sep	2	0	5	5	-	-	-	-	5	-	-	-
		3	3	3	6	3	-	-	-	3	-	-	-
	29-Sep	1	1	0	1	1	-	-	-	-	-	-	-
	06-Oct	1	0	0	0	-	-	-	-	-	-	-	-
		2	0	0	0	-	-	-	-	-	-	-	-
		3	0	0	0	-	-	-	-	-	-	-	-
		4	0	0	0	-	-	-	-	-	-	-	-
		1	7	11	18	5	2	0	0	1	7	2	1
		2	9	21	30	7	2	0	0	10	8	2	1
		3	17	28	45	12	5	0	0	13	14	1	0
		4	4	4	8	4	0	0	0	3	1	0	0
		Total	37	64	101	28	9	0	0	27	30	5	2
		% recovered	-	-	-	75.7%	24.3%	0.0%	0.0%	42.2%	46.9%	7.8%	3.1%

a. See daily carcass recovery appendices for reach descriptions.

Appendix 4. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, age, sex and carcass condition, in Ashlu Creek, 1992. a

Application sample								Recovery sample			
Date	Location	POH length (cm)	Sex	Adipose fin	Age	Carcass condition	Spaghetti tag number	Date	Location	Carcass condition	Days out
11-Sep	1	76.5	F	P		1	17010	16-Sep	1	2	5
							17010	18-Sep	1	3	7
11-Sep	1	68.5	F	P		3	17011	16-Sep	1	2	5
							17011	18-Sep	1	3	7
11-Sep	1	77.0	F	P		2	17012	22-Sep	2	4	11
11-Sep	1	n/a	F	P		4	17014	22-Sep	2	4	11
11-Sep	1	72.5	F	P		1	17016	16-Sep	2	3	5
							17016	18-Sep	3	3	7
							17016	22-Sep	2	4	11
11-Sep	2	76.0	F	P		2	17018	16-Sep	2	3	5
							17018	18-Sep	2	4	7
11-Sep	2	75.0	F	A		1	17019	16-Sep	2	3	5
							17019	18-Sep	2	3	7
11-Sep	2	69.0	F	P		1	17020	16-Sep	2	3	5
							17020	18-Sep	3	4	7
							17020	22-Sep	2	4	11
11-Sep	2	78.5	M	P		2	17021	16-Sep	2	3	5
11-Sep	2	73.5	F	P		1	17022	18-Sep	3	4	7
11-Sep	2	73.5	F	P		1	17023	16-Sep	2	3	5
11-Sep	2	75.5	F	P		1	17025	18-Sep	3	3	7
11-Sep	2	68.5	F	P		1	17026	18-Sep	3	3	7
11-Sep	3	80.0	F	P		1	17100	22-Sep	3	3	11
11-Sep	3	88.5	F	P		1	17101	22-Sep	3	3	11
11-Sep	3	76.0	F	P		3	17103	18-Sep	3	3	7
11-Sep	3	88.0	M	P		2	17104	18-Sep	4	4	7
11-Sep	3	77.0	F	P		3	17105	18-Sep	4	4	7
11-Sep	3	71.5	F	P		3	17106	18-Sep	4	4	7
11-Sep	3	79.5	F	P		2	17107	18-Sep	4	4	7
16-Sep	1	82.0	M	P		1	17027	18-Sep	1	2	2
16-Sep	1	69.5	F	P		1	17028	18-Sep	1	2	2
16-Sep	1	80.0	F	P		1	17029	18-Sep	1	3	2
16-Sep	1	82.5	F	P		1	17031	22-Sep	1	2	6
16-Sep	1	80.0	M	P		1	17032	18-Sep	1	2	2
16-Sep	1	77.0	F	P		2	17033	18-Sep	1	3	2
16-Sep	2	80.5	M	P		2	17034	18-Sep	2	2	2
16-Sep	2	74.0	F	P		1	17036	18-Sep	3	2	2
16-Sep	2	77.0	F	A		2	17040	18-Sep	3	4	2
16-Sep	2	74.0	F	P		2	17041	18-Sep	3	4	2
16-Sep	3	76.0	F	P		2	17115	18-Sep	3	2	2
16-Sep	3	77.0	F	P		2	17116	18-Sep	3	2	2
16-Sep	3	66.5	M	P		2	17117	18-Sep	3	2	2
16-Sep	3	66.0	F	P		2	17118	18-Sep	3	3	2
16-Sep	3	67.5	F	P		3	17120	18-Sep	3	3	2

Continued

Appendix 4. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, age, sex and carcass condition, in Ashlu Creek, 1992 continued. a

Application sample								Recovery sample			
Date	Location	POH length (cm)	Sex	Adipose fin	Age	Carcass condition	Spaghetti tag number	Date	Location	Carcass condition	Days out
16-Sep	3	75.5	M	P		2	17121	18-Sep	3	3	2
16-Sep	3	57.0	M	P		2	17122	18-Sep	3	3	2
16-Sep	3	74.5	F	P		1	17123	18-Sep	4	3	2
16-Sep	3	73.0	F	P		2	17128	18-Sep	3	3	2
16-Sep	3	73.0	F	P		2	17129	18-Sep	3	3	2
16-Sep	3	81.0	F	A		3	17130	18-Sep	3	3	2
							17130	22-Sep	3	3	6
16-Sep	4	68.5	F	P		1	17127	18-Sep	4	3	2
18-Sep	1	75.0	F	A		1	17131	22-Sep	2	2	4
18-Sep	2	80.0	F	A		2	17049	22-Sep	2	3	4
18-Sep	3	80.5	F	P		1	17051	22-Sep	3	3	4
29-Sep	3	71.0	M	P		1	17138	06-Oct	2	3	7

a. see daily carcass recovery appendices for location descriptions.

Appendix 5a. Daily application of disk tags and secondary marks, by adipose fin status and sex, to chinook adults and jacks in the Cheakamus River, 1988.

			Adipose fin present				Adipose fin absent				Total			
Mark type	Date	Reach a	Male	Female	Jack	Total	Male	Female	Jack	Total	Male	Female	Jack	Total
Disk tag only	13-Sep	3	1	1	5	7	1	0	0	1	2	1	5	8
		1	2	6	2	10	0	0	0	0	2	6	2	10
	15-Sep	3	2	0	3	5	0	0	0	0	2	0	3	5
	Total	1	2	6	2	10	0	0	0	0	2	6	2	10
		3	3	1	8	12	1	0	0	1	4	1	8	13
		Total	5	7	10	22	1	0	0	1	6	7	10	23
Secondary mark only	Total b	-	22	15	61	98	0	1	2	3	22	16	63	101

a. See daily carcass recovery appendix for reach descriptions.

b. Released during hatchery brood stock acquisition; dates were not recorded.

Appendix 5b. Daily application of spaghetti tags and secondary marks, by adipose fin status and sex, to chinook adults in the Cheakamus River, 1989.

		Adipose fin present			Adipose fin absent			Total		
Date	Reach a	Male	Female	Total	Male	Female	Total	Male	Female	Total
25-Aug	1	1	1	2	1	0	1	2	1	3
31-Aug	4	11	6	17	0	1	1	11	7	18
06-Sep	4	11	5	16	1	0	1	12	5	17
07-Sep	4	2	2	4	0	0	0	2	2	4
14-Sep	1	3	0	3	0	1	1	3	1	4
14-Sep	4	4	0	4	0	2	2	4	2	6
Total	1	4	1	5	1	1	2	5	2	7
	4	28	13	41	1	3	4	29	16	45
	Total	32	14	46	2	4	6	34	18	52

a. See daily carcass recovery appendices for reach descriptions.

Appendix 5c. Daily application of spaghetti tags and secondary marks, by adipose fin status and sex, to chinook adults in the Cheakamus River, 1990-1992.

			Adipose fin present			Adipose fin absent			Total		
Year	Date	Reach a	Male	Female	Total	Male	Female	Total	Male	Female	Total
1990	23-Aug	3	0	0	0	0	1	1	0	1	1
	23-Aug	4	4	2	6	1	3	4	5	5	10
	24-Aug	4	7	2	9	0	0	0	7	2	9
	27-Aug	4	4	3	7	0	3	3	4	6	10
	30-Aug	4	2	2	4	1	1	2	3	3	6
	31-Aug	4	5	3	8	0	0	0	5	3	8
	07-Sep	1	5	1	6	1	0	1	6	1	7
	12-Sep	4	2	1	3	0	0	0	2	1	3
	14-Sep	3	0	1	1	0	0	0	0	1	1
	14-Sep	4	0	1	1	0	0	0	0	1	1
	Total	1	5	1	6	1	0	1	6	1	7
		2	0	0	0	0	0	0	0	0	0
		3	0	1	1	0	1	1	0	2	2
		4	24	14	38	2	7	9	26	21	47
		Total	29	16	45	3	8	11	32	24	56
1991	20-Aug	3	1	1	2	2	0	2	3	1	4
	21-Aug	3	4	2	6	1	0	1	5	2	7
	22-Aug	3	5	1	6	0	0	0	5	1	6
	23-Aug	3	2	1	3	1	0	1	3	1	4
	27-Aug	3	0	2	2	1	1	2	1	3	4
	28-Aug	3	4	0	4	3	0	3	7	0	7
	05-Sep	3	3	2	5	0	0	0	3	2	5
	24-Sep	3	2	1	3	0	0	0	2	1	3
	Total	3	21	10	31	8	1	9	29	11	40
1992	18-Aug	3	4	9	13	0	0	0	4	8	12
		4	8	7	15	1	2	3	9	9	18
	20-Aug	3	1	1	2	0	1	1	1	2	3
		4	3	4	7	0	2	2	3	6	9
	25-Aug	3	1	1	2	0	1	1	1	2	3
		4	3	2	5	1	1	2	4	3	7
	27-Aug	4	0	2	2	0	2	2	0	4	4
	10-Sep	3	0	0	0	0	1	1	0	1	1
		3	0	1	1	0	0	0	0	1	1
	Total	3	6	12	18	0	3	3	6	14	20
		4	14	15	29	2	7	9	16	22	38
		Total	20	27	47	2	10	12	22	36	58

a. See daily carcass recovery appendices for reach descriptions.

Appendix 6a. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, age and sex, of chinook adults released in the Cheakamus River, 1988-1989. a

	Application sample					Recovery sample						
Year	Date	Location	NF length (cm)	Sex	Primary tag number	Date	Location	POH length (cm)	Sex	Age	Adipose fin	Days out
1988	13-Sep	C3	n/a	F	Y90802	24-Sep	C3	76.0	F	R	P	11
	13-Sep	C1	n/a	F	Y90811	15-Sep	C1	74.0	F	R	P	2
	13-Sep	C1	n/a	J	Y90817	15-Sep	C1	47.0	J	3/2	P	2
	13-Sep	C3	n/a	J	Y90804	21-Sep	C4	47.0	J	2/1	P	8
	13-Sep	C3	n/a	M	Y90806	12-Oct	C1	52.0	M	5/2	P	29
	13-Sep	C1	n/a	F	Y90812	26-Sep	C1	79.5	F	5/2	P	13
	13-Sep	C1	n/a	F	Y90814	26-Sep	C1	71.5	F	R	P	13
	15-Sep	C3	n/a	M	Y90819	20-Sep	W2	55.5	M	5/2	P	5
	Secondary tag only applied. b					07-Sep	C1	76.0	M	5/2	P	n/a
	Secondary tag only applied. b					08-Sep	W2	36.0	J	R	P	n/a
	Secondary tag only applied. b					12-Sep	C1	42.0	J	2/1	P	n/a
	Secondary tag only applied. b					12-Sep	C1	81.5	F	5/2	P	n/a
	Secondary tag only applied. b					12-Sep	C1	74.0	M	R	A	n/a
	Secondary tag only applied. b					12-Sep	C1	48.0	J	3/2	P	n/a
	Secondary tag only applied. b					13-Sep	C2	36.0	J	2/1	P	n/a
	Secondary tag only applied. b					15-Sep	C1	75.0	F	5/2	P	n/a
	Secondary tag only applied. b					20-Sep	C1	30.0	J	4/2	P	n/a
	Secondary tag only applied. b					05-Oct	C1	50.0	J	3/2	P	n/a
	Females initially identified an male:				0 (0.0%)			Days out until recovery:			Mean:	10
	Males initially identified as female:				0 (0.0%)						Maxumum:	29
											Minimum:	2
1989	25-Aug	C1	99.0	F	1401	05-Sep	C1	82.0	F	5/2	P	11
	25-Aug	C1	85.0	M	1402	05-Sep	C1	61.0	M	4/2	P	11
	31-Aug	C4	80.5	F	1412	18-Sep	C1	66.4	F	4/2	P	18
	31-Aug	C4	69.5	M	1417	14-Sep	C4	57.0	M	3/1	P	14
	06-Sep	C4	94.0	F	1424	04-Oct	C4	70.8	F	4/2	P	28
	06-Sep	C4	99.0	F	1428	06-Oct	C1	81.4	F	n/a	P	30
	06-Sep	C4	82.0	M	1430	20-Sep	C4	62.8	M	3/1	P	14
	14-Sep	C1	79.5	M	1448	18-Sep	C1	64.3	M	3/1	P	4
	14-Sep	C1	85.0	F	1449	21-Sep	C1	70.4	F	3/1	A	7
	14-Sep	C1	76.0	M	1451	18-Sep	C1	58.5	M	3/1	P	4
	14-Sep	C4	74.0	M	1444	19-Sep	C4	57.1	M	3/1	P	5
	Primary tag lost; application data unknown.					14-Sep	C1	62.5	M	3/1	A	n/a
	Primary tag lost; application data unknown.					21-Sep	C1	71.0	M	5/2	P	n/a
	Primary tag lost; application data unknown.					25-Sep	C1	65.1	M	3/1	P	n/a
	Primary tag lost; application data unknown.					26-Sep	C4	63.2	M	3/1	P	n/a
	Females initially identified an male:				0 (0.0%)			Days out until recovery:			Mean:	13
	Males initially identified as female:				0 (0.0%)						Maxumum:	30
											Minimum:	4

a. In 1988 only, disk tags were applied to Cheakamus River chinook surplus to hatchery brood stock needs. In 1989, spaghetti tags were applied in Cheakamus River. See daily carcass recovery appendices for location descriptions.

b. Fish intentionally released with only a secondary mark.

Appendix 6b. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, age and sex, of chinook adults released in the Cheakamus River, 1990-1992. a

	Application sample					Recovery sample						
Year	Date	Location	NF length (cm)	Sex	Spaghetti tag number	Date	Location	POH length (cm)	Sex	Age	Adipose fin	Days out
1990	23-Aug	C4	89.5	F	6502	14-Sep	C4	71.1	F	4/1	P	22
	23-Aug	C4	102.0	F	6505	07-Sep	C1	83.0	F	4/1	A	15
	23-Aug	C4	95.0	F	6508	05-Sep	C4	78.5	F	4/1	P	13
	27-Aug	C4	88.5	F	6522	12-Sep	C4	71.0	F	4/1	P	16
	30-Aug	C4	99.0	F	6534	27-Sep	C4	-	F	-	P	28
	31-Aug	C4	99.0	F	6538	05-Sep	C4	82.0	F	4/1	P	5
	07-Sep	C1	72.5	M	6547	11-Sep	C1	55.5	M	R	P	4
	Primary tag lost; application data unknown.					05-Sep	C4	80.5	M	R	P	n/a
	Primary tag lost; application data unknown.					10-Sep	W2	47.0	M b	2/1	P	n/a
	Primary tag lost; application data unknown.					27-Sep	C4	78.0	M	R	A	n/a
	Primary tag lost; application data unknown.					29-Sep	W2	74.5	M	R	P	n/a
	Females initially identified an male:				0 (0.0%)			Days out until recovery:			Mean:	15
	Males initially identified as female:				1 (20.0%)						Maxumum:	28
											Minimum:	4
1991	28-Aug	C3	82.0	M	13626	11-Sep	C4	64.4	M	R	A	14
	Primary tag lost; application data unknown.					11-Sep	T	66.1	M	3/1	A	n/a
	Primary tag lost; application data unknown.					17-Sep	A2	b	F	c	A	n/a
	Primary tag lost; application data unknown.					18-Sep	T	61.0	M	3/1	P	n/a
	Primary tag lost; application data unknown.					18-Sep	T	64.0	M	3/1	A	n/a
	Females initially identified an male:				0 (0.0%)			Days out until recovery:			Mean:	14
	Males initially identified as female:				0 (0.0%)						Maxumum:	14
											Minimum:	14
1992	18-Aug	C4	100.0	F	17416	02-Sep	C2	89.2	F	4/1	n/a	15
	18-Aug	C3	93.0	F	17404	10-Sep	C1	77.5	F	4/1	P	23
	18-Aug	C3	90.0	F	17402	10-Sep	C1	73.0	F	4/1	P	23
	18-Aug	C3	98.0	F	17410	15-Sep	C4	76.5	F	4/1	P	28
	27-Aug	C4	90.5	F	17453	15-Sep	C2	72.5	F	4/1	A	19
	10-Sep	C4	92.4	F	17459	21-Sep	C1	75.5	F	4/1	P	11
	Primary tag lost; application data unknown.					08-Sep	C4	81.5	M	4/1	P	n/a
	Primary tag lost; application data unknown.					10-Sep	W2	74.5	F	4/1	P	n/a
	Primary tag lost; application data unknown.					15-Sep	C4	81.0	F	4/1	A	n/a
	Primary tag lost; application data unknown.					15-Sep	C1	74.5	F	4/1	P	n/a
	Primary tag lost; application data unknown.					08-Sep	C4	77.5	M	4/1	P	n/a
	Females initially identified an male:				0 (0.0%)			Days out until recovery:			Mean:	20
	Males initially identified as female:				0 (0.0%)						Maxumum:	28
											Minimum:	11

a. See daily carcass recovery appendices for location descriptions.

b. Incorrect sex identification at tag application.

b. Unavailable; the carcass was partially consumed by bears.

Appendix 7a. Daily application of spaghetti tags and secondary marks, by adipose fin status and sex, to chinook adults in the Mamquam River, 1992.

River	Date	Reach a	Adipose fin present			Adipose fin absent			Total		
			Male	Female	Total	Male	Female	Total	Male	Female	Total
Mamquam River	19-Aug	3	0	0	0	1	0	1	1	0	1
	26-Aug	3	0	0	0	1	2	3	1	2	3
	11-Sep	3	1	0	1	0	0	0	1	0	1
		Total	1	0	1	2	2	4	3	2	5

a. See daily carcass recovery appendices for reach descriptions.

Appendix 7b. Carcass recoveries, by application and recovery date and location, size, age and sex, of chinook adults released in the Mamquam River with spaghetti tags and secondary marks, 1992. a

River	Application sample					Recovery sample						
	Date	Location	NF length (cm)	Sex	Spaghetti tag number	Date	Location	POH length (cm)	Sex	Age	Adipose fin	Days out
Mamquam River	26-Aug	M3	85.5	M	17304	09-Sep	M3	71.0	M	4/1	A	14
	26-Aug	M3	90.0	F	17303	14-Sep	M1	78.5	F	4/1	P	19
	26-Aug	M3	85.5	F	17302	14-Sep	M1	73.5	F	4/1	A	19
	Females initially identified an male:				0 (0.0%)			Days out until recovery:			Mean:	17
	Males initially identified as female:				0 (0.0%)						Maxumun	19
											Minimum:	14

a. See daily carcass recovery appendices for location descriptions.

Appendix 8a. Daily chinook carcass recoveries, by mark status, sex and reach, in Ashlu Creek, 1990. a

					Spaghetti tag				Strap tag									
		Unmarked			Tag and secondary mark		Secondary mark only		Tag and secondary mark		Secondary mark only		Total			Adipose fin absent b		
Date	Reach c	M	F	J	M	F	M	F	M	F	M	F	M	F	J	M	F	J
06-Sep	2	3	3	2	0	0	0	0	0	0	0	0	3	3	2	0	0	0
	3	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
	4	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
07-Sep	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	4	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
10-Sep	2	2	1	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0
	4	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
13-Sep	2	2	4	1	0	0	0	0	0	0	0	0	2	4	1	0	0	0
	3	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	4	5	0	1	0	0	0	0	0	0	0	0	5	0	1	0	0	0
16-Sep	2	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
	3	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	4	1	2	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0
20-Sep	2	0	3	1	0	0	0	0	0	0	0	0	0	3	1	0	0	0
	3	2	0	2	0	0	0	0	0	0	0	0	2	0	2	0	0	0
	4	3	2	2	0	0	0	0	0	0	0	0	3	2	2	1	0	1
24-Sep	2	1	2	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0
	4	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0
27-Sep	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	4	1	2	1	0	0	0	0	0	0	0	0	1	2	1	0	0	0
01-Oct	2	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
	3	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0
	4	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Summary	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	12	15	4	0	0	0	0	0	0	0	0	12	15	4	0	0	0
	3	3	3	5	0	0	0	0	0	0	0	0	3	3	5	0	0	0
	4	14	11	5	0	0	0	0	0	0	0	0	14	11	5	1	0	1
	Total	29	29	14	0	0	0	0	0	0	0	0	29	29	14	1	0	1

a. Codes are: M - adult male; F - female; J - jack male.

b. Included in "Total".

c. Reaches were: 1 - Falls to the logging road bridge;
2 - Bridge to log jam (1.6 km);
3 - Log jam to the Squamish River;
4 - Side channel, west side, from the bridge downstream for 0.8 km.

Appendix 8b. Daily chinook carcass recoveries, by mark status, sex and reach, in Ashlu Creek, 1991. a

					Spaghetti tag				Strap tag									
		Unmarked			Tag and secondary mark		Secondary mark only		Tag and secondary mark		Secondary mark only		Total			Adipose fin absent b		
Date	Reach c	M	F	J	M	F	M	F	M	F	M	F	M	F	J	M	F	J
06-Sep	2	2	3	0	0	0	0	0	0	0	0	1	2	4	0	0	0	0
10-Sep	2	4	7	1	0	0	0	0	0	0	0	0	4	7	1	0	0	0
	3	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
13-Sep	2	4	4	0	0	0	0	0	0	0	0	0	4	4	0	0	0	0
	3	2	2	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0
17-Sep	1	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
	2	6	8	0	0	0	0	1	0	0	0	0	6	9	0	0	2	0
	3	6	2	1	0	0	0	0	0	0	0	0	6	2	1	0	0	0
20-Sep	2	6	12	0	0	0	0	0	0	0	0	0	6	12	0	1	1	0
	3	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
24-Sep	2	3	9	0	0	0	0	0	0	0	0	0	3	9	0	0	2	0
	3	2	3	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0
27-Sep	2	2	10	0	0	0	0	0	1	0	0	0	3	10	0	0	1	0
	3	2	2	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0
01-Oct	1	1	3	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0
	2	2	2	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0
	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
03-Oct	2	2	3	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0
	3	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
07-Oct	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	2	3	5	0	0	0	0	0	0	0	0	1	3	6	0	0	0	0
	3	3	1	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0
10-Oct	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	2	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Summary	1	1	7	0	0	0	0	0	0	0	0	0	1	7	0	0	0	0
	2	34	65	1	0	0	0	1	1	0	0	2	35	68	1	1	6	0
	3	18	13	1	0	0	0	0	0	0	0	0	18	13	1	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	53	85	2	0	0	0	1	1	0	0	2	54	88	2	1	6	0

a. Codes are: M - adult male; F - female; J - jack male.

b. Included in "Total".

c. Reaches were: 1 - Falls to the logging road bridge;
2 - Bridge to log jam (1.6 km);
3 - Log jam to the Squamish River;
4 - Side channel, west side, from the bridge downstream for 0.8 km.

Appendix 8c. Daily chinook carcass recoveries, by mark status, sex and reach, in Ashlu Creek, 1992. a

						Spaghetti tag				Strap tag									
		Unmarked				Tag and secondary mark		Secondary mark only		Tag and secondary mark		Secondary mark only		Total			Adipose fin absent b		
Date	Reach c	M	F	J		M	F	M	F	M	F	M	F	M	F	J	M	F	J
02-Sep	2	1	0	0	d	0	0	0	0	0	0	0	0	1	0	0 d	0	0	0
	3	3	2	0	d	0	0	0	0	0	0	0	0	3	2	0 d	1	1	0
	4	2	1	0	d	0	0	0	0	0	0	0	0	2	1	0 d	0	1	0
11-Sep	1	2	5	0	d	0	0	0	0	0	0	0	0	2	5	0 d	0	0	0
	2	1	8	0		0	0	0	0	0	0	0	0	1	8	0	0	1	0
	3	4	7	0		0	0	0	0	0	0	0	0	4	7	0	0	0	0
	4	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
16-Sep	1	3	4	0		0	0	0	0	0	0	0	0	3	4	0	0	0	0
	2	5	6	0	e	0	0	0	0	1	0	0	1	6	7	0 e	0	1	0
	3	4	13	1		0	0	0	0	0	0	0	0	4	13	1	1	1	0
	4	0	1	0		0	0	0	0	0	0	0	0	0	1	0	0	0	0
18-Sep	1	0	2	0		0	0	0	0	0	0	0	0	0	2	0	0	1	0
	2	1	1	0		0	0	0	0	0	0	0	0	1	1	0	0	1	0
	3	1	3	0		0	0	0	0	0	0	0	0	1	3	0	0	0	0
	4	1	2	1		0	0	0	0	0	0	0	0	1	2	1	0	0	0
22-Sep	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	5	0	d	0	0	0	0	0	0	0	0	0	5	0 d	0	1	0
	3	2	3	1		0	0	0	0	0	0	0	0	2	3	1	0	1	0
	4	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
29-Sep	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	1	0	0		0	0	0	0	0	0	0	0	1	0	0	0	0	0
	4	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
06-Oct	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	d	0	0	0	0	0	0	0	0	0	0	0 d	0	0	0
	4	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Summary	1	5	11	0	d	0	0	0	0	0	0	0	0	5	11	0 d	0	1	0
	2	8	20	0	f	0	0	0	0	1	0	0	1	9	21	0 f	0	4	0
	3	15	28	2	g	0	0	0	0	0	0	0	0	15	28	2 g	2	3	0
	4	3	4	1	d	0	0	0	0	0	0	0	0	3	4	1 d	0	1	0
	Total	31	63	3	h	0	0	0	0	1	0	0	1	32	64	3 h	2	9	0

a. Codes are: M - adult male; F - female; J - jack male.

b. Included in "Total".

c. Reaches were: 1 - Falls to the logging road bridge;
2 - Bridge to log jam (1.6 km);
3 - Log jam to the Squamish River;
4 - Side channel, west side, from the bridge downstream for 0.8 km.

d. Does not include 1 adult carcass of unknown sex.

e. Does not include 6 adult carcasses of unknown sex.

f. Does not include 8 adult carcass of unknown sex.

g. Does not include 2 adult carcasses of unknown sex.

h. Does not include 12 adult carcasses of unknown sex.

Appendix 9a. Daily chinook carcass recoveries, by mark status, sex and reach, in the Cheakamus River, 1988.

		Unmarked			Disk tag only			Secondary mark only b			Total			Adipose fin absent c		
Date	Reach a	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
02-Sep	W2	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
04-Sep	W2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
06-Sep	1	4	13	1	0	0	0	0	0	0	4	13	1	1	3	0
07-Sep	1	1	3	0	0	0	0	1	0	0	2	3	0	0	0	0
	W2	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0
08-Sep	1	2	7	1	0	0	0	0	0	0	2	7	1	0	1	0
	W2	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
09-Sep	3	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0
	4	1	2	1	0	0	0	0	0	0	1	2	1	0	0	0
12-Sep	1	6	11	6	0	0	0	1	1	2	7	12	8	2	2	0
	W2	0	1	1	0	0	0	0	0	0	0	1	1	0	0	1
13-Sep	W2	0	0	1	0	0	0	0	0	1	0	0	2	0	0	0
15-Sep	1	3	7	2	0	1	1	0	1	0	3	9	3	0	0	0
16-Sep	1	1	2	0	0	0	0	0	0	0	1	2	0	0	1	0
	3	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
	W2	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0
20-Sep	1	2	6	7	0	0	0	0	0	1	2	6	8	0	1	1
	3	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0
	W2	0	0	3	1	0	0	0	0	0	1	0	3	0	0	1
21-Sep	1	2	3	1	0	0	0	0	0	0	2	3	1	0	0	0
	4	1	4	1 d	0	0	1	0	0	0	1	4	2 d	0	2	0
	W2	0	1	2	0	0	0	0	0	0	0	1	2	0	0	0
23-Sep	2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	W2	0	0	2	0	0	0	0	0	0	0	0	2	0	0	1
24-Sep	3	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
	W2	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
26-Sep	1	3	3	3	0	2	0	0	0	0	3	5	3	0	0	1
27-Sep	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Sep	4	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0
29-Sep	2	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
	4	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
30-Sep	1	2	6	6	0	0	0	0	0	0	2	6	6	0	1	0
03-Oct	3	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0
05-Oct	1	1	5	2	0	0	0	0	0	1	1	5	3	0	0	0
06-Oct	3	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
11-Oct	2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	3	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	4	2	1	0	0	0	0	0	0	0	2	1	0	0	0	0
12-Oct	1	5	5	1	1	0	0	0	0	0	6	5	1	0	0	0

Continued

Appendix 9a. Daily chinook carcass recoveries, by mark status, sex and reach, in the Cheakamus River, 1988, continued.

		Unmarked			Disk tag only			Secondary mark only b			Total			Adipose fin absent c		
Date	Reach a	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
Summary	1	32	71	30	1	3	1	2	2	4	35	77	35	3	9	2
	2	2	1	0	0	0	0	0	0	0	2	1	0	0	0	0
	3	2	3	2	0	1	0	0	0	0	2	4	2	1	1	0
	4	6	8	2 d	0	0	1	0	0	0	6	8	3 d	0	2	0
	W2	3	5	10	1	0	0	0	0	2	4	4	12	1	1	3
	Total	45	88	44 d	2	4	2	2	2	6	49	94	52 d	5	13	5

a. Reaches were: 1 - "Road's End" to the Culliton Creek;
2 - Culliton Creek to the Paradise Valley Road Bailey Bridge;
3 - Bailey Bridge to the Outdoors School;
4 - Outdoors School to the Upper Squamish Road Bridge (Fergies);
5 - Fergies to the Squamish River;
W2 - a carcass weir at the bottom of Reach 3.

b. Secondary marks were applied independently in 1988, not in conjunction with a primary tag.

c. Included in "Total".

d. Does not include 2 adult carcasses of unknown sex.

Appendix 9b. Daily chinook carcass recoveries, by mark status, sex and reach, in the Cheakamus River, 1989.

Date	Reach a	Unmarked			Spaghetti tag and secondary mark			Secondary mark only			Total			Adipose fin absent b		
		Male	Female	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
28-Aug	1	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0
29-Aug	1	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0
30-Aug	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
31-Aug	4	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0
01-Sep	1	4	0	0	0	0	0	0	0	0	4	0	0	0	0	0
	3	3	0	0	0	0	0	0	0	0	3	0	0	1	0	0
04-Sep	3	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
05-Sep	1	3	1	1	1	1	0	0	0	0	4	2	1	1	0	0
06-Sep	4	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
	W2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	W3	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
07-Sep	2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
11-Sep	1	3	7	2 c	0	0	0	0	0	0	3	7	2 c	0	0	0
	W1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
12-Sep	2	3	0	0	0	0	0	0	0	0	3	0	0	1	0	0
	3	2	0	1	0	0	0	0	0	0	2	0	1	0	0	0
13-Sep	W2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
14-Sep	1	6	10	5 c	0	0	0	1	0	0	7	10	5 c	2	0	0
	4	6	3	0	1	0	0	0	0	0	7	3	0	0	2	0
	W2	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0
15-Sep	2	4	2	0 c	0	0	0	0	0	0	4	2	0 c	1	0	0
18-Sep	1	3	2	7	2	1	0	0	0	0	5	3	7	0	0	0
	W2	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0
19-Sep	3	6	1	1	0	0	0	0	0	0	6	1	1	1	0	0
	4	8	3	1	1	0	0	0	0	0	9	3	1	0	0	0
20-Sep	2	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0
	3	0	3	1	0	0	0	0	0	0	0	3	1	0	0	0
	4	16	5	3	1	0	0	0	0	0	17	5	3	1	0	0
	W2	0	0	1 d	0	0	0	0	0	0	0	0	1 d	0	0	0
21-Sep	1	7	5	0	0	1	0	1	0	0	8	6	0	0	2	0
22-Sep	4	1	2	2	0	0	0	0	0	0	1	2	2	0	0	0
25-Sep	1	1	3	3	0	0	0	1	0	0	2	3	3	0	0	0
	3	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
	W2	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
26-Sep	4	1	2	0	0	0	0	1	0	0	2	2	0	0	0	0
28-Sep	4	7	7	4	0	0	0	0	0	0	7	7	4	0	3	0
	W2	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0
	W3	2	2	0	0	0	0	0	0	0	2	2	0	0	2	0
29-Sep	1	2	7	4	0	0	0	0	0	0	2	7	4	0	1	0
02-Oct	3	2	3	0	0	0	0	0	0	0	2	3	0	0	0	0
	4	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
03-Oct	3	0	1	1	0	0	0	0	0	0	0	1	1	0	1	0
04-Oct	2	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0
	4	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0

Continued

Appendix 9b. Chinook carcass recoveries, by mark status, sex, date and reach, in the Cheakamus River River, 1989, continued.

Date	Reach a	Unmarked			Spaghetti tag and secondary mark			Secondary mark only			Total			Adipose fin absent b		
		Male	Female	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
05-Oct	4	3	1	0 d	0	0	0	0	0	0	3	1	0 d	0	0	0
06-Oct	1	2	4	1	0	1	0	0	0	0	2	5	1	0	1	0
	3	3	6	0	0	0	0	0	0	0	3	6	0	0	0	0
	4	4	4	0 d	0	0	0	0	0	0	4	4	0 d	0	0	0
	W2	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
07-Oct	W2	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
16-Oct	4	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Summary	1	32	43	23 d	3	4	0	3	0	0	38	47	23 d	3	4	0
	2	9	6	0 c	0	0	0	0	0	0	9	6	0 c	2	0	0
	3	16	16	4	0	0	0	0	0	0	16	16	4	2	1	0
	4	47	30	11 e	3	1	0	1	0	0	51	31	11 e	1	5	0
	W1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
	W2	4	4	4 d	0	0	0	0	0	0	4	4	4 d	0	0	0
	W3	2	3	0	0	0	0	0	0	0	2	3	0	0	2	0
	Total	110	102	43 f	6	5	0	4	0	0	120	107	43 f	8	12	0

a. Reaches were: 1 - "Road's End" to the suspension bridge;
2 - Suspension bridge to the Paradise Valley Road Bailey Bridge;
3 - Bailey Bridge to the Outdoors School;
4 - Outdoors School to the Upper Squamish Road Bridge (Fergies);
5 - Fergies to the Squamish River;
W1 - a small carcass weir near the Suspension Bridge in Reach 1;
W2 - the main carcass weir a the bottom of Reach 3;
W3 - a small carcass weir at the power lines in Reach 4.

b. Included in "Total".

c. Does not include 1 adult carcass of unknown sex .

d. Does not include 2 adult carcasses of unknown sex.

e. Does not include 4 adult carcasses of unknown sex.

f. Does not include 9 adult carcasses of unknown sex.

Appendix 9c. Daily chinook carcass recoveries, by mark status, sex, and reach, in the Cheakamus River, 1990. a

						Spaghetti tag				Strap tag													
		Unmarked				Tag and secondary mark		Secondary mark only		Tag and secondary mark			Secondary mark only			Total				Adipose fin absent b			
Date	Reach c	M	F	J		M	F	M	F	M	F	J	M	F	J	M	F	J		M	F	J	
26-Aug	3	1	0	0		0	0	0	0	0	0	0	0	0	0	1	0	0		0	0	0	
27-Aug	3	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
	4	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
	W2	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	0	
28-Aug	1	1	1	0		0	0	0	0	0	0	0	0	0	0	1	1	0		0	0	0	
29-Aug	1	1	3	0		0	0	0	0	0	0	0	0	0	0	1	3	0		0	0	0	
	3	1	0	0		0	0	0	0	0	0	0	0	0	0	1	0	0		0	0	0	
	4	0	1	0	d	0	0	0	0	0	0	0	0	0	0	0	1	0	d	0	0	0	
	W2	0	1	1		0	0	0	0	0	0	0	0	0	0	0	1	1		0	0	0	
30-Aug	4	0	3	0		0	0	0	0	0	0	0	0	0	0	0	3	0		0	1	0	
	W2	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
31-Aug	4	1	1	0		0	0	0	0	0	0	0	0	0	0	1	1	0		0	0	0	
	W2	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
01-Sep	W2	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
04-Sep	1	0	11	0		0	0	0	0	0	0	0	0	0	0	0	11	0		0	1	0	
05-Sep	4	5	7	0		0	2	1	0	0	0	0	0	0	0	6	9	0		0	1	0	
	W2	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	0	
06-Sep	2	3	3	1		0	0	0	0	0	0	0	0	0	0	3	3	1		0	1	0	
	3	0	2	0		0	0	0	0	0	0	0	0	0	0	0	2	0		0	1	0	
	W2	1	2	1		0	0	0	0	0	0	0	0	0	0	1	2	1		0	0	0	
07-Sep	1	1	7	2		0	1	0	0	0	0	0	0	0	0	1	8	2		0	2	0	
	W2	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	0	
08-Sep	W2	1	0	1		0	0	0	0	0	0	0	0	0	0	1	0	1		0	0	0	
10-Sep	3	1	2	0		0	0	0	0	0	0	0	0	0	0	1	2	0		0	0	0	
	4	4	5	0	d	0	0	0	0	0	0	0	0	0	0	4	5	0	d	0	0	0	
	W2	1	1	3	d	0	0	1	0	0	0	0	0	0	0	2	1	3	d	1	0	0	
11-Sep	1	5	17	4		1	0	0	0	0	0	0	0	0	0	6	17	4		2	4	0	
	W2	1	1	1		0	0	0	0	0	0	0	0	0	0	1	1	1		0	0	1	
12-Sep	3	1	1	0	d	0	0	0	0	0	0	0	0	0	0	1	1	0	d	0	1	0	
	4	1	4	2		0	1	0	0	0	0	0	0	0	0	1	5	2		1	1	0	
	W2	3	0	2		0	0	0	0	0	0	0	0	0	0	3	0	2		0	0	0	
13-Sep	2	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
	3	0	2	0		0	0	0	0	0	0	0	0	0	0	0	2	0		0	0	0	
	W2	0	0	3		0	0	0	0	0	0	0	0	0	0	0	0	3		0	0	0	
14-Sep	4	4	7	0		0	1	0	0	0	0	0	0	0	0	4	8	0		1	0	0	
15-Sep	W2	0	1	1		0	0	0	0	0	0	0	0	0	0	0	1	1		0	0	0	
16-Sep	W2	0	1	4		0	0	0	0	0	0	0	0	0	0	0	1	4		0	0	0	
17-Sep	1	8	9	1	d	0	0	0	0	0	0	0	0	0	0	8	9	1	d	1	1	0	
	W2	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	0	

Continued

Appendix 9c. Daily chinook carcass recoveries, by mark status, sex, and reach, in the Cheakamus River, 1990, cont'd. a

						Spaghetti tag				Strap tag													
		Unmarked				Tag and secondary mark		Secondary mark only		Tag and secondary mark			Secondary mark only			Total				Adipose fin absent b			
Date	Reach c	M	F	J		M	F	M	F	M	F	J	M	F	J	M	F	J		M	F	J	
18-Sep	2	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	1	0	
	3	1	0	1		0	0	0	0	0	0	0	0	0	0	1	0	1		0	0	0	
	4	1	2	1		0	0	0	0	0	0	0	0	0	0	1	2	1		0	0	0	
	W2	2	1	1		0	0	0	0	0	0	0	0	0	0	2	1	1		1	0	0	
19-Sep	2	1	0	0		0	0	0	0	0	0	0	0	0	0	1	0	0		0	0	0	
	4	3	2	2	d	0	0	0	0	0	0	0	0	0	0	3	2	2	d	0	0	2	
	W2	0	1	1		0	0	0	0	0	0	0	0	0	0	0	1	1		0	0	0	
20-Sep	1	0	7	2		0	0	0	0	0	0	0	0	0	0	0	7	2		0	0	0	
	3	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	0	
	4	1	2	2	d	0	0	0	0	0	0	0	0	0	0	1	2	2	d	0	0	0	
21-Sep	2	3	5	4		0	0	0	0	0	0	0	0	0	0	3	5	4		1	0	2	
	3	0	3	0		0	0	0	0	0	0	0	0	0	0	0	3	0		0	0	0	
	4	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
22-Sep	W2	0	0	2		0	0	0	0	0	0	0	0	0	0	0	0	2		0	0	0	
23-Sep	W2	0	0	2		0	0	0	0	0	0	0	0	0	0	0	0	2		0	0	0	
24-Sep	W2	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
25-Sep	3	0	1	1		0	0	0	0	0	0	0	0	0	0	0	1	1		0	0	0	
	4	3	3	0	e	0	0	0	0	0	0	0	0	0	0	3	3	0	e	0	1	0	
26-Sep	1	5	7	6	d	0	0	0	0	0	0	0	0	0	0	5	7	6	d	1	2	1	
	2	2	2	5	d	0	0	0	0	0	0	1	0	0	0	2	2	6	d	1	0	0	
27-Sep	4	0	1	1		0	1	1	0	0	0	0	0	0	0	1	2	1		0	0	1	
28-Sep	4	1	1	1		0	0	0	0	0	0	0	0	0	0	1	1	1		1	1	0	
29-Sep	W2	1	0	0		0	0	1	0	0	0	0	0	0	0	2	0	0		0	0	0	
01-Oct	3	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
	4	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
02-Oct	1	3	1	1		0	0	0	0	0	0	0	0	0	0	3	1	1		0	0	0	
03-Oct	1	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
	2	3	2	6		0	0	0	0	0	0	0	0	0	0	3	2	6		0	0	1	
05-Oct	W2	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	
Summary	1	24	64	16	e	1	1	0	0	0	0	0	0	0	0	25	65	16	e	4	10	1	
	2	12	14	16		0	0	0	0	0	0	1	0	0	0	12	14	17	d	2	2	3	
	3	5	13	3	d	0	0	0	0	0	0	0	0	0	0	5	13	3	d	0	2	0	
	4	24	42	9	f	0	5	2	0	0	0	0	0	0	0	26	47	9	f	3	5	3	
	W2	10	14	27	d	0	0	2	0	0	0	0	0	0	0	12	14	27	d	2	0	1	
	Total	75	147	71	g	1	6	4	0	0	0	1	0	0	0	80	153	72	g	11	19	8	

a. Codes are: M - male adult; F - female; J - male jack.

b. Included in "Total".

c. Reaches were: 1 - "Road's End" to Culliton Creek;
2 - Culliton Creek to the Paradise Valley Road Bailey Bridge;
3 - Bailey Bridge to the Outdoors School;
4 - Outdoors School to the Upper Squamish Road Bridge;
5 - Squamish R. Br. (Fergies) to the Squamish River.
W2 - Carcass weir at the bottom of Reach 3.

d. Does not include 1 adult carcass of unknown sex.

e. Does not include 2 adult carcasses of unknown sex.

f. Does not include 6 adult carcasses of unknown sex.

g. Does not include 11 adult carcasses of unknown sex.

Appendix 9d Daily chinook carcass recoveries, by mark status, sex, and reach, in the Cheakamus River, 1991. a

					Spaghetti tag				Strap tag									
		Unmarked			Tag and secondary mark		Secondary mark only		Tag and secondary mark		Secondary mark only		Total			Adipose fin absent b		
Date	Reach c	M	F	J	M	F	M	F	M	F	M	F	M	F	J	M	F	J
05-Sep	3	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
10-Sep	1	1	2	0	0	0	0	0	0	0	0	0	1	2	0	1	0	0
11-Sep	3	2	1	0	0	0	0	0	0	0	0	0	2	1	0	1	0	0
	4	3	2	0	1	0	0	0	0	0	0	0	4	2	0	3	0	0
	T	0	2	0	0	0	1	0	0	0	0	0	1	2	0	1	0	0
13-Sep	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
17-Sep	2	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
18-Sep	3	1	2	0	0	0	0	0	0	0	0	0	1	2	0	0	1	0
	T	7	6	1	0	0	2	0	0	0	0	0	9	6	1	1	0	0
20-Sep	4	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
23-Sep	1	4	7	0	0	0	0	0	1	0	0	0	5	7	0	0	1	0
24-Sep	3	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
	4	3	2	1 d	0	0	0	0	0	0	0	0	3	2	1 d	0	0	0
25-Sep	1	1	3	0 d	0	0	0	0	0	0	0	0	1	3	0 d	0	1	0
	T	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
30-Sep	3	1	4	0	0	0	0	0	0	0	0	0	1	4	0	1	0	0
	4	3	2	0 d	0	0	0	0	0	0	0	0	3	2	0 d	1	0	0
01-Oct	1	2	2	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0
04-Oct	1	4	6	0	0	0	0	0	0	0	1	0	5	6	0	0	1	0
07-Oct	4	0	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
08-Oct	3	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
09-Oct	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Summary	1	13	21	0 d	0	0	0	0	1	0	1	0	15	21	0 d	1	3	0
	2	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	3	7	10	0	0	0	0	0	0	0	0	0	7	10	0	2	2	0
	4	11	9	1 e	1	0	0	0	0	0	0	0	12	9	1 e	4	0	0
	T	7	9	1	0	0	3	0	0	0	0	0	10	9	1	2	0	0
	Total	38	50	2 f	1	0	3	0	1	0	1	0	44	50	2 f	9	5	0

a. Codes are: M - male adult; F - female; J - male jack.

b. Included in "Total".

c. Reaches were: 1 - "Road's End" to Culliton Creek;
2 - Culliton Creek to the Paradise Valley Road Bailey Bridge;
3 - Bailey Bridge to the Outdoors School;
4 - Outdoors School to the Upper Squamish Road Bridge (Fergies);
5 - Fergies to the Squamish River.
T - Tenderfoot Creek.

d. Does not include 1 adult carcass of unknown sex.

e. Does not include 2 adult carcasses of unknown sex.

f. Does not include 3 adult carcasses of unknown sex.

Appendix 9e. Daily chinook carcass recoveries, by mark status, sex, and reach, in the Cheakamus River, 1992. a

						Spaghetti tag				Strap tag											
		Unmarked				Tag and secondary mark		Secondary mark only		Tag and secondary mark			Secondary mark only		Total				Adipose fin absent b		
Date	Reach c	M	F	J		M	F	M	F	M	F	J	M	F	M	F	J		M	F	J
19-Aug	1	1	0	0		0	0	0	0	0	0	0	0	0	1	0	0		0	0	0
26-Aug	1	1	7	0		0	0	0	0	0	0	0	0	0	1	7	0		0	0	0
31-Aug	1	1	0	0		0	0	0	0	0	0	0	0	0	1	0	0		1	0	0
01-Sep	1	9	17	2	d	0	0	0	0	0	3	0	0	0	9	20	2	d	3	4	0
02-Sep	2	2	2	2		0	1	0	0	0	0	0	0	0	2	3	2		0	0	1
03-Sep	4	0	1	0		0	0	1	0	0	0	0	0	0	1	1	0		0	0	0
03-Sep	W2	0	1	0		0	0	0	0	0	0	0	0	0	0	1	0		0	0	0
08-Sep	4	2	3	0		0	0	1	0	0	0	0	0	0	3	3	0		0	1	0
	W2	1	2	3		0	0	0	0	0	0	0	0	0	1	2	3		0	0	1
09-Sep	1	15	23	9	d	0	0	0	0	1	2	0	0	0	16	25	9	d	5	2	3
10-Sep	1	4	25	1		0	2	0	0	0	6	0	0	0	4	33	1		1	7	0
	4	0	0	1		0	0	0	0	0	0	0	0	0	0	0	1		0	0	0
	W2	4	3	6		0	0	0	1	0	0	0	0	0	4	4	6		2	1	2
15-Sep	1	4	26	5		0	0	0	1	0	4	1	1	0	5	31	5		1	6	3
	2	0	5	2		0	1	0	0	0	1	0	0	0	0	7	2		0	2	2
	3	0	4	1	d	0	0	0	0	1	0	0	0	0	1	4	1	d	0	0	0
	4	3	6	0		0	1	0	1	0	1	0	0	0	3	9	0		1	3	0
	W2	1	3	0		0	0	0	0	0	0	0	0	0	1	3	0		0	1	0
16-Sep	W2	1	1	2		0	0	0	0	0	0	0	0	0	1	1	2		1	0	1
17-Sep	1	2	5	0		0	0	0	0	0	1	0	0	0	2	6	0		0	2	0
	3	1	0	0		0	0	0	0	0	0	0	0	0	1	0	0		1	0	0
	4	3	2	1		0	0	0	0	0	0	0	0	0	3	2	1		0	0	1
	W2	1	1	0		0	0	0	0	0	1	0	0	0	1	2	0		1	0	0
18-Sep	1	0	0	1		0	0	0	0	0	0	0	0	0	0	0	1		0	0	1
	W2	0	2	0		0	0	0	0	0	0	0	0	0	0	2	0		0	0	0
21-Sep	1	0	1	2		0	1	0	0	0	0	0	0	0	0	2	2		0	0	0
	W2	1	3	0		0	0	0	0	0	0	0	0	0	1	3	0		0	0	0
30-Sep	1	3	8	0		0	0	0	0	0	0	0	0	0	3	8	0		0	0	0
	2	0	2	0		0	0	0	0	0	0	0	0	0	0	2	0		0	0	0
05-Oct	4	0	1	0		0	0	0	0	0	0	0	0	0	0	1	0		0	0	0
07-Oct	3	0	4	0	d	0	0	0	0	0	0	0	0	0	0	4	0	d	0	0	0
08-Oct	4	0	1	0		0	0	0	0	0	1	0	0	0	0	2	0		0	0	0
Summary	1	40	112	20	d	0	3	0	1	1	16	1	1	0	42	132	20	d	11	21	7
	2	2	9	4	d	0	2	0	0	0	1	0	0	0	2	12	4	d	0	2	3
	3	1	8	1	e	0	0	0	0	1	0	0	0	0	2	8	1	e	1	0	0
	4	8	14	2		0	1	2	1	0	2	0	0	0	10	18	2		1	4	1
	W2	9	16	11		0	0	0	1	0	1	0	0	0	9	18	11		4	2	4
	Total	60	159	38	f	0	6	2	3	2	20	1	1	0	65	188	38	f	17	29	15

a. Codes are: M - male adult; F - female; J - male jack.

b. Included in "Total".

c. Reaches: 1 - "Road's End" to Culliton Creek;
2 - Culliton Creek to the Paradise Valley Road Bailey Bridge;
3 - Bailey Bridge to the Outdoors School;
4 - Outdoors School to the Upper Squamish Road Bridge; (Fergies);
5 - Fergies to the Squamish River.
W2 - Carcass weir at the bottom of Reach 3.

d. Does not include 1 adult carcass of unknown sex.

e. Does not include 2 adult carcasses of unknown sex.

f. Does not include 4 adult carcasses of unknown sex.

Appendix 10a. Daily chinook carcass recoveries, by mark status, sex and reach, in the Marnquam River, 1991. a

					Spaghetti tag				Strap tag									
		Unmarked			Tag and secondary mark		Secondary mark only		Tag and secondary mark		Secondary mark only		Total			Adipose fin absent b		
Date	Reach c	M	F	J	M	F	M	F	M	F	M	F	M	F	J	M	F	J
09-Sep	3	2	5	0	0	0	0	0	0	0	0	0	2	5	0	1	1	0
	Mchl	4	1	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0
12-Sep	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
	2	1	3	0	0	0	0	0	0	0	0	0	1	3	0	0	1	0
	3	2	7	0	0	0	0	0	0	0	0	1	2	8	0	0	0	0
	4	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
	Mcr	2	4	1	0	0	0	0	0	1	0	0	2	5	1	0	0	0
16-Sep	1	1	6	0	0	0	0	0	0	0	0	0	1	6	0	0	2	0
	Mcr	6	9	0	0	0	0	0	0	1	1	0	7	10	0	3	2	0
19-Sep	1	1	5	1	0	0	0	0	1	0	0	0	2	5	1	0	1	1
	2	15	10	2	0	0	0	0	4	0	0	0	19	10	2	2	4	1
	3	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
20-Sep	3	13	6	2	0	0	0	0	1	0	0	0	14	6	2	1	1	0
23-Sep	2	12	4	1	0	0	0	0	1	0	1	0	14	4	1	2	1	1
	3	3	4	0	0	0	0	0	1	0	1	0	5	4	0	1	0	0
	Mchl	2	1	0	0	0	0	0	1	0	0	0	3	1	0	0	0	0
	Mcr	3	11	0	0	0	0	0	0	0	0	0	3	11	0	0	4	0
25-Sep	1	4	10	0	0	0	0	0	1	0	1	0	6	10	0	2	3	0
26-Sep	2	10	13	0	0	0	0	0	1	1	0	0	11	14	0	3	3	0
	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	4	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Mcr	1	4	0	0	0	0	0	0	0	0	0	1	4	0	0	2	0
30-Sep	1	0	3	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0
	2	4	2	0	0	0	0	0	0	0	0	0	4	2	0	2	0	0
	3	7	3	1	0	0	0	0	1	0	1	0	9	3	1	0	0	0
	Mcr	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
02-Oct	1	1	2	0	0	0	0	0	0	0	0	0	1	2	0	0	1	0
	2	2	0	1	0	0	0	0	0	0	0	0	2	0	1	0	0	1
	3	4	3	0	0	0	0	0	1	0	1	0	6	3	0	1	0	0
	4	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Mcr	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
04-Oct	2	2	1	1	0	0	0	0	1	0	0	0	3	1	1	0	0	0
	3	2	1	0	0	0	0	0	0	0	0	1	2	2	0	0	0	0
	Mcr	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
08-Oct	1	1	7	0	0	0	0	0	0	0	0	0	1	7	0	0	1	0
	2	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
	3	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
	Mcr	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
11-Oct	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Continued

Appendix 10a. Daily chinook carcass recoveries, by mark status, sex and reach, in the Mamquam River, 1991, continued.

					Spaghetti tag				Strap tag									
		Unmarked			Tag and secondary mark		Secondary mark only		Tag and secondary mark		Secondary mark only		Total			Adipose fin absent		
Date	Reach a	M	F	J	M	F	M	F	M	F	M	F	M	F	J	M	F	J
Summary	1	9	34	1	0	0	0	0	2	0	1	0	12	34	1	3	9	1
	2	47	34	5	0	0	0	0	7	1	1	0	55	35	5	9	9	3
	3	35	31	3	0	0	0	0	4	0	3	2	42	33	3	4	3	0
	4	3	1	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0
	Mchl	6	2	0	0	0	0	0	1	0	0	0	7	2	0	0	0	0
	Mcr	13	32	1	0	0	0	0	0	2	1	0	14	34	1	3	8	0
	Total	113	134	10	0	0	0	0	14	3	6	2	133	139	10	19	29	4

a. Codes are: M - Male adult; F - Female; J - male jack.

b. Included in "Total".

c. Reachs were: 1 - Ring Creek to the falls;
2 - Ring Creek to Mashiter Creek;
3 - Mashiter Cr. to the Hwy. 99 Bridge;
4 - Hwy. 99 Bridge to the Squamish River;
Mcr - Mashiter Creek;
Mchl - Mamquam Channel.

Appendix 10b. Daily chinook carcass recoveries, by mark status, sex and reach, in the Mamquam River, 1992. a

		Spaghetti tag							Strap tag											
		Unmarked			Tag and secondary mark		Secondary mark only		Tag and secondary mark		Secondary mark only		Total				Adipose fin absent b		
Date	Reach c	M	F	J	M	F	M	F	M	F	M	F	M	F	J		M	F	J
31-Aug	3	1	0	0	0	0	0	0	0	0	0	0	1	0	0		0	0	0
03-Sep	1	0	4	0	0	0	0	0	0	0	0	0	0	4	0		0	1	0
	2	1	0	0	0	0	0	0	0	0	0	0	1	0	0		0	0	0
08-Sep	2	1	1	0	0	0	0	0	0	0	0	0	1	1	0		0	1	0
09-Sep	3	4	2	2 d	1	0	0	0	0	1	1	0	6	3	2	d	5	3	1
11-Sep	3	1	0	1	0	0	0	0	0	0	0	0	1	0	1		0	0	0
14-Sep	1	2	3	0	0	2	0	0	0	0	0	0	2	5	0		0	1	0
	2	4	12	3 d	0	0	0	0	0	2	1	1	5	15	3	d	1	4	2
16-Sep	2	2	3	1	0	0	0	0	0	0	0	0	2	3	1		2	1	1
17-Sep	1	1	7	0	0	0	0	0	0	0	0	0	1	7	0		0	0	0
	2	3	4	0 d	0	0	0	0	0	0 d	0	0	3	4	0	e	1	0	0
	3	1	4	0	0	0	0	0	1	0	0	0	2	4	0		2	1	0
22-Sep	1	0	3	0	0	0	0	0	0	1	0	0	0	4	0		0	0	0
	2	1	1	0	0	0	0	0	0	1	0	0	1	2	0		0	0	0
	3	3	1	3	0	0	0	0	0	0	0	0	3	1	3		1	0	1
28-Sep	3	2	3	0 d	0	0	0	0	0	0	0	0	2	3	0	d	0	0	0
Summary	1	3	17	0	0	2	0	0	0	1	0	0	3	20	0		0	2	0
	2	12	21	4 e	0	0	0	0	0	3 d	1	1	13	25	4	f	4	6	3
	3	12	10	6 e	1	0	0	0	1	1	1	0	15	11	6	e	8	4	2
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0
	Mchl	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0
	Mcr	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0
	Total	27	48	10 g	1	2	0	0	1	5 d	2	1	31	56	10	h	12	12	5

a. Codes are: M - Male adult; F - Female; J - male jack.

b. Included in "Total".

c. Reachs were: 1 - Ring Creek to the falls;
2 - Ring Creek to Mashiter Creek;
3 - Mashiter Cr. to the Hwy. 99 Bridge;
4 - Hwy. 99 Bridge to the Squamish River;
Mcr - Mashiter Creek;
Mchl - Mamquam Channel.

d. Does not include 1 adult carcass of unknown sex.

e. Does not include 2 adult carcasses of unknown sex.

f. Does not include 3 adult carcasses of unknown sex.

g. Does not include 4 adult carcasses of unknown sex.

h. Does not include 5 adult carcasses of unknown sex.

Appendix 11. Daily chinook carcass recoveries, by mark status, sex and reach, in Shovelnose Creek, 1991-1992. a

					Spaghetti tag				Strap tag									
		Unmarked			Tag and secondary mark		Secondary mark only		Tag and secondary mark		Secondary mark only		Total			Adipose fin absent b		
Year	Date	M	F	J	M	F	M	F	M	F	M	F	M	F	J	M	F	J
1991	11-Sep	24	18	3	0	0	0	0	0	0	0	0	24	18	3	2	1	1
	17-Sep	72	57	19	0	0	0	0	0	0	0	0	72	57	19	3	11	3
	Total	96	75	22	0	0	0	0	0	0	0	0	96	75	22	5	12	4
1992	09-Sep	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0
	22-Sep	0	8	0	0	0	0	0	0	0	0	0	0	8	0	0	2	0
		1	9	0	0	0	0	0	0	0	0	0	1	9	0	1	3	0

a. Codes are: M - adult male; F - female; J - jack male.

b. Included in "Total".

Appendix 12. Annual Tenderfoot Creek Hatchery chinook brood stock capture, by mark status, sex and location, in the Squamish River system, 1988-1992.

					Spaghetti tag				Strap tag									
		Unmarked			Tag and secondary mark		Secondary mark only		Tag and secondary mark		Secondary mark only		Total			Adipose fin absent b		
Year	Location	M	F	J	M	F	M	F	M	F	M	F	M	F	J	M	F	J
1988	Ashlu Creek	36	30	5	0	0	0	0	0	0	0	0	36	30	5	0	1	1
	Cheakamus River	91	114	46	0	0	0	0	0	0	0	0	91	114	46	18	34	8
	Squamish River	58	60	6	0	0	0	0	0	0	0	0	58	60	6	0	0	1
1989	Ashlu Creek	30	21	1	0	0	0	0	0	0	0	0	30	21	1	1	0	0
	Cheakamus River	98	86	3	0	0	0	0	0	0	0	0	98	86	3	28	13	1
	Squamish River	71	82	6	0	0	0	0	0	0	0	0	71	82	6	4	0	1
1990	Ashlu Creek	25	12	0	0	0	0	0	0	0	0	0	25	12	0	3	0	0
	Cheakamus River	93	122	12	0	0	0	0	0	0	0	0	93	122	12	16	32	6
	Mamquam River	3	1	17	0	0	0	0	0	0	0	0	3	1	17	2	0	6
	Squamish River	46	51	3	0	0	0	0	0	0	0	0	46	51	3	3	2	3
	Howe Sound	9	14	45	0	0	0	0	0	0	0	0	9	14	45	8	3	41
1991	Ashlu Creek	6	7	0	0	0	0	0	0	0	0	0	6	7	0	0	0	0
	Cheakamus River	25	26	0	0	0	0	0	0	0	0	0	25	26	0	3	4	0
	Mamquam River c	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
	Shovelnose Creek	8	4	0	0	0	0	0	0	0	0	0	8	4	0	1	0	0
	Howe Sound	378	385	61	0	0	0	0	0	0	0	0	378	385	61	104	84	61
1992	Ashlu Creek	37	30	8	0	0	0	0	0	2	0	0	37	32	8	3	2	3
	Cheakamus River	62	102	26	0	0	0	0	2	3	1	0	65	105	26	10	11	21
	Mamquam River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Squamish River:																	
	25-26 mile	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	26-27 mile	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	30.5 mile	4	4	0	0	0	0	0	0	0	0	0	4	4	0	2	0	0
	Shovelnose Creek	55	68	3	0	0	0	0	0	0	0	0	55	68	3	4	8	1
	Powerhouse	7	2	3	0	0	0	0	0	0	0	0	7	2	3	1	0	3
	Total	67	75	6	0	0	0	0	0	0	0	0	67	75	6	7	8	4
	Howe Sound	126	175	41	0	0	0	0	0	0	0	0	126	175	41	42	34	26

a. Codes are: M - adult male; F - female; J - jack male.

b. Included in "Total".

c. Captured during pink brood stock acquisition.

Appendix 13a. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Ashlu Creek chinook spawning ground recoveries, 1990.

		Female			Male		
Mark status	Age	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	6/2	0	0.0%	-	0	0.0%	-
	5/2	8	38.1%	82.3	2	7.1%	76.5
	5/1	0	0.0%	-	1	3.6%	90.5
	4/2	7	33.3%	69.4	9	32.1%	66.6
	4/1	5	23.8%	77.0	0	0.0%	-
	3/2	0	0.0%	-	3	10.7%	45.7
	3/1	0	0.0%	-	5	17.9%	64.6
	2/1	1	4.8%	43.5	8	28.6%	42.4
	Sub-1	6	28.6%	-	14	50.0%	-
	Sub-2	15	71.4%	-	14	50.0%	-
	Total a	29	41.4%	74.1	41	58.6%	60.6
Adipose fin clip	6/2	0	0.0%	-	0	0.0%	-
	5/2	0	0.0%	-	0	0.0%	-
	5/1	0	0.0%	-	0	0.0%	-
	4/2	0	0.0%	-	0	0.0%	-
	4/1	0	0.0%	-	0	0.0%	-
	3/2	0	0.0%	-	0	0.0%	-
	3/1	0	0.0%	-	1	100.0%	69.0
	2/1	0	0.0%	-	0	0.0%	-
	Sub-1	0	0.0%	-	1	100.0%	-
	Sub-2	0	0.0%	-	0	0.0%	-
	Total a	0	0.0%	-	2	100.0%	56.3
Total	6/2	0	0.0%	-	0	0.0%	-
	5/2	8	38.1%	82.3	2	6.9%	76.5
	5/1	0	0.0%	-	1	3.4%	90.5
	4/2	7	33.3%	69.4	9	31.0%	66.6
	4/1	5	23.8%	77.0	0	0.0%	-
	3/2	0	0.0%	-	3	10.3%	45.7
	3/1	0	0.0%	-	6	20.7%	65.3
	2/1	1	4.8%	43.5	8	27.6%	42.4
	Sub-1	6	28.6%	-	15	51.7%	-
	Sub-2	15	71.4%	-	14	48.3%	-
	Total a	29	40.3%	74.1	43	59.7%	60.3

a. Totals include unageable samples; flesh colour not recorded.

Appendix 13b. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Ashlu Creek chinook spawning ground recoveries, 1991.

		Female			Male		
Mark status	Age a	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	6/2	0	0.0%	-	1	3.2%	82.0
	5/2	16	24.6%	80.2	5	16.1%	79.6
	4/2	20	30.8%	68.5	7	22.6%	65.8
	4/1	12	18.5%	74.0	5	16.1%	78.8
	3/2	0	0.0%	-	1	3.2%	43.0
	3/1	17	26.2%	67.2	12	38.7%	65.0
	Sub-1	29	44.6%	-	17	54.8%	-
	Sub-2	36	55.4%	-	14	45.2%	-
	Red	1	1.2%	82.0	1	2.0%	62.0
	White	81	98.8%	72.0	50	98.0%	69.5
	Total	77	64.2%	72.1	43	35.8%	69.4
Adipose fin clip	4/1	2	100.0%	77.0	0	0.0%	-
	3/1	0	0.0%	-	1	100.0%	60.5
	Sub-1	2	100.0%	-	1	100.0%	-
	Sub-2	0	0.0%	-	0	0.0%	-
	Red	0	0.0%	-	0	0.0%	-
	White	6	100.0%	76.8	1	100.0%	60.5
	Total	6	85.7%	76.8	1	14.3%	60.5
Total	6/2	0	0.0%	-	1	3.1%	82.0
	5/2	16	23.9%	80.2	5	15.6%	79.6
	5/1	0	0.0%	-	0	0.0%	-
	4/2	20	29.9%	68.5	7	21.9%	65.8
	4/1	14	20.9%	74.5	5	15.6%	78.8
	3/2	0	0.0%	-	1	3.1%	43.0
	3/1	17	25.4%	67.2	13	40.6%	64.9
	2/1	0	0.0%	-	0	0.0%	-
	Sub-1	31	46.3%	-	18	56.3%	-
	Sub-2	36	53.7%	-	14	43.8%	-
	Red	1	1.1%	82.0	1	1.9%	62.0
	White	87	98.9%	72.3	51	98.1%	69.3
	Total	81	64.8%	72.4	44	35.2%	69.2

a. Totals include unageable samples; sex or flesh colour was not recorded for all samples.

Appendix 13c. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Ashlu Creek chinook spawning ground recoveries, 1992.

		Female			Male		
Mark status	Age a	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	5/2	15	33.3%	78.0	4	14.8%	85.5
	4/2	6	13.3%	71.6	5	18.5%	63.0
	4/1	22	48.9%	74.7	12	44.4%	76.2
	3/2	0	0.0%	-	2	7.4%	59.8
	3/1	2	4.4%	70.0	3	11.1%	64.3
	2/1	0	0.0%	-	1	3.7%	46.5
	Sub-1	24	53.3%	-	16	59.3%	-
	Sub-2	21	46.7%	-	11	40.7%	-
	Red	0	0.0%	-	0	0.0%	-
	White	55	100.0%	75.2	32	100.0%	71.5
	Total	55	62.5%	75.2	33	37.5%	71.5
Adipose fin clip	4/1	9	100.0%	77.3	0	0.0%	-
	3/2	0	0.0%	-	0	0.0%	-
	3/1	0	0.0%	-	1	100.0%	36.0
	Sub-1	9	100.0%	-	1	100.0%	-
	Sub-2	0	0.0%	-	0	0.0%	-
	Red	0	0.0%	-	0	0.0%	-
	White	9	100.0%	77.3	2	100.0%	54.8
	Total	9	81.8%	77.3	2	18.2%	54.8
Total	5/2	15	27.8%	78.0	4	14.3%	85.5
	5/1	0	0.0%	-	0	0.0%	-
	4/2	6	11.1%	71.6	5	17.9%	63.0
	4/1	31	57.4%	75.5	12	42.9%	76.2
	3/2	0	0.0%	-	2	7.1%	59.8
	3/1	2	3.7%	70.0	4	14.3%	57.3
	2/1	0	0.0%	-	1	3.6%	46.5
	Sub-1	33	61.1%	-	17	60.7%	-
	Sub-2	21	38.9%	-	11	39.3%	-
	Red	0	0.0%	-	0	0.0%	-
	White	64	100.0%	75.5	35	100.0%	70.5
	Total	64	64.6%	75.5	35	35.4%	70.5

a. Totals include unageable samples; sex or flesh colour was not recorded for all samples.

Appendix 14a. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Cheakamus River chinook spawning ground recoveries, 1988.

		Female			Male		
Mark status	Age	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	6/3	1	1.8%	76.0	0	0.0%	-
	5/2	38	69.1%	77.7	14	29.8%	77.9
	5/1	3	5.5%	75.0	1	2.1%	81.0
	4/2	6	10.9%	68.0	5	10.6%	58.4
	4/1	5	9.1%	74.3	0	0.0%	-
	3/2	1	1.8%	48.5	11	23.4%	44.4
	3/1	0	0.0%	-	3	6.4%	59.0
	2/1	1	1.8%	37.0	13	27.7%	39.5
	Sub-1 b	9	16.4%	-	19	33.9%	-
	Sub-2-3 b	46	83.6%	-	37	66.1%	-
	Total c	80	47.9%	74.4	87	52.1%	55.4
Adipose fin clip	6/3	0	0.0%	-	0	0.0%	-
	5/2	2	22.2%	70.5	1	16.7%	43.0
	5/1	1	11.1%	85.0	0	0.0%	-
	4/2	0	0.0%	-	0	0.0%	-
	4/1	6	66.7%	71.1	2	33.3%	74.3
	3/2	0	0.0%	-	0	0.0%	-
	3/1	0	0.0%	-	1	16.7%	60.0
	2/1	0	0.0%	-	2	33.3%	38.5
	Sub-1	7	77.8%	-	5	83.3%	-
	Sub-2	2	22.2%	-	1	16.7%	-
	Total c	13	56.5%	72.3	10	43.5%	54.0
Total	6/3	1	1.6%	76.0	0	0.0%	-
	5/2	40	62.5%	77.4	15	28.3%	78.0
	5/1	4	6.3%	77.5	1	1.9%	81.0
	4/2	6	9.4%	68.0	5	9.4%	58.4
	4/1	11	17.2%	72.6	2	3.8%	74.3
	3/2	1	1.6%	48.5	11	20.8%	44.4
	3/1	0	0.0%	-	4	7.5%	59.0
	2/1	1	1.6%	37.0	15	28.3%	39.4
	Sub-1 b	16	25.0%	-	24	38.7%	-
	Sub-2-3 b	48	75.0%	-	38	61.3%	-
	Total c	91	48.9%	74.2	95	51.1%	55.3

a. Does not include 6 carcasses of indeterminate sex.

b. Totals include unageable samples for which marine age was unreadable.

c. Totals include unageable samples; flesh colour not recorded.

Appendix 14b. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Cheakamus River chinook spawning ground recoveries, 1989.

		Female			Male		
Mark status	Age	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	6/2	0	0.0%	-	1	1.0%	77.8
	5/2	6	11.8%	79.1	8	8.0%	75.8
	5/1	0	0.0%	-	0	0.0%	-
	4/2	22	43.1%	68.8	9	9.0%	66.5
	4/1	7	13.7%	69.2	5	5.0%	74.4
	3/2	0	0.0%	-	11	11.0%	43.4
	3/1	16	31.4%	63.4	51	51.0%	59.5
	2/2	0	0.0%	-	1	1.0%	31.1
	2/1	0	0.0%	-	14	14.0%	41.2
	Sub-1	23	45.1%	-	70	70.0%	-
	Sub-2	28	54.9%	-	30	30.0%	-
	Total a	90	37.7%	69.9	149	62.3%	59.4
Adipose fin clip	6/2	0	0.0%	-	0	0.0%	-
	5/2	0	0.0%	-	0	0.0%	-
	5/1	1	16.7%	82.5	0	0.0%	-
	4/2	2	33.3%	68.9	0	0.0%	-
	4/1	1	16.7%	74.2	1	20.0%	73.0
	3/2	0	0.0%	-	0	0.0%	-
	3/1	2	33.3%	67.2	4	80.0%	64.7
	2/2	0	0.0%	-	0	0.0%	-
	Sub-1	4	66.7%	-	5	100.0%	-
	Sub-2	2	33.3%	-	0	0.0%	-
	Total a	12	60.0%	69.2	8	40.0%	63.9
Total	6/2	0	0.0%	-	1	1.0%	77.8
	5/2	6	10.5%	79.1	8	7.6%	75.8
	5/1	1	1.8%	82.5	0	0.0%	-
	4/2	24	42.1%	68.8	9	8.6%	66.5
	4/1	8	14.0%	69.8	6	5.7%	74.2
	3/2	0	0.0%	-	11	10.5%	43.4
	3/1	18	31.6%	63.8	55	52.4%	59.9
	2/2	0	0.0%	-	1	1.0%	31.1
	2/1	0	0.0%	-	14	13.3%	41.2
	Sub-1	27	47.4%	-	75	71.4%	-
	Sub-2	30	52.6%	-	30	28.6%	-
	Total a	102	39.4%	69.8	157	60.6%	59.6

a. Totals include unageable samples; flesh colour not recorded.

Appendix 14c. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Cheakamus River chinook spawning ground recoveries, 1990.

		Female			Male		
Mark status	Age	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	6/2	1	1.0%	78.4	0	0.0%	-
	5/2	17	17.7%	78.6	3	3.3%	72.3
	5/1	0	0.0%	-	0	0.0%	-
	4/2	5	5.2%	72.5	7	7.8%	67.0
	4/1	66	68.8%	76.7	19	21.1%	73.6
	3/2	0	0.0%	-	4	4.4%	46.6
	3/1	7	7.3%	67.5	14	15.6%	58.2
	2/1	0	0.0%	-	43	47.8%	42.3
	Sub-1	73	76.0%	-	76	84.4%	-
	Sub-2	23	24.0%	-	14	15.6%	-
	Total a	134	50.2%	75.3	133	49.8%	55.9
Adipose fin clip	6/2	0	0.0%	-	0	0.0%	-
	5/2	0	0.0%	-	0	0.0%	-
	5/1	1	7.7%	78.5	0	0.0%	-
	4/2	1	7.7%	80.5	0	0.0%	-
	4/1	11	84.6%	76.2	2	20.0%	77.0
	3/2	0	0.0%	-	0	0.0%	-
	3/1	0	0.0%	-	3	30.0%	62.7
	2/1	0	0.0%	-	5	50.0%	41.9
	Sub-1	12	92.3%	-	10	100.0%	-
	Sub-2	1	7.7%	-	0	0.0%	-
	Total a	19	25.6%	75.3	19	25.6%	55.3
Total	6/2	1	0.9%	78.4	0	0.0%	-
	5/2	17	15.6%	78.6	3	3.0%	72.3
	5/1	1	0.9%	84.0	0	0.0%	-
	4/2	6	5.5%	73.8	7	7.0%	67.0
	4/1	77	70.6%	76.6	21	21.0%	74.0
	3/2	0	0.0%	-	4	4.0%	46.6
	3/1	7	6.4%	67.5	17	17.0%	59.0
	2/1	0	0.0%	-	48	48.0%	42.3
	Sub-1	85	78.0%	-	86	86.0%	-
	Sub-2	24	22.0%	-	14	14.0%	-
	Total a	153	50.2%	76.0	152	49.8%	55.8

a. Totals include unageable samples; flesh colour not recorded.

Appendix 14d. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Cheakamus River chinook spawning ground recoveries, 1991.

		Female			Male		
Mark status	Age a	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	5/2	2	5.6%	76.6	0	0.0%	-
	5/1	2	5.6%	86.5	0	0.0%	-
	4/2	6	16.7%	66.3	2	7.4%	69.6
	4/1	13	36.1%	76.1	10	37.0%	72.6
	3/2	0	0.0%	-	1	3.7%	47.0
	3/1	13	36.1%	66.7	13	48.1%	61.5
	2/1	0	0.0%	-	1	3.7%	39.4
	Sub-1	28	77.8%	-	24	88.9%	-
	Sub-2	8	22.2%	-	3	11.1%	-
	Red	0	0.0%	-	0	0.0%	-
	White	44	100.0%	72.6	37	100.0%	65.8
	Total	44	54.3%	72.6	37	45.7%	65.8
Adipose fin clip	4/2	0	0.0%	-	1	16.7%	84.2
	4/1	2	100.0%	73.8	1	16.7%	84.0
	3/2	0	0.0%	-	0	0.0%	-
	3/1	0	0.0%	-	4	66.7%	65.8
	Sub-1	2	100.0%	-	5	83.3%	-
	Sub-2	0	0.0%	-	1	16.7%	-
	Red	0	0.0%	-	0	0.0%	-
	White	5	100.0%	68.5	9	100.0%	70.9
	Total	5	35.7%	68.5	9	64.3%	70.9
Total	5/2	2	5.3%	76.6	0	0.0%	-
	5/1	2	5.3%	86.5	0	0.0%	-
	4/2	6	15.8%	66.3	3	9.1%	74.5
	4/1	15	39.5%	75.8	11	33.3%	73.6
	3/2	0	0.0%	-	1	3.0%	47.0
	3/1	13	34.2%	67.3	17	51.5%	62.5
	2/1	0	0.0%	-	1	3.0%	39.4
	Sub-1	30	78.9%	-	29	87.9%	-
	Sub-2	8	21.1%	-	4	12.1%	-
	Red	0	0.0%	-	0	0.0%	-
	White	49	100.0%	72.2	46	100.0%	66.8
	Total	49	51.6%	72.2	46	48.4%	66.8

a. Totals include unageable samples; sex or flesh colour was not recorded for all samples.

Appendix 14e. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Cheakamus River chinook spawning ground recoveries, 1992.

		Female			Male		
Mark status	Age a	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	5/2	3	2.2%	77.8	1	1.6%	83.0
	4/2	1	0.7%	68.0	1	1.6%	64.0
	4/1	113	83.1%	76.1	26	42.6%	76.7
	3/2	0	0.0%	-	2	3.3%	43.2
	3/1	19	14.0%	68.4	13	21.3%	60.3
	2/1	0	0.0%	-	18	29.5%	43.0
	Sub-1	132	97.1%	-	57	93.4%	-
	Sub-2	4	2.9%	-	4	6.6%	-
	Red	0	0.0%	-	1	1.4%	74.0
	White	159	100.0%	75.3	70	98.6%	62.2
	Total	159	69.1%	75.3	71	30.9%	62.4
Adipose fin clip	4/1	20	80.0%	72.6	3	11.1%	76.2
	3/2	0	0.0%	-	0	0.0%	-
	3/1	5	20.0%	68.9	12	44.4%	63.7
	2/1	0	0.0%	-	12	44.4%	43.4
	Sub-1	25	100.0%	-	27	100.0%	-
	Sub-2	0	0.0%	-	0	0.0%	-
	Red	0	0.0%	-	0	0.0%	-
	White	29	100.0%	72.4	32	100.0%	54.6
	Total	29	47.5%	72.4	32	52.5%	54.6
Total	5/2	3	1.9%	77.8	1	1.1%	83.0
	5/1	0	0.0%	-	0	0.0%	-
	4/2	1	0.6%	68.0	1	1.1%	64.0
	4/1	133	82.6%	75.6	29	33.0%	76.7
	3/2	0	0.0%	-	2	2.3%	43.2
	3/1	24	14.9%	68.5	25	28.4%	63.5
	2/1	0	0.0%	-	30	34.1%	43.2
	Sub-1	157	97.5%	-	84	95.5%	-
	Sub-2	4	2.5%	-	4	4.5%	-
	Red	0	0.0%	-	1	1.0%	74.0
	White	188	100.0%	74.9	102	99.0%	59.9
	Total	188	64.6%	74.9	103	35.4%	60.0

a. Totals include unageable samples; sex or flesh colour was not recorded for all samples.

Appendix 15a. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Marnquam River chinook spawning ground recoveries, 1991.

		Female			Male		
Mark status	Age a	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	5/1	1	1.1%	78.0	1	1.2%	64.0
	4/2	5	5.7%	68.6	4	4.9%	69.0
	4/1	13	14.9%	78.3	2	2.5%	68.5
	3/2	0	0.0%	-	2	2.5%	47.4
	3/1	68	78.2%	66.4	70	86.4%	62.6
	2/1	0	0.0%	-	2	2.5%	44.0
	Sub-1	82	94.3%	-	75	92.6%	-
	Sub-2	5	5.7%	-	6	7.4%	-
	Red	3	2.7%	71.8	0	0.0%	-
	White	107	97.3%	68.4	114	100.0%	63.0
	Total	110	47.8%	68.5	120	52.2%	62.7
Adipose fin clip	4/1	4	15.4%	78.0	1	5.0%	78.4
	3/2	0	0.0%	-	0	0.0%	-
	3/1	22	84.6%	66.5	15	75.0%	65.3
	2/1	0	0.0%	-	4	20.0%	44.8
	Sub-1	26	100.0%	-	16	100.0%	-
	Sub-2	0	0.0%	-	0	0.0%	-
	Red	0	0.0%	-	1	4.3%	71.0
	White	29	100.0%	68.3	22	95.7%	61.4
	Total	29	55.8%	68.3	23	44.2%	61.8
Total	6/2	0	0.0%	-	0	0.0%	-
	5/2	0	0.0%	-	0	0.0%	-
	5/1	1	0.9%	78.0	1	1.0%	64.0
	4/2	5	4.4%	68.6	4	4.0%	69.0
	4/1	17	15.0%	78.2	3	3.0%	71.8
	3/2	0	0.0%	-	2	2.0%	47.4
	3/1	90	79.6%	66.5	85	84.2%	63.1
	2/1	0	0.0%	-	6	5.9%	44.5
	Sub-1	108	95.6%	-	95	94.1%	-
	Sub-2	5	4.4%	-	6	5.9%	-
	Red	3	2.2%	71.8	1	0.7%	71.0
	White	136	97.8%	68.4	136	99.3%	62.7
	Total	139	49.3%	68.5	143	50.7%	62.7

a. Totals include unageable samples; sex or flesh colour was not recorded for all samples.

Appendix 15b. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Mamquam River chinook spawning ground recoveries, 1992.

		Female			Male		
Mark status	Age a	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	5/2	1	3.4%	78.5	1	5.6%	83.0
	5/1	1	3.4%	72.0	0	0.0%	-
	4/2	0	0.0%	-	2	11.1%	73.3
	4/1	22	75.9%	71.8	6	33.3%	75.7
	3/2	0	0.0%	-	2	11.1%	64.5
	3/1	5	17.2%	66.6	4	22.2%	61.6
	2/1	0	0.0%	-	3	16.7%	45.3
	Sub-1	28	96.6%	-	13	72.2%	-
	Sub-2	1	3.4%	-	5	27.8%	-
	Red	0	0.0%	-	0	0.0%	-
	White	44	100.0%	72.9	24	100.0%	65.7
	Total	44	64.7%	72.9	24	35.3%	65.7
Adipose fin clip	4/1	9	90.0%	72.9	3	20.0%	73.2
	3/1	1	10.0%	71.3	7	46.7%	67.7
	2/1	0	0.0%	-	5	33.3%	42.0
	Sub-1	10	100.0%	-	15	100.0%	-
	Sub-2	0	0.0%	-	0	0.0%	-
	Red	0	0.0%	-	0	0.0%	-
	White	12	100.0%	73.1	17	100.0%	59.9
	Total	12	41.4%	73.1	17	58.6%	59.9
Total	5/2	1	2.6%	78.5	1	3.0%	83.0
	5/1	1	2.6%	72.0	0	0.0%	-
	4/2	0	0.0%	-	2	6.1%	73.3
	4/1	31	79.5%	72.1	9	27.3%	74.8
	3/2	0	0.0%	-	2	6.1%	64.5
	3/1	6	15.4%	67.4	11	33.3%	65.5
	2/1	0	0.0%	-	8	24.2%	43.2
	Sub-1	38	97.4%	-	28	84.8%	-
	Sub-2	1	2.6%	-	5	15.2%	-
	Red	0	0.0%	-	0	0.0%	-
	White	56	100.0%	73.0	41	100.0%	63.3
	Total	56	57.7%	73.0	41	42.3%	63.3

a. Totals include unageable samples; sex or flesh colour was not recorded for all samples.

Appendix 16a. Coded wire tag information, by recovery location and tag code, for coded wire tags recovered on the Cheakamus River spawning grounds, 1988.

Release information				Recovery location			
Brood stock source	Brood year	CWT Code	Release location	Cheakamus River	Tenderfoot Creek	Total	
Squamish, Cheakamus or Ashlu	1983	02 26 37	Tenderfoot Lake	2	-	2	
Squamish, Cheakamus or Ashlu	1984	02 32 21	Tenderfoot Lake	6	-	6	a
Squamish, Cheakamus or Ashlu	1984	02 32 22	Tenderfoot Lake	1	-	1	
Cheakamus River	1986	02 43 07	Tenderfoot Lake	4	-	4	b

a. 1 of 6 was incorrectly aged as a 5-year-old.
b. 2 of 3 were incorrectly aged as 3-year-olds.

Appendix 16b. Coded wire tag information, by recovery location and tag code, for coded wire tags recovered on the Cheakamus River spawning grounds, 1989.

				Recovery location			
Brood stock	Brood year	CWT Code	Release location	Cheakamus River	Tenderfoot Creek	Total	
Squamish, Cheakamus or Ashlu	1983	02 26 37	Tenderfoot Lake	1	-	1	
Squamish, Cheakamus or Ashlu	1985	02 36 52	Tenderfoot Lake	2	-	2	
Squamish, Cheakamus or Ashlu	1985	02 36 53	Tenderfoot Lake	1	-	1	
Squamish, Cheakamus or Ashlu	1985	02 36 54	Tenderfoot Lake	3	-	3	
Cheakamus	1986	02 43 07	Tenderfoot Lake	1	-	1	a
Squamish	1986	02 43 08	Tenderfoot Lake	2	-	2	b
Ashlu	1986	02 43 09	Tenderfoot Lake	7	-	7	c

a. Incorrectly scale aged as a 4-year-old.
b. 1 of 2 was incorrectly scale aged as a 4-year-old.
c. 1 of 6 was incorrectly scale aged as a 4-year-old.

Appendix 16c. Coded wire tag information, by recovery location and tag code, for coded wire tags recovered on the Squamish River system spawning grounds, 1990.

Brood stock	Brood year	CWT Code	Release location	Recovery location: Ashlu Creek	Cheakamus River	Tenderfoot Creek	Total	
Squamish, Cheakamus or Ashlu	1985	02 36 52	Hatchery	-	1	-	1	
Squamish, Cheakamus or Ashlu	1985	02 36 53	Hatchery	-	1	-	1	
Cheakamus	1986	02 43 07	Hatchery	-	5	-	5	a
Squamish	1986	02 43 08	Hatchery	-	3	-	3	
Ashlu	1986	02 43 09	Hatchery	-	8	-	8	b
Squamish	1987	02 53 45	Squamish River	-	1	-	1	
Cheakamus	1987	02 53 46	Hatchery	-	1	-	1	
Cheakamus	1987	02 53 48	Porteau Cove	-	2	-	2	c
Cheakamus	1987	02 53 49	Porteau Cove	-	2	-	2	
Cheakamus	1987	02 55 09	Hatchery	-	1	-	1	
Cheakamus, Squamish	1988	02 57 33	Porteau Cove	-	2	-	2	
Cheakamus, Squamish	1988	02 57 34	Porteau Cove	-	1	-	1	
Squamish	1988	02 57 35	Porteau Cove	-	1	-	1	
Squamish	1988	02 57 36	Porteau Cove	-	2	-	2	
Squamish	1988	02 58 13	Squamish River	1	-	-	1	
Cheakamus	1988	02 60 31	Hatchery	-	1	-	1	

a. 1 of 4 was incorrectly scale aged as a 3-year-old.
b. 2 of 7 was incorrectly scale aged as a 3-year-old, and 1 as a 2-year-old.
c. 1 of 2 was incorrectly scale aged as a 2-year-old.

Appendix 16d. Coded wire tag information, by recovery location and tag code, for coded wire tags recovered on the Squamish River system spawning grounds, 1991.

Brood stock	Brood year	CWT Code	Release location	Recovery location: Ashlu Creek	Cheakamus River	Tenderfoot Creek	Mamquam River	Mashiter Creek	Total	
Ashlu	1987	02 53 44	Ashlu Creek	3	-	-	-	-	3	
Cheakamus	1987	02 53 46	Hatchery	-	2	-	-	-	2	a
Cheakamus	1987	02 53 48	Porteau Cove	-	-	-	3	-	3	
Cheakamus	1987	02 53 49	Porteau Cove	-	1	-	2	-	3	
Cheakamus, Squamish	1988	02 57 33	Porteau Cove	-	-	1	5	3	9	
Cheakamus, Squamish	1988	02 57 34	Porteau Cove	1	-	-	15	4	20	
Squamish	1988	02 57 35	Porteau Cove	-	3	-	3	-	6	b
Squamish	1988	02 57 36	Porteau Cove	-	-	-	2	2	4	
Cheakamus	1988	02 60 31	Hatchery	-	1	1	1	-	3	
Squamish	1988	02 60 32	Mamquam River	-	-	-	5	-	5	
Ashlu, Cheakamus, Squamish	1989	02 04 45	Porteau Cove	-	-	-	2	-	2	
Ashlu, Cheakamus, Squamish	1989	02 04 47	Porteau Cove	-	-	-	1	-	1	
Ashlu, Cheakamus, Squamish	1989	02 04 48	Porteau Cove	-	-	-	1	-	1	

a. 1 of 2 was incorrectly scale aged as a 2-year-old.
b. 1 of 5 was incorrectly scale aged as a 4-year-old.

Appendix 16e. Coded wire tag information, by recovery location and tag code, for coded wire tags recovered on the Squamish River system spawning grounds, 1992.

Brood stock	Brood year	CWT Code	Release location	Recovery location: Ashlu Creek	Cheakamus River	Tenderfoot Creek	Mamquam River	Mashiter Creek	Total	
Cheakamus, Squamish	1988	02 57 33	Porteau Cove	-	8	-	1	-	9	
Cheakamus, Squamish	1988	02 57 34	Porteau Cove	1	3	-	4	-	8	a
Squamish	1988	02 57 35	Porteau Cove	-	4	-	2	-	6	b
Squamish	1988	02 57 36	Porteau Cove	2	5	-	4	-	11	
Ashlu	1988	02 58 12	Ashlu Creek	4	-	-	-	-	4	
Squamish	1988	02 58 13	Squamish River	1	-	-	-	-	1	
Cheakamus	1988	02 60 31	Hatchery	-	3	-	-	-	3	
Squamish	1988	02 60 32	Mamquam River	-	3	-	3	-	6	
Ashlu, Cheakamus, Squamish	1989	02 04 45	Porteau Cove	-	4	-	1	-	5	
Ashlu, Cheakamus, Squamish	1989	02 04 46	Porteau Cove	-	3	-	2	-	5	
Ashlu, Cheakamus, Squamish	1989	02 04 47	Porteau Cove	-	6	-	3	-	9	
Ashlu, Cheakamus, Squamish	1989	02 04 48	Porteau Cove	1	1	-	1	-	3	
Cheakamus	1989	02 04 50	Hatchery	-	1	-	-	-	1	
Cheakamus	1989	02 04 51	Hatchery	-	1	-	-	-	1	
Cheakamus	1989	02 04 52	Hatchery	-	1	-	-	-	1	c
Cheakamus	1990	02 11 29	Hatchery	-	2	-	-	-	2	
Cheakamus	1990	02 11 30	Hatchery	-	2	-	-	-	2	
Cheakamus	1990	02 11 31	Hatchery	-	1	-	2	-	3	
Cheakamus	1990	02 14 24	Porteau Cove	-	1	-	1	-	2	
Cheakamus	1990	02 14 26	Porteau Cove	-	1	-	-	-	1	
Cheakamus	1990	02 14 27	Porteau Cove	-	1	-	-	-	1	
Ashlu, Cheakamus, Squamish	1990	02 15 34	Mamquam River	-	3	-	2	-	5	
Cheakamus	1990	02 15 40	Hatchery	-	2	-	-	-	2	

a. 1 of 8 was incorrectly scale aged as a 3-year-old.

b. 1 of 4 was incorrectly scale aged as a 2-year-old.

c. Was incorrectly scale aged as a 4-year-old.

Appendix 17a. Net counts and observed chinook adult and jack catch, by AFC status, from surveys of the Squamish River Indian fishery, 1988.

Year	Date	Location a	Number of nets	Chinook adults			Chinook jacks		
				Unmarked	Adipose fin clip	Mark incidence	Unmarked	Adipose fin clip	Mark incidence
1988	3-Jul	1	4	1	0	0.0%	0	0	-
		2	2	0	0	-	0	0	-
	10-Jul	1	3	1	0	0.0%	0	0	-
	17-Jul	1	7	5	0	0.0%	0	0	-
	23-Jul	1	1	0	0	-	0	0	-
		2	3	2	0	0.0%	0	0	-
	24-Jul	1	8	4	0	0.0%	0	0	-
		2	5	2	1	33.3%	1	0	0.0%
	7-Aug	1	3	0	1	100.0%	0	0	-
		2	3	0	1	100.0%	2	0	0.0%
	11-Aug	1	1	0	0	-	4	0	0.0%
	13-Aug	1	1	0	0	-	2	0	0.0%
	21-Aug	1	3	0	2	100.0%	2	0	0.0%
		2	1	0	0	-	1	0	0.0%
	28-Aug	1	8	2	1	33.3%	6	0	0.0%
		2	6	4	0	0.0%	1	0	0.0%
	4-Sep	1	9	1	2	66.7%	1	0	0.0%
		2	7	2	1	33.3%	0	0	-
	11-Sep	1	6	1	0	0.0%	0	0	-
		2	11	0	0	-	2	0	0.0%
	18-Sep	1	8	0	0	-	0	0	-
		2	8	1	0	0.0%	0	0	-
	2-Oct	1	3	1	0	0.0%	0	0	-
		2	6	0	0	-	0	0	-
	7-Oct	1	9	1	0	0.0%	0	0	-
	14-Oct	2	8	0	1	100.0%	0	0	-
	Total	1	74	17	6	26.1%	15	0	0.0%
		2	60	11	4	26.7%	7	0	0.0%
		Total	134	28	10	26.3%	22	0	0.0%

a. Locations were: 1 - Below Cheakamus River;
2 - Above Cheakamus River;

Appendix 17b. Proportion at age and mean POH length at age, by sex, of adipose fin clipped and unmarked chinook recovered from the Squamish River Indian fishery, 1988.

		Female					Male				
				Mean length (cm) b					Mean length (cm) b		
Mark status	Age a	Sample size	Percent	NF	POH	Mean weight (kg)	Sample size	Percent	NF	POH	Mean weight (kg)
Unmarked	5/2	1	100.0%	90.0	80.0	-	3	20.0%	77.0	63.7	6.3
	4/2	0	0.0%	-	-	-	2	13.3%	80.0	62.8	-
	3/2	0	0.0%	-	-	-	5	33.3%	56.7	45.2	1.9
	2/1	0	0.0%	-	-	-	5	33.3%	49.5	39.3	1.5
	Sub-1	0	0.0%	-	-	-	5	33.3%	49.5	39.3	1.5
	Sub-2	1	100.0%	90.0	80.0	-	10	66.7%	67.5	54.3	4.6
	Total	2	9.1%	89.0	75.0	8.2	20	90.9%	62.2	49.9	3.2
Adipose fin clip c	4/2	0	-	-	-	-	1	25.0%	96.0	74.0	11.3
	3/2	0	-	-	-	-	1	25.0%	65.0	54.0	-
	2/1	0	-	-	-	-	2	50.0%	53.8	44.3	1.8
	Sub-1	0	-	-	-	-	2	50.0%	53.8	44.3	1.8
	Sub-2	0	-	-	-	-	2	50.0%	80.5	64.0	11.3
	Total	0	-	-	-	-	4	100.0%	67.1	64.1	11.3
Total	5/2	1	100.0%	90.0	80.0	-	3	15.8%	77.0	63.7	6.3
	4/2	0	0.0%	-	-	-	3	15.8%	85.3	66.5	11.3
	3/2	0	0.0%	-	-	-	6	31.6%	58.0	46.7	1.9
	2/1	0	0.0%	-	-	-	7	36.8%	50.7	40.7	1.6
	Sub-1	0	0.0%	-	-	-	7	36.8%	50.7	40.7	1.6
	Sub-2	1	100.0%	90.0	80.0	-	12	63.2%	69.6	55.9	5.7
	Total	2	7.7%	89.0	75.0	8.2	24	92.3%	63.0	50.6	3.8

a. Totals include unageable samples; sex or flesh colour was not recorded for all samples.

b. Regressions for males NF = 1.207 POH + 1.89; POH = 0.786 NF + 1.08; R2 = 0.949.

c. CWT recoveries were: 1 of 02 32 22; 1 of 02 43 07;
1 of 02 36 52; 1 of 02 43 08.

Appendix 17c. Net counts and observed chinook adult and jack catch, by AFC status, from surveys of the Squamish River Indian fishery, 1989.

				Chinook adults			Chinook jacks		
Year	Date	Location a	Number of nets	Unmarked	Adipose fin clip	Mark incidence	Unmarked	Adipose fin clip	Mark incidence
1989	9-Jul	1	7	1	1	50.0%	0	0	-
	13-Jul	1	1	0	0	-	0	0	-
	16-Jul	1	2	0	0	-	0	0	-
		2	3	1	0	0.0%	1	0	0.0%
	23-Jul	1	4	3	0	0.0%	0	0	-
		2	5	1	0	0.0%	0	0	-
	30-Jul	1	5	10	1	9.1%	3	0	0.0%
		2	5	3	0	0.0%	0	0	-
	6-Aug	1	2	2	0	0.0%	1	1	50.0%
		2	5	9	2	18.2%	1	0	0.0%
	3-Sep	1	4	4	0	0.0%	0	0	-
		2	2	3	0	0.0%	0	0	-
	10-Sep	1	6	1	0	0.0%	1	0	0.0%
		2	2	1	0	0.0%	0	0	-
	3-Oct	1	3	0	0	-	0	0	-
	7-Oct	1	9	1	0	0.0%	0	0	-
		2	7	0	0	-	0	0	-
	15-Oct	1	8	0	0	-	0	0	-
		2	13	0	0	-	2	0	0.0%
	Total	1	47	18	2	10.0%	5	1	16.7%
		2	40	15	2	11.8%	4	0	0.0%
		Total	87	33	4	10.8%	9	1	10.0%

a. Locations were: 1 - Below Cheakamus River mouth;
2 - Above Cheakamus River mouth.

Appendix 18a. Spawning success in female chinook carcasses, by mark status, recovered on the Cheakamus River spawning grounds, 1988-1990.

Year	Location	Mark type	Sample size	Percent spawned			
				0%	50%	100%	Weighted mean
1988	Cheakamus River	Disk tag or secondary mark	5	0.0%	0.0%	100.0%	100.0%
		Unmarked	78	6.4%	6.4%	87.2%	90.4%
		Total	83	6.0%	6.0%	88.0%	91.0%
1989	Cheakamus River	Spaghetti tag or secondary mark	7	0.0%	14.3%	85.7%	92.9%
		Unmarked	85	1.2%	0.0%	98.8%	98.8%
		Total	92	1.1%	1.1%	97.8%	98.4%
1990	Cheakamus River	Spaghetti tag or secondary mark	5	0.0%	20.0%	80.0%	90.0%
		Unmarked	139	0.0%	1.4%	98.6%	99.3%
		Total	144	0.0%	2.1%	97.9%	99.0%

Appendix 18b. Spawning success in female chinook carcasses, by location and mark status, recovered on the Squamish River system spawning grounds, 1991.

Location	Mark type	Sample size	Percent spawned			
			0%	50%	100%	Weighted mean
Ashlu River	Strap tag or secondary mark	2	0.0%	0.0%	100.0%	100.0%
	Spaghetti tag or secondary mark	1	0.0%	0.0%	100.0%	100.0%
	Unmarked	84	0.0%	1.2%	98.8%	99.4%
	Total	87	0.0%	1.1%	98.9%	99.4%
Cheakamus River	Strap tag or secondary mark	0	-	-	-	-
	Spaghetti tag or secondary mark	0	-	-	-	-
	Unmarked	40	0.0%	0.0%	100.0%	100.0%
	Total	40	0.0%	0.0%	100.0%	100.0%
Tenderfoot Creek	Strap tag or secondary mark	0	-	-	-	-
	Spaghetti tag or secondary mark	0	-	-	-	-
	Unmarked	9	0.0%	0.0%	100.0%	100.0%
	Total	9	0.0%	0.0%	100.0%	100.0%
Mamquam River	Strap tag or secondary mark	3	0.0%	0.0%	100.0%	100.0%
	Spaghetti tag or secondary mark	0	-	-	-	-
	Unmarked	95	0.0%	0.0%	100.0%	100.0%
	Total	98	0.0%	0.0%	100.0%	100.0%
Mashiter Creek	Strap tag or secondary mark	2	0.0%	0.0%	100.0%	100.0%
	Spaghetti tag or secondary mark	0	-	-	-	-
	Unmarked	32	3.1%	0.0%	96.9%	96.9%
	Total	34	2.9%	0.0%	97.1%	97.1%
Mamquam Channel	Strap tag or secondary mark	0	-	-	-	-
	Spaghetti tag or secondary mark	0	-	-	-	-
	Unmarked	2	0.0%	0.0%	100.0%	100.0%
	Total	2	0.0%	0.0%	100.0%	100.0%
Total	Strap tag or secondary mark	7	0.0%	0.0%	100.0%	100.0%
	Spaghetti tag or secondary mark	1	0.0%	0.0%	100.0%	100.0%
	Unmarked	262	0.4%	0.4%	99.2%	99.4%
	Total	270	0.4%	0.4%	99.3%	99.4%

Appendix 18c. Spawning success in female chinook carcasses, by location and mark status, recovered on the Squamish River system spawning grounds, 1992.

Location	Mark type	Sample size	Percent spawned			
			0%	50%	100%	Weighted mean
Ashlu River	Strap tag or secondary mark	1	0.0%	0.0%	100.0%	100.0%
	Spaghetti tag or secondary mark	0	-	-	-	-
	Unmarked	63	0.0%	0.0%	100.0%	100.0%
	Total	64	0.0%	0.0%	100.0%	100.0%
Cheakamus River	Strap tag or secondary mark	20	0.0%	0.0%	100.0%	100.0%
	Spaghetti tag or secondary mark	9	0.0%	0.0%	100.0%	100.0%
	Unmarked	159	1.3%	3.1%	95.6%	97.2%
	Total	188	1.1%	2.7%	96.3%	97.6%
Mamquam River	Strap tag or secondary mark	6	0.0%	0.0%	100.0%	100.0%
	Spaghetti tag or secondary mark	2	0.0%	0.0%	100.0%	100.0%
	Unmarked	48	0.0%	2.1%	100.0%	100.0%
	Total	56	0.0%	1.8%	98.2%	99.1%
Total	Strap tag or secondary mark	27	0.0%	0.0%	100.0%	100.0%
	Spaghetti tag or secondary mark	11	0.0%	0.0%	100.0%	100.0%
	Unmarked	270	0.7%	2.2%	97.4%	98.5%
	Total	308	0.6%	1.9%	97.7%	98.7%

Appendix 19a. Water temperatures, by date, in the Cheakamus River, 1988-1989. a

Year	Date	Time	Water temperature (C)	Date	Time	Water temperature (C)
1988	2-Sep	10:00	8	22-Sep	8:00	8
	3-Sep	-	-	23-Sep	8:00	8
	4-Sep	8:15	10	24-Sep	-	-
	5-Sep	7:30	10	25-Sep	-	-
	6-Sep	8:25	12	26-Sep	8:00	8
	7-Sep	8:00	11	27-Sep	-	8
	8-Sep	8:30	9	28-Sep	-	-
	9-Sep	-	9	29-Sep	-	8
	10-Sep	-	8	30-Sep	-	8
	11-Sep	-	8	1-Oct	-	8
	12-Sep	8:00	11	2-Oct	-	-
	13-Sep	-	-	3-Oct	-	-
	14-Sep	-	-	4-Oct	-	-
	15-Sep	-	9	5-Oct	-	-
	16-Sep	-	9	6-Oct	-	8
	17-Sep	-	-	7-Oct	-	-
	18-Sep	-	-	8-Oct	-	-
	19-Sep	-	-	9-Oct	-	-
	20-Sep	8:15	8	10-Oct	-	-
	21-Sep	8:15	8	11-Oct	-	-
1989	25-Aug	8:00	9	14-Sep	-	9
	26-Aug	-	-	15-Sep	-	9
	27-Aug	-	-	16-Sep	-	-
	28-Aug	-	10	17-Sep	-	-
	29-Aug	-	10	18-Sep	-	9
	30-Aug	-	10	19-Sep	-	-
	31-Aug	-	10	20-Sep	-	-
	1-Sep	-	10	21-Sep	-	-
	2-Sep	-	-	22-Sep	-	12
	3-Sep	-	10	23-Sep	-	-
	4-Sep	-	-	24-Sep	-	-
	5-Sep	-	9	25-Sep	-	10
	6-Sep	-	9	26-Sep	-	10
	7-Sep	-	10	27-Sep	-	-
	8-Sep	-	10	28-Sep	-	10
	9-Sep	-	-	29-Sep	-	10
	10-Sep	-	-	30-Sep	-	-
	11-Sep	-	9	1-Oct	-	-
	12-Sep	-	9	2-Oct	-	9
	13-Sep	-	9			

a. Temperature was measured to the nearest degree with an uncalibrated pocket thermometer. Temperature was normally recorded in the morning; however, the actual time was often not recorded.

Appendix 19b. Water temperatures, by location and date, in the Squamish River system, 1990. a

Location	Date	Time	Water temperature (C)	Date	Time	Water temperature (C)
Ashlu Creek	6-Sep	10:00	10	20-Sep	9:45	11
	7-Sep	9:30	11	21-Sep	-	-
	8-Sep	-	-	22-Sep	-	-
	9-Sep	-	-	23-Sep	-	-
	10-Sep	9:00	11	24-Sep	10:00	11
	11-Sep	-	-	25-Sep	-	-
	12-Sep	-	-	26-Sep	-	-
	13-Sep	10:00	11	27-Sep	9:00	11
	14-Sep	-	-	28-Sep	-	-
	15-Sep	-	-	29-Sep	-	-
	16-Sep	9:45	11	30-Sep	-	-
	17-Sep	-	-	1-Oct	9:00	9
	18-Sep	-	-	2-Oct	-	-
Cheakamus River	24-Aug	-	10	17-Sep	-	11
	25-Aug	-	-	18-Sep	-	10
	26-Aug	-	10	19-Sep	-	-
	27-Aug	-	10	20-Sep	-	11
	28-Aug	-	10	21-Sep	-	11
	29-Aug	-	10	22-Sep	-	11
	30-Aug	-	-	23-Sep	-	10
	31-Aug	-	10	24-Sep	-	11
	1-Sep	-	9	25-Sep	-	11
	2-Sep	-	-	26-Sep	-	11
	3-Sep	-	11	27-Sep	-	11
	4-Sep	-	11	28-Sep	-	10
	5-Sep	-	12	29-Sep	-	-
	6-Sep	-	-	30-Sep	-	-
	7-Sep	-	-	1-Oct	-	10
	8-Sep	-	-	2-Oct	-	10
	9-Sep	-	-	3-Oct	-	9
	10-Sep	-	-	4-Oct	-	9
	11-Sep	-	-	5-Oct	-	10
	12-Sep	-	11	6-Oct	-	-
	13-Sep	-	11	7-Oct	-	-
	14-Sep	-	11	8-Oct	-	-
	15-Sep	-	-	9-Oct	-	9
	16-Sep	-	-			

a. Temperature was measured to the nearest degree with an uncalibrated pocket thermometer. Temperature was normally recorded in the morning; however, the actual time was often not recorded.

Appendix 19c. Water temperatures, by date and location, in the Squamish River system, 1991. a

Location	Date	Time	Water temperature (C)	Date	Time	Water temperature (C)
Ashlu Creek	20-Sep	-	11	27-Sep	-	10
	21-Sep	-	-	28-Sep	-	-
	22-Sep	-	-	29-Sep	-	-
	23-Sep	-	-	30-Sep	-	-
	24-Sep	-	-	1-Oct	-	-
	25-Sep	-	-	2-Oct	-	-
	26-Sep	-	-	3-Oct	-	10
Cheakamus River	20-Aug	-	9	11-Sep	-	11
	21-Aug	-	12	13-Sep	-	11
	22-Aug	-	12	14-Sep	-	-
	23-Aug	-	14	15-Sep	-	-
	24-Aug	-	-	16-Sep	-	-
	25-Aug	-	-	17-Sep	-	11
	26-Aug	-	-	18-Sep	-	10
	27-Aug	-	12	19-Sep	-	-
	28-Aug	-	-	20-Sep	-	-
	29-Aug	-	-	21-Sep	-	-
	30-Aug	-	-	22-Sep	-	-
	31-Aug	-	-	23-Sep	-	10
	1-Sep	-	-	24-Sep	-	10
	2-Sep	-	-	25-Sep	-	10
	3-Sep	-	-	26-Sep	-	-
	4-Sep	-	-	27-Sep	-	-
	5-Sep	-	11	28-Sep	-	-
	6-Sep	-	-	30-Sep	-	9
	7-Sep	-	-	1-Oct	-	9
	8-Sep	-	-	4-Oct	-	9
	9-Sep	-	-	7-Oct	-	9
	10-Sep	-	11	8-Oct		9
Mamquam River	9-Sep	-	11	16-Sep	-	10
	10-Sep	-	-	17-Sep	-	-
	11-Sep	-	-	18-Sep	-	-
	12-Sep	-	11	19-Sep	-	10
	13-Sep	-	-	2-Oct	-	9
	14-Sep	-	-	3-Oct	-	-
	15-Sep	-	-			

a. Temperature was measured to the nearest degree with an uncalibrated pocket thermometer. Temperature was normally recorded in the morning; however, the actual time was often not recorded.

Appendix 19d. Water temperatures, by date and location, in the Squamish River system, 1992. a

Location	Date	Water temperature (C)	Date	Water temperature (C)	Date	Water temperature (C)
Cheakamus River	18-Aug	13	2-Sep	11	20-Sep	-
	19-Aug	-	3-Sep	11	21-Sep	7
	20-Aug	12	4-Sep	-	22-Sep	-
	21-Aug	-	5-Sep	-	23-Sep	7
	22-Aug	-	6-Sep	-	24-Sep	-
	23-Aug	-	7-Sep	-	25-Sep	-
	24-Aug	-	8-Sep	11	26-Sep	-
	25-Aug	17	9-Sep	10	27-Sep	-
	26-Aug	-	13-Sep	11	28-Sep	-
	27-Aug	12	14-Sep	-	30-Sep	-
	28-Aug	-	15-Sep	7	1-Oct	-
	29-Aug	-	16-Sep	-	4-Oct	-
	30-Aug	-	17-Sep	7	7-Oct	-
	31-Aug	11	18-Sep	7	8-Oct	-
	1-Sep	11	19-Sep	-		
Mamquam River	21-Jul	13	14-Aug	-	7-Sep	-
	22-Jul	-	15-Aug	-	8-Sep	-
	23-Jul	-	16-Aug	-	9-Sep	10
	24-Jul	-	17-Aug	12	10-Sep	-
	25-Jul	-	18-Aug	-	11-Sep	11
	26-Jul	-	19-Aug	12	12-Sep	-
	27-Jul	-	20-Aug	-	13-Sep	-
	28-Jul	-	21-Aug	-	14-Sep	9
	29-Jul	12	22-Aug	-	15-Sep	-
	30-Jul	-	23-Aug	-	16-Sep	-
	31-Jul	-	24-Aug	-	17-Sep	8
	1-Aug	-	25-Aug	-	18-Sep	-
	2-Aug	-	26-Aug	12	19-Sep	-
	3-Aug	-	27-Aug	-	20-Sep	-
	4-Aug	-	28-Aug	12	21-Sep	-
	5-Aug	12	29-Aug	-	22-Sep	-
	6-Aug	-	30-Aug	-	23-Sep	-
	7-Aug	-	31-Aug	12	24-Sep	-
	8-Aug	-	1-Sep	-	25-Sep	-
	9-Aug	-	2-Sep	-	26-Sep	-
	10-Aug	-	3-Sep	12	27-Sep	-
	11-Aug	-	4-Sep	-	28-Sep	8
	12-Aug	12	5-Sep	-		
	13-Aug	-	6-Sep	-		

a. Temperature was measured to the nearest degree with an uncalibrated pocket thermometer. Temperature was normally recorded in the morning; however, the actual time was often not recorded.

Appendix 20. Darroch population estimates for the Squamish River system chinook return calculated using three stratification schemes. a

Year	Sex	Base estimate	Stratification 1 Estimate	Stratification 1 Percent of base	Stratification 2 Estimate	Stratification 2 Percent of base	Stratification 3 Estimate	Stratification 3 Percent of base
1991	Male	7,624	6,884	-9.7%	3,665	-51.9%	4,091	-46.3%
	Female	n/a	9,392	-	5,792	-	n/a	-
	Total	18,320	16,161	-11.8%	11,866	-35.2%	9,096	-50.3%
1992	Male	2,593	2,619	1.0%	2,919	12.6%	3,018	16.4%
	Female	4,000	4,553	13.8%	3,986	-0.3%	4,496	12.4%
	Total	6,649	7,496	12.7%	6,698	0.7%	7,550	13.6%

a. Stratification schemes were: Base - Ashlu, Cheakamus and Mamquam separate.
1 - Ashlu and Cheakamus combined, Mamquam separate;
2 - Cheakamus and Mamquam combined, Ashlu separate;
3 - Ashlu and Mamquam combined, Cheakamus separate.