Assessment of Kitsumkalum River Chinook Salmon with Revised Escapement Estimates 1984 to 2020

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Escapement estimates for Kitsumkalum River Chinook salmon were calculated using individual encounter histories (IEH) and open population models for mark-recapture studies conducted from 1984 to 2020. The new escapements averaged 27% lower than previous estimates for the time series. The populations of large Chinook salmon studied failed closure tests in all years tested due to additions to the populations during the programs. The lack of closure in the populations supported the use of open population models. Open population models (POPAN) in program MARK were developed to estimate escapement for each annual mark-recapture study. Models were stratified temporally by occasion, spatially by river reach and biologically by gender (group).

A simple Ricker (1975) model was selected as the best model to represent Kitsumkalum Chinook salmon in the stock-recruit analyses of complete brood years 1984 to 2013. The maximum likelihood estimate (MLE) of the spawning escapement required to produce maximum sustained yield (S_{MSY}) was 5,214 and Capacity (S_{EQ}) was 13,493 large Chinook salmon (age >3_2). MLE's, medians and 95% Bayesian credibility intervals produced with the simple Ricker model were presented for the Ricker parameters (α, β, σ) as well as for metrics useful in the development of benchmarks (U_{MSY}, S_{GEN}, 25% S_{MSY} , 85% S_{MSY} and U at 85% S_{MSY}).

The life history characteristics of Kitsumkalum Chinook salmon were reviewed and average size was found to have declined from 1984 to 2020. Size differences were driven primarily by reduced age at maturity but were also influenced by reduced size at age. The predominant age at maturity has changed from age 6_2 to age 5_2 through the time series.

RESUMÉ

Winther, I., Vélez-Espino, L.A., Brown, G.S. and Wor, C. 2021. Assessment of Kitsumkalum River Chinook salmon with revised escapement estimates 1984 to 2020. Can. Manuscr. Rep. Fish. Aquat. Sci. 3217: ix + 131 p.

Les estimations des échappées pour le saumon quinnat de la rivière Kitsumkalum ont été calculées à l'aide d'histoires de rencontres individuelles et de modèles de population ouverte pour les études de marquage-recapture menées de 1984 à 2020. Les nouvelles échappées étaient en moyenne de 27% inférieures aux estimations précédentes pour la série chronologique. Les populations de grands saumons quinnats étudiées ont échoué aux tests de fermeture toutes les années testées en raison des ajouts aux populations au cours des programmes. L'absence de fermeture dans les populations a soutenu l'utilisation de modèles de population ouverts. Des modèles de population ouverts (POPAN) dans le programme MARK ont été élaborés pour estimer les échappées pour chaque étude annuelle de marquage-recapture. Les modèles ont été stratifiés temporellement par occasion, spatialement par tronçon de rivière et biologiquement par sexe (groupe).

Un modèle simple de Ricker (1975) a été choisi comme le meilleur modèle pour représenter le saumon quinnat Kitsumkalum dans les analyses stock-recrue des années complètes de couvée 1984 à 2013. L'estimation du maximum de vraisemblance (EMM) de l'échappée de frai nécessite de produire un rendement maximum soutenu (SMSY) était de 5 214 et la capacité (SEQ) était de 13 493 grands saumons quinnats (âge> 32). Les MLE, les médianes et les intervalles de crédibilité bayésiens à 95% produits avec le modèle simple de Ricker ont été présentés pour les paramètres de Ricker (α, β, σ) ainsi que pour les métriques utiles dans le développement de benchmarks (UMSY, SGEN, 25% SMSY, 85% SMSY et U à 85% SMSY).

Les caractéristiques du cycle biologique du saumon quinnat Kitsumkalum ont été examinées et la taille moyenne a diminué de 1984 à 2020. Les différences de taille étaient principalement attribuables à la réduction de l'âge à la maturité, mais également à la réduction de la taille à l'âge. L'âge prédominant à la maturité est passé de 62 ans à 52 ans au cours de la série chronologique.

INTRODUCTION

The summer run of Chinook salmon *(Oncorhynchus tshawytscha)* in the Kitsumkalum River is the second largest conservation unit (CU) in the Skeena River watershed. These fish are among the largest salmon in the world and are highly prized by sport, commercial and First Nations' fisheries. Escapement estimates have been produced for this stock of Chinook salmon since 1984 using mark-recapture methods. McNicol (1999) estimated the stock-recruit relationship (S_{MSY} = 8,876) which was updated by Parken et al. in 2006 (S_{MSY} = 8,621) using the Petersen-based escapement estimates. Typically the analyses have consisted of stratified Petersen estimators that rely on assumptions of closure to provide unbiased estimates. Closure implies that the population doesn't change in size or composition during the study and additions (immigration) and losses (emigration) are violations to the closure assumption. Vélez-Espino et al. (2016) recommended the use of open population models for determining escapement estimates for Chinook salmon populations that violated the closure assumptions required by Petersen estimators. Their examples included analyses of five years of Kitsumkalum summer Chinook salmon escapement data as well as data from three other Chinook salmon stocks. Revised escapement estimates from the open models were lower and noticeably more precise in most examples than those calculated with Petersen closed population estimators.

The objectives of this report were to: (1) evaluate the assumption that the annual Kitsumkalum summer Chinook populations were closed for the purpose of the mark-recapture analyses; (2) update escapement estimates from 1984 to 2020 for the Kitsumkalum summer run Chinook stock using the open population models and the procedures described by Vélez-Espino et al. (2016); and (3) define the metrics useful to the development of benchmarks for Kitsumkalum summer run Chinook salmon.

The Kitsumkalum River summer run Chinook stock serves as the CWT indicator stock for the Skeena River and the Skeena River is an escapement indicator stock for northern BC. Neither the Kitsumkalum summer run CU nor the Skeena River summer run Chinook salmon aggregate of CU's have escapement goals that have been agreed to by PSC Chinook salmon Technical Committee (CTC) .

Methods used to analyze the Kitsumkalum Chinook salmon mark-recapture data remained static until Vélez-Espino et al. (2016) used 5 years of Kitsumkalum data as examples for the application of open-population models to estimate escapement. A significant influence on this work was advice from the PSC Sentinel Stocks Committee that we bring the analyses of Kitsumkalum mark-recapture data up to the state of the art in mark-recapture analyses using program MARK or similar approaches. A primary reason for the Vélez-Espino et al. (2016) publication was to lay the foundation for analyses presented here, to define the approach and to provide advance notice of revisions to the Kitsumkalum Chinook salmon time series of escapement.

Holtby and Ciruna (2007) recognized two Chinook salmon CUs in the Kitsumkalum watershed based on life history, genetics and timing. The summer run Chinook salmon CU was named *Kitsumkalum-late timing* (acronym *KALUM-L*, code *CK-50*) and the spring timed Chinook salmon run was named *Kitsumkalum-early timing* (acronym *KALUM-E,* code *CK-49*). The spring run is distinct from the summer run in timing, spawning location, age at maturity and genetics. The summer run spawns in the Kitsumkalum River below Kitsumkalum Lake and the spring run spawn in the Cedar River and Clear Creek, above Kitsumkalum Lake. The summer run Chinook salmon CU *Kitsumkalum-late timing* is the focus of the mark-recapture experiments reported here. All references to Chinook salmon in this document will be specific to the *Kitsumkalum-late* Chinook salmon CU unless stated otherwise.

Prior to 1984, declines in Chinook salmon populations in British Columbia (BC) and the United States of America (US) were attributed to overfishing. Measures taken to protect and rebuild Chinook salmon stocks included management and enhancement actions and included both domestic and international measures associated with the Pacific Salmon Treaty in 1985 (PSC, 2004). A “Key Streams Program” was developed in British Columbia in1984 to measure the effects of management actions taken to protect Chinook salmon. The Kitsumkalum River was identified as a “key stream” to monitor Chinook salmon and act as an indicator for other stocks in Northern British Columbia (Andrew and Webb, 1988). The objectives of the program were:

1. *to accurately estimate wild escapement on key streams;*
2. *to estimate harvest rates, and contributions to fisheries and escapement, based on an analysis of coded wire tagged (CWT) and adipose fin clipped returns, including estimates of the total escapement of CWTs to the key stream system; and*
3. *to estimate the contribution of hatchery production to the total key stream escapement.*

The key stream objectives have remained the primary intent of the Kitsumkalum Chinook salmon Program with additional emphasis placed on estimating age specific catch and escapement information after 2001 (PSC, 2004) and supporting the CWT program results after 2008 (CWT Workgroup, 2008).

The primary objectives of the annual studies of Kitsumkalum River Chinook salmon were to estimate the wild and hatchery contributions to the return and produce marked Chinook salmon fry from each brood. The Kitsumkalum River Chinook salmon project generated the escapement data and produced the marked fish required for an exploitation rate indicator stock. The projects included collection of brood stock, production of yearling and sub-yearling Chinook salmon fry, marking the fry with coded wire tags (CWT’s) and adipose fin clips, releasing the fry, estimating the wild and enhanced returns and determining the age composition of the returns. Kitsumkalum Chinook salmon were developed as an exploitation rate indicator stock to inform the international Pacific Salmon Commission (PSC) and the domestic Fisheries and Oceans Canada (DFO) management bodies. The project was integrated with the international CWT Mark Recovery Program.

Initially Kitsumkalum data were not included in the PSC Chinook salmon model calculations as the first model only included the 10 most abundant Chinook salmon stocks with CWT's encountered in mixed stock fisheries (CTC, 1988). Kitsumkalum Chinook salmon were included as an exploitation rate indicator stock in the PSC's Chinook salmon model in 1992. Escapement data were not included in the1992 analyses but recoveries were deemed important to understand catch distribution (CTC, 1993). Escapement data were included after 1992 (CTC, 1994). The Kitsumkalum stock was used as an exploitation rate indicator stock in support of abundance based management regimes beginning in 1999. Kitsumkalum summer run Chinook salmon data were presented with brood exploitation rates, stock catch distribution, quantitative estimates of escapement and releases of CWT and adipose fin clipped Chinook salmon during the base period (1979-1982) (CTC, 2001). However the data available for CWT releases during the 1979-1982 base period were incomplete. Releases were initially reported for 1982 (CTC, 1993, 1994) but the releases (CWT codes 022533 and 022534) were from the Cedar River, part of the early-timed Chinook salmon CU, and could not be included as part of the base period releases for the exploitation rate (ER) calculations for the summer run population.

The PSC Chinook salmon model currently uses 45 Chinook salmon stocks as indicators for the annual exploitation rate analyses and model calibrations. The Kitsumkalum stock is the only indicator for the North Coast of British Columbia (NBC). Data from CWT releases and recoveries for each stock support cohort analyses where estimates of age-specific and fishery-specific exploitation rates are used to reconstruct the cohort size for each brood year. The analyses also provide maturation rates and survival to age-3 for stream type stocks like Kitsumkalum (CTC, 2021).

Kitsumkalum Chinook salmon are encountered in the PST Aggregate Abundance Based Management (AABM) fisheries in Southeast Alaska (SEAK all gear) and Northern British Columbia (NBC Troll and Haida Gwaii Sport). They also contribute to the Individual Stock Based Management (ISBM) fisheries in Northern British Columbia including gillnet, tidal sport, non-tidal sport, tidal First Nations (FN) and non-tidal FN fisheries. Kitsumkalum Chinook salmon are north migrating so they do not contribute to the West Coast Vancouver Island (WCVI) AABM fisheries nor do they contribute appreciably to ISBM fisheries south of the Skeena River.

The Kitsumkalum River supports five species of Pacific salmon; Chinook salmon, Coho (*O. kisutch*), Sockeye (*O. nerka*), Pink (*O. gorbuscha)* and Chum (*O. keta*). Other salmonid fish species encountered included Rainbow/Steelhead Trout (*O. mykiss*), Coastal Cutthroat Trout (*O. clarki*), Rocky Mountain Whitefish (*Prosopium williamsoni*), Bull Trout (*Salvelinus confluentus*) and Dolly Varden Char (*S. malmus*).

Study Area

The Kitsumkalum River watershed is located between the Nass and Kitimat Ranges of the Coast Mountains of British Columbia, Canada. The Kitsumkalum River flows east to Kitsumkalum Lake from headwaters near Morton Peak in the Kitimat Range. This portion of the river is locally referred to as the Beaver river. Kitsumkalum Lake is fed by several large basins including the upper Kitsumkalum, Nelson, and Cedar rivers and Mayo, Clear, Douglas, Wesach, Maroon and Goat Creeks as well as several smaller creeks. The Kitsumkalum River exits the south end of Kitsumkalum Lake and flows south through Redsand and Treston Lakes to the Skeena River. Several small creeks enter the river between the lake and the Skeena River including Star, Alice, Glacier, Luncheon, Lean-to, Spring and Deep Creeks. The Kitsumkalum River enters the right bank of the Skeena River at the city of Terrace (Figure 1). The difference in elevation between Kitsumkalum Lake and the confluence of the Kitsumkalum and Skeena Rivers is approximately 104 m (from 153 m to 49 m, Google earth). The watershed area is approximately 2,255 km^2 (Parken et al. 2006).

The portion of the Kitsumkalum River included in the mark-recapture studies is from Treston Lake to the Skeena River, a distance of approximately 20 km. The river follows a course of approximately 30.5 km from the outlet of Treston Lake (54° 41'N X 128° 46' W) to the confluence with the Skeena River (54° 31' N X 128° 40' W). A canyon approximately 10 km upstream from the confluence with the Skeena River separates the upper and lower reaches of the Kitsumkalum River study area (Figure 2). The canyon is not a barrier to fish passage but is a barrier to virtually all boat traffic.

METHODS

Staff from the Terrace Salmonid Enhancement Society (TSES) have conducted the mark-recapture studies to estimate Chinook salmon escapement in the Kitsumkalum River since the inception of the key stream program in 1984. The TSES worked under contract to DFO and operated Deep Creek Hatchery, a small hatchery owned by DFO that was constructed in 1983 to produce Chinook salmon fry marked with CWT's for the key stream program. The fish production portion of the project included collection of brood stock, production of yearling and sub-yearling Chinook salmon, rearing, feeding and marking the fry with CWT's and adipose fin clips and releasing the marked juveniles. The mark-recapture and brood stock programs were integrated such that samples of adult returns provided the data required to estimate wild and enhanced components as well as the age composition of the returns.

Field Procedures and Data Collection

Chinook salmon escapements to the Kitsumkalum River were assessed through a two event mark-recapture procedure that collected the data necessary to provide estimates of the wild and enhanced fractions of the escapement. The Kitsumkalum River was accessed by jet boat from boat launches between Highway 16 and the CN railway bridge in the lower river and at kilometer 22 of the Nisga'a Highway for the upper river.

The first events or tagging events of the annual mark-recapture programs began in mid-August and ended in early September. Chinook salmon were caught using tangle nets drifted through spawning and holding reaches of the river. Fish were marked with uniquely numbered tags and a mutilation mark consisting of a 7 mm hole was punched through the operculum. Fish were marked with Petersen disc tags in 1984, spaghetti tags in 1985 and 1986, and Ketchum Kurl lock ® tags from 1987 to 2020. The mutilation mark and the Kurl lock tag were applied to the left operculum of fish marked in the lower reach of the river and to the right operculum of fish marked in the upper reach of the river. Petersen disc tags and spaghetti tags were applied to the base of the dorsal fin with attachments passed between the pterygiophores.

The second events consisted of dead pitches where carcasses were recovered from the river and checked for marks. Carcasses were collected by hand and gaff. The dead pitches occurred through the duration of the die-off after spawning, usually from mid-September to mid-October. Detailed start and end dates for the tagging and dead pitch portions of mark-recapture projects from 1984 to 2020 appear in Table 1.

Gender specific data were required for the mark application and mark recovery portions of the work. Gender was identified visually for live fish and for decayed or mutilated dead fish. Gender was also identified by incising the body cavities of intact dead fish.

Egg retention in dead females was assessed as a measure of pre-spawn mortality (or the inverse, survival until after egg release). Intact female carcasses were examined for eggs remaining in the body cavity and recorded as full egg retention (75%-100%), partial egg retention (10-75%) and no egg retention or few eggs remaining (<10%). In some years additional strata were included but were pooled here to the 3 strata common to all years. The lack of eggs in intact carcasses provided an indication of spawning success and partial or full egg loads provided an index of pre-spawn mortality.

Scales were collected to provide the age data necessary to identify the brood year components of the return. Scales were collected according to procedures described by MacLellan (1999) and matched to size, gender and capture information. Scale samples were read at the Pacific Biological Station Sclerochronolgy lab in Nanaimo, B.C. Data from scales collected prior to 1996 were available as summaries and could not be matched to the other biological data collected from the fish. Ages were recorded using the Gilbert-Rich coding system.

Scale age data from wild Chinook salmon were applied to estimates of escapement to determine age and gender specific estimates of the wild returns. An exception was 1996 when the scale samples of males was so low that the age 5 to 6 ratio in females was used to predict the age of males.

Heads were recovered from adipose fin clipped Chinook salmon encountered in the tagging and recovery events. All adipose fin clipped fish encountered in the dead pitch were sampled except in 1984 when clipped fish were not sampled. A sub-sample of adipose fin clipped fish encountered during the tagging events were sampled from 1985 to 2008. Data from heads collected prior to 1996 were recovered but could not be matched to the other biological data collected from the fish. Beginning in 2009 all adipose fin clipped

Chinook salmon encountered in the tagging event were sampled for CWT's. CWT's were extracted and read as part of a separate contract with J.O. Thomas and Associates.

Most adipose fin clipped fish sampled for CWT's were also sampled for scales (conditions permitting). CWT data were used to verify scale ages and scale age data were used to confirm freshwater and marine components of the total age.

Data Handling and Estimation Procedures

The analyses of the Kitsumkalum Chinook salmon mark-recapture data followed the methods described by Vélez-Espino et al. (2016). The approach included (1) testing for demographic closure, (2) including information from all encounters, including losses on capture and recaptures during tagging events, and (3) expressing different hypotheses within a model selection framework about the attributes and capture history of the population.

Data Sources

Kitsumkalum Chinook salmon mark-recapture reports prepared by the TSES and raw data sheets were recovered from archives at DFO, Prince Rupert and from the Deep Creek Hatchery in Terrace for data collected from 1984 to 1993. These data were entered into Excel ® spreadsheets. Data from 1994 to 1998 reported by McNicol (1999) were received from McNicol in electronic format. Data from 1999 to 2020 were received from the TSES in electronic format. Data sets were modified to a common format. A process of error checking was performed on all data sets, returning to the field data sheets to correct discrepancies when necessary.

Contracts between DFO and the TSES included reporting requirements where data were included for encounters of individual fish as well as summaries with preliminary escapement estimates. These grey literature reports were the source of much of the data necessary for the open model analyses for 1984 to 1993 (Anon, 1984, 1985, 1986, 1987, 1990, 1991, 1992, 1993, Hazelwood, 1988, Hazelwood and Whelpley, 1989). A search of records archived at the Deep Creek Hatchery also produced raw data sheets for some years which were used to augment the information in the reports.

Data Stratification

Temporal, spatial and group (gender) strata were included in all years except 1984 when there was no spatial stratification.

Temporal stratification was based on individual days worked applying tags or recovering carcasses. Each work day was described as an event and events were grouped into occasions. The events were typically grouped by week unless there were particular environmental or biological changes like a flood or the start of die-off requiring the initiation of the dead pitch. The process of grouping events into occasions also attempted to minimize the number of occasions that contained both tag application and carcass recoveries. The total project duration averaged 49 days with a range of 33 to 69 days

(Table 1). The number of occasions within the annual studies ranged from 5 to 9, well below the maximum of 20 sampling occasions suggested by Vélez-Espino et al. (2016) (Table 2).

Spatial stratification included strata for the upper (U) and lower river (L) reaches. Recoveries of dead fish in the lower river from the upper stratum were not considered violations to the spatial stratification as carcasses often drift downstream. Fish were assigned to the river reach that represented their most probable area of spawning. As fish actively moved through the river we expected changes in location. Fish tagged in the lower river and recovered in the lower river were defined as lower river fish. Fish tagged in the lower river and recovered in the upper river were defined as upper river fish. Fish tagged in the upper river were defined as upper river fish regardless of recovery location. Under these assignments movement from the lower river to the upper river was associated with migrating fish. Movement from the upper river to the lower river was associated with drop-back and wash out and was more frequently associated with males than females

Chinook salmon were stratified into three groups; females (F), large males (M) and jacks (J). Jacks were males with one ocean year, most often age 3_2. Jacks were identified by size as they were typically less than 450 mm post orbital to hypural plate (POH) length. The jack components of the male populations were not included in the analyses due to rare encounters in tagging and recapture events leading to few marked recoveries. Thus the group stratification for large Chinook salmon was limited to two strata equivalent to gender.

Converting Data to IEH's

The process of converting the standard mark-recapture data into IEH's was accomplished with a pivot table approach (Vélez-Espino et al. 2016). Each fish was given a unique identifier which included the tag number for marked fish, the brood stock number for brood stock removals, head label numbers for adipose fin clipped recoveries and unique codes for losses-on-capture (Schwarz et al. 1993) and dead pitched fish without marks. Data for each fish consisted of a minimum of one record. Fish that were marked and never encountered again received a single record. Fish that died upon initial capture or fish that were removed from the system as brood stock were considered as losses-on-capture and also received a single record. Finally, dead fish that had not been encountered before received a single record. Multiple records were possible for fish that were captured more than once in the tagging event and/or recovered in the dead pitch event. Data for fish with multiple encounters were converted to a single record through the pivot process thereby generating a table with the dates of encounters (columns) for each fish with a the unique identifier (rows).

Coping with tag loss and tag identification errors

Unique tag numbers or fish identification codes were used in all years. In rare cases a tag number was recorded as recovered when that tag number was not part of the population of tag numbers released. In these situations the data were examined to see if the error could be identified and corrected. The tag numbers on the Kurl-lock tags could be difficult or impossible to read as a result of abrasion. Fish would abrade the tag by digging redds or by actively trying to remove the tag against rocks. Tags abraded to the point where the numbers were illegible were rare (28 instances across 4,082 tag recoveries). In cases where tag numbers could not be read or corrected a tag number was assigned using the procedure described for lost tags below.

Tagged Chinook salmon received a 7 mm hole punch through the operculum as a non-removable mark indicating that they had received a tag. This mutilation mark was specific to the river reach (left for the lower river and right for the upper river). All fish were checked for mutilation marks before applying tags in the tagging events and all carcasses encountered in the dead pitch were examined for mutilation marks to identify tag losses. No secondary tests were performed in any year to assess observer efficiency (i.e. to check if crews missed observing and recording the existence of a mutilation mark without a tag).

Tag losses represented a problem for the IEH process as each fish required a complete history. We dealt with tag losses by assigning recoveries without tags to members of the known tagged population. Untagged recoveries were identified by the presence of a hole punched in the operculum. The location of the punch on the left or right side identified whether the fish was tagged in the lower or upper river respectively. Other information that further reduced the tagged population that an untagged recovery came from included the date of recovery, fish size, fin clip status, and gender. A pool of candidates was identified within the set of fish tagged (i.e. prior to the date of recovery with the same size, gender and fin clip status). A tagged fish was selected at random from within the pool to represent the untagged recovery. This selection often came down to very few fish. In some instances only a single fish met the criteria.

Tag numbers were not recorded in the data recovered for the 1988 mark-recapture experiment. Complete IEH's could not be developed for this escapement year so a regression of open versus closed model estimates was used to fill the open model result for 1988 (Appendix 5).

Testing for closure

The software Close Test Version 3 (T.R. Stanley and J.D. Richards, U.S. Geological Survey, Fort Collins Center, Colorado) was used to test for demographic closure. Closure was tested for the full data set (all strata) for each year as well as for the river reach and gender specific components of upper river males, upper river females, lower river males, and lower river females.

Mark-Recapture Analyses - POPAN

We used Program MARK (Gary C. White, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, Colorado; http://www.phidot.org/software/mark) for the analyses of marked individuals and specifically, the program POPAN within program MARK. POPAN was applied to fit numerous models to data stratified by time, gender and river reach to generate escapement estimates for each year of data.

The mark–recapture analyses followed the model selection approach recommended by Lebreton et al. (1992): (1) start from a global model compatible with species biology and assess with goodness-of-fit tests, (2) select the most parsimonious model using Akaike information criterion (AIC) to limit the number of formal tests, (3) compare the most parsimonious model with neighboring models using likelihood ratio tests and (4) obtain maximum likelihood estimation (MLE) of model parameters with estimates of precision. This approach was applied to open-populations models. Closed-population models were not considered since all years failed the Close-Test analyses. However, analyses using the Petersen method were included to compare the results from the open population models with results from historic approaches that assumed closure.

The global model included the main probability components of capture (p), survival (s) and recruitment into the system (b) which could change through time (t) during each annual study and could differ among gender (g) and river reach (r). Notation for the global model was {p(t g r) s(t g r) b(t g r)} and was common to all 36 years included in the analyses.

The probabilities of capture (p) are confounded for the first and last time periods because they are not bounded by adjacent time periods. It was necessary to adjust (fix) the parameters to allow for the inclusion of the full temporal stratification in the probability of capture. To estimate values for the first and last occasions we adjusted the global model to remove all stratification of the capture probabilities {p(*) s(t g r) b(t g r)} to get an average capture probability. Subsequent model runs that included temporal stratification in the probability of capture had the first and last time parameters fixed with the average estimate (MARK book, Gary C. White, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, Colorado; http://www.phidot.org/software/mark). We used the notation {p(fix-t …} to identify this change to the models.

Hatchery Contribution

The hatchery component was calculated using the weighted average of the adipose fin clip incidence in the first (tagging) and second (dead pitch) mark-recapture events to determine the contribution of fin clipped individuals to the population. The total hatchery contribution was generated by applying the release specific expansions for each tag code encountered in the population.

The proportion of natural influence (pNI) was approximated for an integrated hatchery program as: pNI ~= pNOB / (pNOB + pHOS) where pNOB was the proportion of natural-origin parents in the hatchery broodstock and pHOS was the proportion of hatchery-origin fish on the spawning grounds (Withler et al., 2018).

Timing

Migration timing of Kitsumkalum Chinook salmon was measured from genetic stock identification (GSI) data collected from sport fisheries at Langara Island (ADFG DFO, 2018) and from GSI data collected at the Tyee Test fishery. Migration into the study area was estimated from proportions of fish caught in the mark-recapture tagging events. Brood stock collections and the mark-recapture dead pitch events were examined to determine the timing of spawning and the timing of death.

Cohort Analyses

We used the results of the CTC cohort analyses published by the PSC in the Calibration and Exploitation rate report (CTC, 2021). Specifically these analyses use a revised version of the CTC model designed in 2020 with new fisheries and analyses of data collected up to and including 2019. CWT recoveries in fisheries were available from releases beginning in 1979. No releases of Kitsumkalum summer run Chinook salmon occurred in 1982 and escapement recoveries were not reported prior to 1985 so CWT recoveries from escapements were incomplete for broods 1979 to 1981. Complete escapement CWT recoveries were available from brood years 1983 to 2013. The cohort analyses provide exploitation rates for each brood year by fishery and age, survival of CWT release groups to age 3 recruits, and distribution of catch and total fishing mortalities.

Stock Recruit Analyses

The stock-recruit analysis for the Kitsumkalum Chinook salmon stock was done with data for complete brood years from 1984 to 2013. We used the classic Ricker model (Ricker 1975) as base case and explored alternative formulations that could account for non-stationarity, that is, a model with autocorrelation in recruitment and a model with a time-varying alpha parameter. The base Ricker function was given by:

$$R_t = \alpha \cdot S_t \cdot e^{-\beta \cdot S_t + w_t}$$

$$w_t \sim N(0, \sigma)$$

The derived quantities for S_{MSY}, spawning abundance that produces maximum sustained yield, and U_{MSY}, the exploitation rate associated with S_{MSY}, were calculated following Hilborn and Walters (1992):

$$S_{MSY} = \frac{\log(\alpha)}{\beta} \cdot (0.5 - 0.07 \cdot \log(\alpha))$$

$$U_{MSY} = 0.5 \cdot \log(\alpha) - 0.07 \cdot \log(\alpha)^2$$

The capacity, S_{EQ}, was given by:

$$S_{EQ} = \frac{\log(\alpha)}{\beta}$$

S_{Gen} , defined as spawners that would result in recovery to S_{MSY} in one generation in the absence of fishing, was calculated using the samSim R package (https://github.com/Pacific-salmon-assess/samSim).

Other versions of the model considered included a recursive Bayes formulation with time-varying α and version including auto-correlation in recruitment.

The time varying α is given by:

$$R_t = \alpha_t \cdot S_t \cdot e^{-\beta \cdot S_t + w_t}$$

$$\alpha_t = \alpha_{t-1} + \upsilon_t$$

$$w_t \sim N(0, \sigma)$$

$$\upsilon_t \sim N(0, \sigma_a)$$

And the model with autocorrelation in recruitment deviations was given by:

$$R_t = \alpha \cdot S_t \cdot e^{-\beta \cdot S_t} \cdot e^{w_t + w_{t-1} \cdot \rho}$$

$$w_t \sim N(0, \sigma_{AR})$$

$$\sigma_{AR} = \sigma \cdot \sqrt{1 - \rho^2}$$

where ρ was the autocorrelation coefficient.

Maximum likelihood estimates and Bayesian median and 95% credibility intervals were reported for the preferred model. All the analysis was performed using the R statistical program (R Core Team, 2021) and the TMB and TMBstan R packages. Bayesian estimates were obtained with three chains of 50000 iterations each, and after 50000 iterations were discarded as burn in.

RESULTS

Mark-Recapture

The results represent analyses of 37 years of mark-recapture data for Kitsumkalum Chinook salmon from 1984 to 2020 including a total of 106,941 encounters of 92,765 individual fish.

Stratification

Data collected from the mark-recapture project were stratified temporally, spatially and by fish group (or gender).

The total project duration averaged 49 days with a range of 33 to 69 days across the 37 years. The annual number of events (days worked) averaged 37 days with a range of 29 to 46 days (Table 1). Each annual study was divided temporally into sampling occasions that ranged from 5 to 9 strata (Table 2). Extra temporal strata typically reflected longer project durations. Five sampling occasions were used in 1989 when the mark-recapture program had the second shortest duration at 36 days (only 2001 was shorter at 33 days).

Six sampling occasions were used in 7 years, 7 sampling occasions were used in 24 years and 8 sampling occasions were used in 3 years. Nine sampling occasions were only used once, in 2011 which had the earliest start date, August 10, and the latest end date, October 17, in the time series (Table 2).

Two spatial strata consisting of the upper and lower river reaches were used in all years except 1984 (Figure 2). The 1984 data were not separated by river reach (Anon., 1984).

Fish were stratified by gender and males were grouped by size and age into jacks and large males. Jacks were not included in the estimation procedure making gender and group equivalent for the estimates and discussions of large Chinook salmon.

Gender Identification

Gender of Chinook salmon was identified visually for live fish and by incising dead fish or from visual observation. Incidences where the visual gender identified at tagging was different than that identified on recovery were rare. Examination of 4,082 recoveries from 1984 to 2020 show 188 fish identified as male when tagged were later identified as female when recovered in the dead pitch whereas 100 fish identified as female when tagged were later identified as male when recovered in the dead pitch. The absolute error averaged 7% but the net error was only 2% as the as opposing errors cancelled out. The most prevalent error, fish identified as male during tagging and later as female during the dead pitch, was often attributed to fresh fish caught early in the tagging program before the sexually dimorphic traits developed during spawning were fully apparent (Table 3).

Egg retention as a measure of differential mortality due to tagging

Egg retention in marked females was not significantly greater than that in unmarked females in any year ($p>0.05$, Chi-square tests). Dead females bearing eggs were extremely rare in all years averaging 0.9%. In 6 of the 37 years examined egg retention in female carcasses was zero. The maximum percentage of females retaining any amount of eggs was in 1994 at 5.1%. 1994 appears as an outlier as the next highest percentage of females retaining eggs was in 1984 at 2.3%. Egg retention data were not reported by Nelson (1995a) but these data were collected (Anon., 1994). The difference between egg retention in tagged and untagged fish was not statistically significant. In 24 of 37 years sampled the proportion of tagged females retaining eggs was lower than the proportion of untagged females retaining eggs (Table 4).

Tag loss

Tag loss was low for most years except 1985, 1986 and 1994. Spaghetti tags were used in 1985 and 1986 and the average tag loss rate was 39%. The loss of spaghetti tags was particularly high in males at 64% compared with 18% in females (Andrew & Webb, 1988). Spaghetti tags were abandoned after 1986 due to the high tag loss rate. Ketchum Kurl lock ® tags manufactured as pig ear tags or chick wing tags were used from 1987 to

2020. Average tag loss for the Kurl lock tags was 8.3% across all years. 1994 stands as an outlier in the Kurl lock tag loss data when 39% of marked recoveries were missing tags. Nelson (1995a) reported the tag losses in 1994 but did not suggest a reason for the high loss rate. The average Kurl lock tag loss rate from 1996 to 2020 was 6.3%. Petersen disc tags were used in 1984 and 2 of 36 tag recoveries (6%) lost tags (Table 5).

Closure

Statistically significant violations to the closure assumption were observed in the form of additions (immigration) for every year tested using the data sets for large males and females. Closure was identified in 16 of the 142 specific year, river reach and gender combinations tested (Table 2). Closure assumptions were not violated for: lower females in years, 2009, 2010, 2011, 2017 and 2018; upper females in years 2002, 2006, 2011, 2017 and 2018; and upper males in 1995, 2002, 2007, 2011 and 2017. Data for lower river males violated the closure assumptions in all years.

Since closure was not identified in any year for the data sets that included females and large males (i.e. jacks excluded), the analyses were performed with open-population models, specifically POPAN models developed in program MARK.

Model Selection for Escapement estimation

A total of 25 unique model types were selected as the most parsimonious models to generate escapement estimates across the 36 years tested (Table 6). The number of parameters for the models selected ranged from 21 in 1984 to 64 in 2013. The low number of parameters in 1984 was the result of pooling the river reaches into a single stratum due to the lack of reach specific data. All other years included two river reach strata. The second lowest number of parameters was 30 in 2017. The larger number of parameters in 2013 was partially due to having eight temporal strata. Data for 2011 included nine temporal strata but the most parsimonious model had 40 parameters. The most frequently selected model was {p(fix-t r) s(t g) b(t g r)} which was selected in four years (Table 6). Annual model selection tables from the output of program MARK / POPAN with the AIC values appear as Appendix 1.

Escapement Estimates

The primary product was a revised series of escapement estimates for large Kitsumkalum Chinook salmon from 1984 to 2020 using open population models derived using POPAN. Estimates produced for the time series ranged from a maximum of 19,664 in 2004 to a minimum of 4,132 in 2017 with a mean of 10,416 fish (Table 7). The pattern of escapement shows oscillations about the mean with abundant periods in excess of 15,000 Chinook salmon from 1987 to 1989 and again in 2001, 2003 and 2004. Periods below 10,000 fish were observed from 1984 to 1986, 1995 to 1999, 2008 to 2012 and 2016 to 2020. Abundances below 5000 fish were observed in 1997, 2017 and 2020 (Figure 3). Estimates by gender and river reach are presented in Table 8.

Life History and Age at Maturity

Kitsumkalum Chinook salmon typically have stream type life histories with the predominant portion of returns occurring at age 5_2 and 6_2 for males and at age 6_2 for females. Other age components observed in Kitsumkalum Chinook salmon include males returning from 2 to 7 years from brood and females returning from 4 to 7 years from brood.

Most wild Kitsumkalum Chinook salmon (97.4%) are stream type with a small component (2.6%) of ocean type fish. Males typically return from age 3 to age 7. There was a single record of an age 2_1 wild fish in the data. The most common ages at return for males were ages 4 through 6. Age 3_2 jacks form 5% of male age samples but the jack component of the population was not measured by the mark-recapture analyses so their actual contribution was unknown. Jacks were rare in the tag application samples and even less common in dead pitch samples. Female returns include ages 4 through 7 but the most common (97.6%) ages were age 5_2 and age 6_2. Age 4 and age 7 females were rare at 1.2% and 1.1% respectively (Table 9 and Table 10).

Mean age at maturity is declining in wild Kitsumkalum Chinook salmon. Age at maturity for the first decade in the series, brood years 1979 to 1988, averaged 5.5 years for males and 5.7 years for females compared to averages of 4.7 years for males and 5.3 years for females for the last decade (brood years 2004 to 2013). Mean age at maturity across the entire series of complete brood years, 1979 to 2013, were 5.2 years for males and 5.5 years for females (Figure 4).

Changes in age at maturity have decreased the proportion of 6 year old fish with a concomitant increase in the proportion of 5 year olds (Figure 5). Brood years prior to 1991 produced mostly age 6_2 fish whereas brood years after 2001 produced mostly age 5_2 fish. During the interim decade 1991 to 2001 the proportions oscillated but average contributions were almost equal at 43% age 5_2 and 44% age 6_2.

Size at Age

Kitsumkalum Chinook salmon are large with the mean size of males averaging 738 mm post-orbital to hypural plate length (POH) with a standard error (SE) of 165 mm across the 1984 to 2020 time series. Females averaged 821 mm POH with a SE of 65 mm. The lower average size in males and the larger standard errors reflect the influence of some age 3_2 jacks which are not present in the female population and a much higher proportion of age 4_2 fish in males than females. Overall the mean size of males and females has declined across the time series (Figure 6 and Table 11).

The length frequency histograms for male and female POH typically show a broader distribution of sizes and a larger standard error (SE) about the mean size for males than females (Figure 7 and Appendix 2). This was the case for all years except 1994.

Age 3_2 and age 4_2 males average 395 mm and 596 mm post-orbital to hypural plate length (POH) respectively. Both genders of age 5_2 fish average 770 mm POH. Age 6_2

males averaged 883 mm POH and were slightly larger than age 6_2 females which averaged 841 mm POH.

Mean size at age has declined in both genders of age 5_2 and 6_2 Kitsumkalum Chinook salmon with mean POH estimates declining approximately 50 mm from the beginning to the end of the time series (Figure 8 and Figure 9). These changes were not statistically significant as the standard errors overlapped across all years (Table 12 and Table 13). Age 3_2 and 4_2 males did not appear to change appreciably in size across the time series (Figure 9 and Table 13).

Gender and Age-specific contributions to escapement

Gender and age-specific contributions to escapement were calculated for Kitsumkalum Chinook salmon by return year and by brood year (Table 14 and Table 15). Ages 4 through 7 were included in the escapement estimates.

Mean sex ratio by brood year was 1.04 males per female (SE = 0.30) with a maximum of 1.87 males per female produced from 1991 and a minimum of 0.57 males per female produced from 1988 (Table 15).

Coded Wire Tagged releases

CWT's were first applied to wild Kitsumkalum Chinook salmon fry collected in 1980 from the 1979 brood. Progeny from brood stock collected in 1980 and 1981 were reared at a pilot hatchery at Dry Creek. No summer run fry were reared from the 1982 brood of summer run Kitsumkalum Chinook salmon. The Dry Creek facility was used to raise spring run fry from the Cedar River. Following the construction of the Deep Creek Hatchery in 1983 Kitsumkalum summer run fry were reared at the site continuously until 2020 (Appendix 3).

Yearling releases were first attempted with the 1996 brood with the release of approximately 20,000 yearling fry in 1998. Subsequently yearlings were reared from brood years 1999 to 2018 (Appendix 3). The objectives for the marked releases were to produce 30,000 yearlings from the 1999 to 2007 brood years and 60,000 yearlings from the 2007 to 2020 brood years.

Fry reared from the 2019 brood were released unmarked in April 2020 as a result of social distancing required in response to the novel coronavirus pandemic. This was the first brood year that there were no CWT and adipose fin clipped releases of summer run Kitsumkalum Chinook salmon since 1982.

Hatchery Production, Contribution and PNI

The incidences of adipose fin clipped Chinook salmon observed in the tagging and dead pitch samples formed the basis for estimates of hatchery contributions to escapements (Table 16). Hatchery contributions by tag code are presented in Appendix 4.

Virtually all Kitsumkalum Chinook salmon produced at the Deep Creek hatchery were marked with adipose fin clips and CWT's. The average expansion factor from adipose fin clipped fish to total hatchery contribution across all years was 1.06. The practice was to always use natural-origin spawners for brood stock as evident from the presence of an intact adipose fin. The probability of selecting an unmarked hatchery fish for brood stock were remote and were calculated using the proportion of unmarked hatchery fish present in the brood year and each brood year contribution to a return year. As expected the proportion of natural origin brood stock (pNOB) was greater than 99.2% in all years and averaged 99.8%. In the absence of samples an estimate of pNOB at 100% was used in the calculations for years prior to 1985 (Table 17).

Hatchery production was low relative to the population size. The mean return year hatchery component in escapements from 1985 to 2020 was 452 fish and ranged from a minimum of 74 fish in 1988 to a maximum of 1,471 fish in 2018. The mean proportion of hatchery fish in the returns was 5.0% and ranged from 0.5% in 1988 to 15.4% in 2018. No adipose fin clipped fish were reported in the escapement samples from 1984 (Table 17).

The proportion of natural influence (PNI) averaged 95.4% with a maximum of 99.4% in 1988, 1993 and 1994, and a minimum of 85.3% in 2017. The lowest escapement in the time series (4,132 fish) also contributed to the largest hatchery component in 2017 (Table 17).

The freshwater life history and age at return of the hatchery components of the Kitsumkalum Chinook salmon population differed from wild fish. Hatchery fish exhibited larger (22%) ocean type components than wild fish (2.6%). The ocean type component of male and female hatchery fish sampled from 1997 to 2020 was the same (Table 18 and Table 19). The average proportions of age 4, 5 and 6 fish observed from complete brood years, 1984 to 2013, of hatchery fish were 23%, 63% and 14% respectively (Table 20). The average proportions of age 4, 5 and 6 fish observed from complete broods years of wild fish were 13%, 43% and 43% respectively (Table 15). The proportions of age 4 and age 5 fish were larger in the hatchery returns and the proportion of age 6 fish was smaller than the same age components observed in wild fish. Average age at maturity of large male and female hatchery fish combined (jacks excluded) from escapement was 4.9 years compared with 5.3 years for wild fish (Table 20 and Appendix 4).

Timing of Migration, Spawning and Death

Canadian ocean sport and troll fisheries with harvests of Kitsumkalum Chinook salmon occur in Area 1 off of Graham and Langara Islands. The mean timing of the Kitsumkalum Chinook salmon migration past Langara Island as measured from samples of the sport fishery catch was 27 June. The average dates when 10% and 90% of the catch of Kitsumkalum fish was reached were 4 June and 19 July respectively. On average, 80% of the run was encountered during the 46 days between 4 June and 19 July (Figure 10).

Most of the migration of Kitsumkalum Chinook salmon from tidewater into the Skeena River occurred in July. Average run timing as measured from catch per unit effort

(1984-2020) at the Skeena River test fishery conducted at Tyee shows 80% of the run passed Tyee over the 32 days between 30 June and 31 July. The mean run timing was 15 July (Figure 11). The test fishery began on 25 May for some (8 of 37) years of the series. In other years the test fishery began on or near 10 June. Few fish were caught by the test fishery between 25 May and 10 June. Langara Island is 110 nautical miles (~200 km) from the Tyee Test Fishery located in the Skeena River estuary. The mean speed of migration from Langara Island to Tyee was 6.1 Nm/day (11 km/day).

Capture of Chinook salmon for tagging in the mark-recapture study began in mid-August (average 18 August) and was finished in mid-September (average 13 September) (Table 1). Average run timing as measured from catch per unit effort from 1984 to 2020 indicates 80% of the run was available for capture in the Kitsumkalum River over the 22 days between 23 August and 13 September. The mean timing of capture for tagging and the peak of the capture timing curve was 2 September (Figure 12). Tyee is approximately 100 km from the confluence of the Kitsumkalum and Skeena Rivers. The mean speed of migration from Tyee to the Kitsumkalum River was 1.1 Nm/day (2 km/day).

Spawning occurred from August to October but most spawning occurred in the first half of September. Spawning fish were captured in the tagging events but records of spawning condition were sporadic. Brood stock collections provided evidence of spawning activity in females but was biased toward the beginning of spawning as crews collected ripe females as early as possible to meet egg take objectives for the hatchery. Ripe females collected for brood stock represented fish in a condition immediately prior to spawning or during spawning as evident from loose eggs or partial egg loads. The average timing of the collection of females for brood stock from 1996 to 2020 was 8 September. Average collections reached 10% of the total annual egg take on 3 September and 90% on 14 September. The breadth of 80% of the brood stock collection curve was 12 days wide (Figure 13).

The majority of the post-spawning die off occurred in the latter half of September. Recoveries of dead Kitsumkalum Chinook salmon started in mid-August. The mean timing of dead fish encounters was 23 September. Average encounters of dead fish reached 10% by 14 September and 90% by 2 October resulting in 80% of the dead fish encounters occurring over 19 days (Figure 14). Timing of death based on encounters of dead fish were biased late relative to the actual die off because only a portion of the fish were recovered immediately after dying. Measuring the bias was not possible as the records of carcass condition (fresh versus decayed) were sporadic.

Plots of average cumulative run timing past Langara, Tyee, and in the Kitsumkalum River during tagging, brood stock collection and dead pitch encounters show progressively later curves but the curves are also steeper in the river indicating a narrower timing for spawning and die off (Figure 15).

Survival and Exploitation Rates from the Cohort Analyses

CWT recoveries and estimates of their contributions to fisheries formed the basis for the cohort analyses. Kitsumkalum Chinook salmon were caught in AABM fisheries in Alaska and in AABM and ISBM fisheries in northern British Columbia. Observed and estimated CWT recoveries by fishery were presented for fry releases (KLM) in Table 21 and for yearling releases (KLY) in Table 22. Results from the cohort analyses (TCCHINOOK SALMON 20-1) include the distribution of total fishing mortalities for Kitsumkalum fry releases (Table 23) and yearling releases (Table 24).

Total brood year exploitation rates (BYER) computed for Kitsumkalum Chinook salmon include recoveries from ocean and terminal fisheries. BYER decreased from average levels of 49% for 1984 to 1993 to an average of 39% for 2004 to 2013 (Figure 16). Over the entire time series 1984 to 2013, BYER averaged 45% and ranged from 31% for 2004 to 69% for 1989. Incidental mortalities averaged 7.1% and ranged from 4.6% to 10%.

Most Kitsumkalum Chinook salmon enter the ocean as yearlings so fry survival was estimated to age 3. Survival rates for CWT fry releases averaged 0.7% and ranged from 0.14% to 1.7% from 1984 to 2013. Survival of the last complete brood year, 2013, was 0.56% (Figure 17).

Production

Brood year spawning stock by age and adult production by age from brood are presented in Table 25. Parameters from the CTC (2021) cohort analyses appear in Appendix 6. The average number of adult recruits produced per spawning fish (R/S) by brood year was 1.8. R/S declined from 2.3 in 1985 to 0.5 in 1994 then increased to a maximum of 6.4 in 1998. R/S oscillated while it declined to a minimum of 0.3 in 2003 and increased to 2.7 in 2010. The final 3 years in the time series show a decline to 0.8 R/S in the 2013 brood year (Figure 18 and Table 25).

Stock Recruit Relationship

The simple version of the Ricker model was selected as the preferred model to represent the time series of Kitsumkalum Chinook salmon stock and recruit data. The versions of the model with non-stationarity were discarded based on Akaike Information Criterion (AIC) model selection (Table 26), investigation of residual patterns (Figure 19), biological interpretation of parameter estimates (e.g. autocorrelation coefficient was estimated to be near zero, $\rho = 0.08$) and empirical knowledge. The current data do not support the assumption of non-stationarity in the stock-recruitment dynamics.

The parameter estimates and model predictions are reported for the simple Ricker model only. The maximum likelihood estimates, medians and 95% Bayesian credibility intervals of the parameters α, β, σ, S_{MSY}, U_{MSY}, S_{eq} (Capacity), S_{gen}, 25% S_{MSY} , 85% S_{MSY} and U at 85% S_{MSY} produced with the simple Ricker model appear in Table 27. The Ricker recruitment curve is presented in Figure 20. Posterior probability distributions for the simple Ricker model are presented in Figure 21. The contrast in spawning escapements included in the time series was 4.2 with the largest escapement of 19,633 spawners occurring in 2004 and the smallest escapement of 4,646 spawners occurring in 1997 (Table 25).

DISCUSSION

Data Sources

Field work was conducted by the TSES from 1984 to 1996 but separate contracts were issued to analyze the data and publish manuscript reports (Andrew and Webb, 1988; Carolsfeld et al., 1990; Nass and Bocking, 1992; Nelson, 1993a, 1993b, 1994, 1995a, 1995b; Blakely and Nelson, 1996). The assessment of Kitsumkalum Chinook salmon by McNicol (1999) reviewed and revised the escapement estimates from 1984 to 1996 and provided escapement estimates for 1997 and 1998. Although these sources of primary literature reported methods, summaries and estimates, the data were not included at the scale necessary to produce the individual encounter histories. Data from the TSES reports and raw data sheets from 1984 to 1993 were entered into Excel ® spread sheets and used to generate the IEH’s. Electronic versions of the raw tagging, recapture and dead pitch data were available in most years after 1994 but often had to be checked and corrected against the raw data. The recovered electronic data sets were in several different formats. All data recovered were entered into Excel ® spread sheets with a common format.

The process of generating IEH’s revealed that some historic work had not been rigorous in checking to ensure that tag recoveries came from the population of tags released and/or that gender on recovery matched gender on release. These relatively small changes could result in significant differences in estimates as an incorrect assignment of gender essentially moves a recovery (R) from the male to the female population data or vice versa.

Data stratification

Stratification by gender was essential. The morphological and behavioral differences caused virtually all samples to be biased by gender.

The tag application samples were collected with tangle nets and they typically encountered more male Chinook salmon than females. Males appeared to be more belligerent, often facing the net rather than moving out of the way. The male morphology was more angular with more pronounced fins, a larger kype and larger teeth, all of which were more easily tangled in the net. In contrast, females often moved away from the nets. The female morphology was more fusiform and round with smaller fins, kype and teeth so were less likely tangled and could more readily escape the nets.

The dead pitch or recovery sample of carcasses typically encountered more female carcasses. Females would guard their redds as long as they were able then would move into slower flows before death. Thus females died in close proximity to their spawning location and were more likely to remain in the study area. Males often moved after mating, looking for another mate and/or being moved by the current as they weakened.

Age 3_2 males, or jacks, were rare in the tagging event. Their morphology was more like females, more fusiform and rounder than older males. Additionally they were less likely to be tangled in the web that was designed to capture larger fish. Jacks were even less common in the dead-pitch. Possibly more easily moved by the current and removed by predators. The jack components of the male populations were not included in the analyses due to rare recaptures and recoveries. Including jacks in the POPAN analyses often resulted in the models not converging or odd results like extremely large variances or variances of zero (Vélez-Espino et al., 2016).

Gender identification errors cancelled out in most years so we elected not to adjust the gender identification of fish that were not recovered. It was essential to the IEH procedure to correct gender assignments that differed between the tagging and recovery samples.

All models selected included stratification by gender and most included temporal and spatial strata as well.

Bad weather, high water conditions and even contract issues influenced the temporal strata in the tagging and dead pitch events. An exception to the duration of the dead pitch occurred in 2001 when the contractor reached the amount of fish identified in the contract to be dead pitched and ended operations after only 8 days on this part of the program. In 2013 the dead pitch operated to October 16th but only one fish was encountered after October 4th. In 2017 the tagging event started August 15th but only one fish was caught and tagged before August 20th due to high water. An extreme weather event in September 2011 resulted in some of the highest water levels experienced on the Kitsumkalum River, even exceeding freshet conditions.

Egg retention

There was no evidence that the marking treatment caused harm significant enough to influence egg retention in female Chinook salmon. Tangle netting is not benign so the marking procedure included a check for vitality such that fish not expected to survive were not tagged. Such incidences were rare and were documented as losses on capture. The fish were robust to the process of capture, handling, tag application and punching opercula even after some fish were captured multiple times.

Egg retention in carcass recoveries provided sure evidence of pre-spawn mortality. Egg retention was generally low in females regardless of mark status. While egg retention may not have served as a sensitive measure of stress to fish from marking these data do provide a baseline in case water temperatures rise in the Kitsumkalum River making the fish more sensitive to handling.

Availability of fish to the Mark-recapture

The average start date for the first marking event of the mark-recapture study was 18 August but ranged from 10 to 23 August. Recent contracts have been written with 17 August as the start date for the tagging program, water conditions permitting. The 2011 mark-recapture project was initiated 10 August and completed 17 October in an attempt to improve the precision of the escapement estimate and increase CWT recoveries. These objectives were in response to the PSC's CWT improvement initiative (CWT Workgroup, 2008). It was anticipated that more fish could be encountered by extending the program thereby improving the mark-recapture estimate and increasing the access to CWT'd Chinook salmon in the escapement.

Starting the program earlier was not successful as few of the fish were available to the tangle netting procedure in the period between 10 and 17 August. Fish were either holding in deep water areas not accessible to the capture method or they hadn't moved into the Kitsumkalum River from the Skeena River. Based on these data, Kitsumkalum Chinook salmon hold in the Skeena River between Tyee and Terrace for over a month. Extending the program later resulted in few additional carcass recoveries. These results are supported by the timing curves for the tagging and dead pitch events (Figure 12 and Figure 14). The end result was that extending the tagging and dead pitch components temporally did not result in significantly more fish encounters or CWT recoveries. However, CWT recoveries were increased significantly by sacrificing all adipose fin clipped Chinook salmon encountered in the tag application process.

Life history

Kitsumkalum Chinook salmon are unique in their age structure. Their life histories are consistent with those observed in most northern Chinook salmon populations except that the Kitsumkalum River returns tended to be a year older. Fish returning 7 years from brood are more common in the Kitsumkalum River than in other stocks. Other stream type stocks have life histories composed of predominantly age 4_2 and 5_2 males and age 5_2 females.

McNicol (1999) reported mean ages of 5.5 years for males and 5.7 years for females for fish returning from 1984 to 1998 which match the results presented here. We used 1984 to 1995 age data from McNicol (1999). Ocean type and stream type Chinook salmon age data were combined for 1991 to 1995 (McNicol, 1999). The ageing results could not be linked back to the fish sampled so the ocean and stream types could not be separated, additionally variances could not be calculated. Ageing data collected after 1995 was linked to specific fish samples.

The results were confounded by changes in scale sampling objectives over time. The analyses suffer from very low sample sizes for males in 1995 to 1997 with age results for 15, 4 and 7 fish respectively. In 1996 only 4 scale samples were collected from males with two age 5_2 and two age 7_2 fish (Table 10). The 1996 male length frequency data (Figure 7) shows a peak at th e 850 to 900 mm bin. Age 6_2 males average 883 mm POH which confirm the ages from the low sample size didn't represent the population. We used the age 5 to 6 ratio in females was used to predict the proportion of age 6 males in 1996.

The reasons for the sampling changes observed from 1994 to 1997 are not clear but this coincides with a number of changes within DFO and the TSES. DFO reorganized in 1994 and the Salmonid Enhancement Program (SEP) discontinued funding of Community Economic Development Program projects, including the Kitsumkalum program. The new Stock Assessment Division within DFO Science took over funding of the project such that the indicator stock could be maintained. The TSES hired a new hatchery manager in 1994.

The size and gender data for 1994 show a significant portion of the fish identified as female in the 500 to 700 mm POH size (Figure 7). Additionally the SE about the mean size of females in 1994 was a notable outlier. The average size of 1994 males and females was almost equal at 842 mm and 840 mm POH respectively but the SE for females was 107 mm while the SE for males was 72 mm. The large SE in 1994 female size was attributed to the large component of female fish from 500 to 700 mm POH (Figure 7 and Table 12). This size range was associated with age 4_2 fish, a component not observed in any abundance for females sampled in other years. Age 4_2 females were rare across all years sampled (Table 9). Too few lengths were recorded in the 1984 tagged recoveries to provide evidence of significant gender assignment errors for the 500 to 700 mm POH size class of fish. However the data suggest that smaller males were incorrectly identified as female.

Size at age

Age at maturity and size at age are attributes that make Kitsumkalum Chinook salmon unique. Further, the age composition drives the size distribution. Loss of the oldest components represent significant loss of the production potential of the population due to lower fecundity and possibly lower fitness of the progeny due to smaller egg sizes.

Reductions in size at age and in age at maturity could be influenced by sampling protocols. While there could be procedural differences in sampling for some of the early data the collections since 1996 followed known protocols. The largest changes in size at age and age at maturity were observed in the time series between 1996 and 2020.

Data gaps

Summer run Kitsumkalum Chinook salmon from the 1982 brood year were not marked with CWT's and released. The Chinook salmon from the 1982 brood came from the Cedar River which is part of the early timed CU. Unfortunately this represented a break in the time series for CWT releases of the summer run CU during the initial base period (1979-1982) described for the PSC Chinook salmon model.

Tag numbers were not retained for the tags applied to Chinook salmon in the 1988 mark-recapture experiment or to fish recaptured in the tagging event. As a consequence complete IEH's could not be developed for this escapement year. The 1988 open model results were filled from a regression of open versus closed model estimates (Appendix 5).

Yearling releases from the 2005 brood failed as a result of predation by otters in November 2006. Only 247 yearlings survived to be released in 2007 out of approximately 30,000 CWT'd fish. This event revealed the risk in holding fish to the yearling stage and highlighted the need to protect the ponds from predators. The loss of this release influenced the CWT data available for yearling returns in 2009 to 2011.

All fry from the 2019 brood were released unmarked in 2020. The risks to human health associated with the work of tagging the fry during the COVID-19 pandemic were too uncertain to ensure safety of the staff. Loss of the data from the 2019 brood will influence fry and yearling production estimates in 2023 to 2025.

Hatchery Influence

The Kitsumkalum Chinook salmon program was designed as an assessment project and hatchery production was a tool to generate fry for marking with fin clips and CWTs. Care was taken to minimize the hatchery influence by not using clipped fish as part of the brood stock, clipping almost all of the releases, and more recently, removing adipose clipped fish encountered in the first event of the mark-recapture to assess the returning stock. The project attempts to make the best use of the hatchery production by marking as many of the progeny as possible with CWT's and adipose fin clips. Unmarked fish were typically fish that were too small to CWT or that had physical mutations.

Care was also taken to emulate wild Chinook salmon with the hatchery releases. Fry were marked and released at 3 grams and yearlings were held to 15 grams before release. However higher proportions of ocean type fish in the hatchery returns (22%) than wild returns (2.6%) suggest hatchery fish may reach a size threshold that allows them to enter the marine environment early. The hatchery uses ground water and the advantage may have resulted from the additional thermal units available to the rearing hatchery fry. These results also identify plasticity in the life history that appears to be driven by the environment experienced early in life in fresh water.

Timing of migration, spawning and death

Most fisheries for Chinook salmon intercept mature fish migrating to their natal rivers to spawn as opposed to catching immature fish rearing in the fishing area. In the absence of rearing fish, run timing defines when and where particular stocks are available for harvest. The time and speed with which they transit fishing areas influences their vulnerability.

Timing curves representing death, spawning, live capture in the Kitsumkalum River, capture in the Skeena River test fishery at Tyee and capture in the sport fishery at Langara Island (Area 1) were compared. As the Chinook salmon runs were reconstructed from the river through ever distant marine fisheries we expected the migration pattern to be earlier and more dispersed. This pattern was supported by the GSI data at Tyee and Langara. We used GSI samples from the NBC AABM Sport fishery at Langara Island to represent marine fisheries as the fishery was sampled continuously through the fishing season from mid-May to mid-September for over a decade. Langara Island roughly represents the geographical center of the NBC AABM Sport and Troll fisheries and is only 27 nautical miles from Cape Muzon on the border between BC and Alaska.

Brood stock collections underestimated the full duration of spawning. Crews looked for evidence of ripe females before bringing out the equipment necessary to collect gametes. Once started the egg collection objective was filled as quickly as possible so brood stock samples were biased toward the beginning of spawning. The average brood stock collection sample was the narrowest of the timing curves.

Radio tagging data show that Chinook salmon move much more quickly than 2 km/d based on the timing between samples collected at Tyee and in the Kitsumkalum River. Chinook salmon migration through the lower Skeena River occurs quickly with estimates of 20 to 30 km/d. These movements were followed by long periods when the fish would hold in the pools in the Skeena and Kitsumkalum Rivers before moving on to spawning areas (Gottesfeld, 2011).

Comparison to Petersen Estimates

Historically the Petersen method has been applied to generate escapement estimates for Kitsumkalum Chinook salmon using the approach established by Andrew and Webb (1988) and refined by McNicol (1999). Estimates were reported in the annual CTC Catch and Escapement reports (CTC, 2020). The Petersen estimates were larger in most cases than the estimates produced by the open-population models especially in years of greater abundance (Figure 22 and Appendix 5). Petersen estimates were 27% larger than the POPAN estimates on average across the time series and the range of difference was from -7% to 113%. The greatest difference was in 2002 when the Petersen estimate of 23,849 was 113% larger than the POPAN estimate of 11,220. In 2020 the POPAN estimate of 4,777 was 7% larger than the Petersen estimate of 4,433. Estimates for 2018 were almost equal at 9,537 for the Petersen estimate and 9,550 for the POPAN estimate.

The Petersen methods of generating estimates for the Kitsumkalum Chinook salmon stock rely on the assumption of closure. The Close Test analyses identified additions to the populations in every year studied, supporting the use of open-population models.

Stock Recruit Relationship

We selected the simple version of the Ricker model as the preferred model to represent the stock and recruit data as supported by the AIC and biological interpretation of the parameters. However there were attributes of the model with time varying productivity that deserved consideration. Investigation of the residual patterns of the time varying productivity model show non-trending residuals with greater symmetry and lower range than the simple Ricker model. Empirical knowledge of productivity influences was lacking, especially for the marine environment. The observed declines in age at maturity and size at age represent reduced production potential due to the lower fecundity of smaller fish. Even though the freshwater environment has changed due to the loss of glaciers in the watershed and flood events, it would be difficult to relate those changes to productivity over the short time span of 37 years with data. In addition, most of the major logging events happened long before 1984 and forests have regrown in many areas so the watershed is relatively stable in that respect. However, in this analysis the freshwater and marine components of productivity are combined and the marine environment has probably been less stable due to climate change. Results of the Ricker model with time varying productivity are presented in Appendix 7.

Implications of the results

The purpose of this study was to revise the time series of data for the Kitsumkalum Chinook salmon indicator stock and bring the analyses to contemporary norms. We found most escapement estimates measured with open models to be significantly lower than previous Petersen estimates (Appendix 5). These differences were more extreme when abundances were large. The revised estimates have improved precision and have significant influence on the estimates of population metrics. Lower escapements mean that exploitation rate estimates increase but so does production per spawner. The development of the population metrics of S_{MSY}, U_{MSY}, Capacity, S_{GEN} and their variants provides managers with reference points and allows for the development of benchmarks for this CU. Further, these estimates will have significant influence on the estimation of population metrics for other Skeena River CU’s.

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The volunteers, contractors and staff involved in the Kitsumkalum Chinook salmon program over the past four decades number in the hundreds. We thank you for your assistance and apologize for any errors or omissions in this brief acknowledgement.

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REFERENCES

ADFG DFO. 2018. Impacts to Southeast Alaska, Transboundary Rivers and Northern British Columbia Origin Chinook salmon Stocks in Fisheries of Southeast Alaska and Northern British Columbia. ADFG DFO Technical Staff Work Assignment presented to the Pacific Salmon Commission 13 February 2018. 68 p. Contributors: E.J. Jones, I. Winther, J.H. Clarke, S. Gotch, W. Templin, R. Peterson, J. Carlisle.

Andrew, J.H. and T.M. Webb. 1988. Abundance, age, sex, and coded wire tag recoveries for Chinook salmon escapements of Kitsumkalum River, 1984-1986. Can. MS rep. Fish. Aquat. Sci. 2044:62p.

Anon. 1984. The Kitsumkalum River Project 1984 Report. [Unpublished manuscript]. Terrace Salmonid Enhancement Society.

Anon. 1985. The Kitsumkalum River Project 1985 Report. [Unpublished manuscript]. Terrace Salmonid Enhancement Society.

Anon. 1986. The Kitsumkalum River Project 1986 Report. [Unpublished manuscript]. Terrace Salmonid Enhancement Society.

Anon. 1987. The Kitsumkalum River Project 1987 Report. [Unpublished manuscript]. Terrace Salmonid Enhancement Society.

Anon. 1990. Kitsumkalum Chinook salmon 1990. [Unpublished manuscript]. Terrace Salmonid Enhancement Society.

Anon. 1991. Kitsumkalum Chinook salmon 1991. [Unpublished manuscript]. Terrace Salmonid Enhancement Society.

Anon. 1992. Kitsumkalum Chinook salmon Mark-Recapture 1992. [Unpublished manuscript]. Terrace Salmonid Enhancement Society.

Anon. 1993. Kitsumkalum Chinook salmon Mark-Recapture 1993. [Unpublished manuscript]. Terrace Salmonid Enhancement Society.

Blakley, A.C. and Nelson, T.C. 1998. Abundance, age, size, sex and coded wire tag recoveries for Chinook salmon escapement of Kitsumkalum River, 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2446: viii + 54p.

Carolsfeld J., K.K. English, P. Frank and T.M. Webb. 1990. Abundance, age, size, sex and coded wire tag recoveries for Chinook salmon escapements of Kitsumkalum River, 1987-1988. Can. MS Rep. Fish. Aquat. Sci. 2074: viii + 54p.

CTC (Chinook salmon Technical Committee). 1988. Exploitation rate analysis. A report of the Analytical Work Group of the Chinook salmon Technical Committee. Report TCCHINOOK SALMON-88-2-Appendix-II. Pacific Salmon Commission, Vancouver, BC, Canada. 117 p.

CTC (Chinook salmon Technical Committee). 1993. Pacific Salmon Commission Joint Chinook salmon Technical Committee 1992 Annual Report. Report TCCHINOOK SALMON (93)-2. Pacific Salmon Commission, Vancouver, BC, Canada. 297 p.

CTC (Chinook salmon Technical Committee). 1994. Pacific Salmon Commission Joint Chinook salmon Technical Committee 1993 Annual Report. Report TCCHINOOK SALMON (94)-1. Pacific Salmon Commission, Vancouver, BC, Canada. 315 p.

CTC (Chinook salmon Technical Committee). 1999. Pacific Salmon Commission Joint Chinook salmon Technical Committee Report TCCHINOOK SALMON (99)-3. Maximum sustained yield of biologically based escapement goals for selected Chinook salmon stocks used by the Pacific Salmon Commission's Chinook salmon Technical Committee for Escapement Assessment. Pacific Salmon Commission, Vancouver, BC, Canada. 108 p.

CTC (Chinook salmon Technical Committee). 2001. Pacific Salmon Commission Joint Chinook salmon Technical Committee Report. Annual exploitation rate analysis and model calibration. Report TCCHINOOK SALMON (01)-2. Pacific Salmon Commission, Vancouver, BC, Canada. 177 p.

CTC (Chinook salmon Technical Committee). 2020. Pacific Salmon Commission Joint Chinook salmon Technical Committee Report. Annual report of catch and escapement for 2019. Report TCCHINOOK SALMON (20)-01. Pacific Salmon Commission, Vancouver, BC, Canada. 205 p.

CTC (Chinook salmon Technical Committee). 2021. Pacific Salmon Commission Joint Chinook salmon Technical Committee Report. 2019 Exploitation rate analysis and model calibration volume one. Report TCCHINOOK SALMON (2021)-01. Pacific Salmon Commission, Vancouver, BC, Canada. 155 p.

CTC (Chinook salmon Technical Committee). 2021. Pacific Salmon Commission Joint Chinook salmon Technical Committee Report. 2019 Exploitation rate analysis and model calibration volume two: Appendix supplement. Report TCCHINOOK SALMON (2021)-01 V2. Pacific Salmon Commission, Vancouver, BC, Canada. 154 p.

CWT Workgroup (Pacific Salmon Commission Coded Wire Tag Workgroup). 2008. An action plan in response to Coded Wire Tag (CWT) Expert Panel Recommendations. Pacific Salmon Comm. Tech. Rep. No. 25: 170 p.

Gottesfeld, A.S. 2011. [Personal communication] Head Scientist, Skeena Fisheries Commission. Kispiox, British Columbia.

Hazelwood, G. and Whelpley, M. 1989. Kitsumkalum River Project 1989 Report. [Unpublished manuscript]. Terrace Salmonid Enhancement Society.

Hazelwood, G. 1988. Kitsumkalum River Project 1988 Report. [Unpublished manuscript]. Terrace Salmonid Enhancement Society.

Holt, C. A., A. Cass, B. Holtby, and B. Riddell. 2009. Indicators of Status and Benchmarks for Conservation Units in Canada's Wild Salmon Policy. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/058. viii + 74 p.

Holtby, B.L. and K.A.Ciruna. 2007. Conservation units for Pacific Salmon under the Wild Salmon Policy. Canadian Stock Assessment Secretariat Research Document 2007/070. 352 p.

Lebreton, J.D., K.P. Burnam, J. Clobert and D.R. Anderson. 1992. Modelling survival and testing biological hypotheses using marked animals: a unified approach with case studies. Ecological Monographs 62: 67-118.

MacLellan, S. E. 1999. Guide for sampling structures used in age determination of Pacific salmon. Fisheries & Oceans Canada, Stock Assessment Branch, Pacific Biological Station, Nanaimo, British Columbia.

McNicol, R.E. 1999. An assessment of Kitsumkalum River summer Chinook salmon, a North Coast indicator stock. Canadian Stock Assessment Secretariat Research Document 99/164. 49 p.

Nass, B.L. and R.C. Bocking. 1992. Abundance, age, size, sex and coded wire tag recoveries for Chinook salmon escapements of Kitsumkalum River, 1989-1990. Can. Manuscr. Rep. Fish. Aquat. Sci. 2147: ix + 62p.

Nelson, T.C. 1993a. Abundance, age, size, sex and coded wire tag recoveries for Chinook salmon escapement of Kitsumkalum River, 1991. Can. Manuscr. Rep. Fish. Aquat. Sci. 2182: viii + 43 p.

Nelson, T.C. 1993b. Abundance, age, size, sex and coded wire tag recoveries for Chinook salmon escapement of Kitsumkalum River, 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2201: viii + 44 p.

Nelson, T.C. 1994. Abundance, age, size, sex and coded wire tag recoveries for Chinook salmon escapement of Kitsumkalum River, 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2249: viii + 47 p.

Nelson, T.C. 1995a. Abundance, age, size, sex and coded wire tag recoveries for Chinook salmon escapement of Kitsumkalum River, 1994. Can. Manuscr. Rep. Fish. Aquat. Sci. 2332: viii + 48 p.

Nelson, T.C. 1995b. Abundance, age, size, sex and coded wire tag recoveries for Chinook salmon escapement of Kitsumkalum River, 1995. Can. Manuscr. Rep. Fish. Aquat. Sci. 2405: ix + 57 p.

PSC (Pacific Salmon Commission). 2004. Pacific Salmon Treaty. PSC, Vancouver, BC.

PSC (Pacific Salmon Commission). 2019. Treaty between the government of Canada and the Government of the United States of America concerning Pacific salmon. PSC, Vancouver, BC.

Parken, C.K., R.E. McNicol and J.R. Irvine. 2006. Habitat-based methods to estimate escapement goals for data limited Chinook salmon stocks in British Columbia, 2004. Canadian Stock Assessment Secretariat Research Document 2006/083. 74 p.

R Core Team. 2021. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ricker, W.E. 1975. Computations and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.

Vélez-Espino L.A., J.R. Irvine, I. Winther, R. Dunlop, G. Mullins, K, Singer and N. Trouton. 2016. Robust and defensible mark–recapture methodologies for salmonid escapement: Modernizing the use of data and resources. North American Journal of Fisheries Management, 36:1, 183-206, DOI: 10.1080/02755947.2015.1114540.

Withler, R.E., Bradford, M.J., Willis, D.M., and Holt, C. 2018. Genetically Based Targets for Enhanced Contributions to Canadian Pacific Chinook salmon Populations. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/019. xii + 88 p.

FIGURES

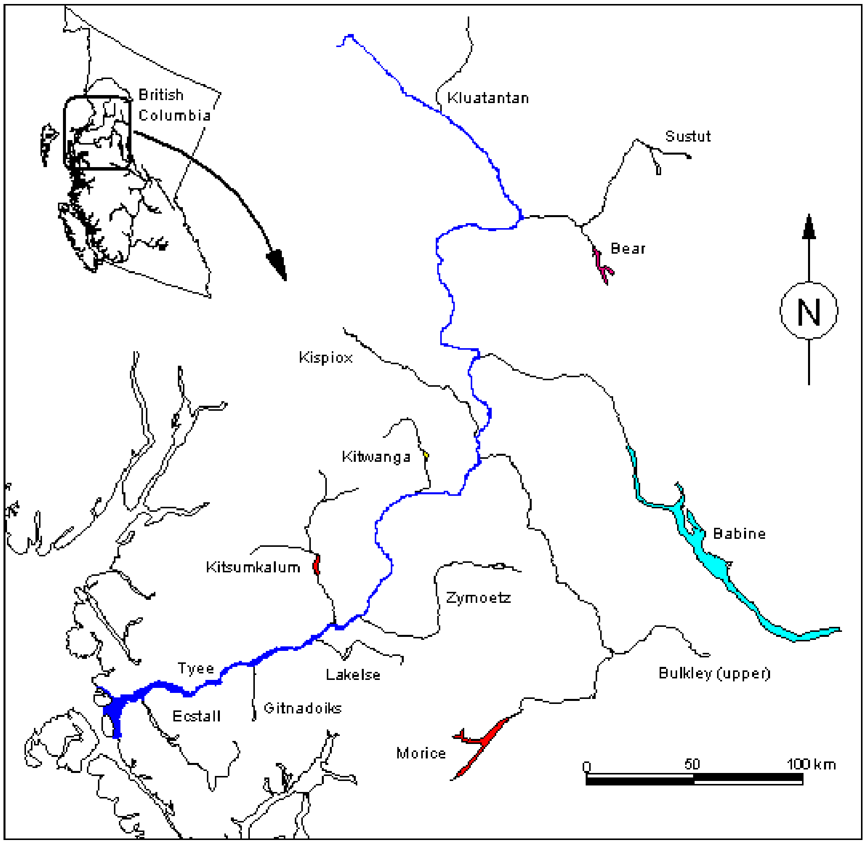

Figure 1. The Skeena River watershed in northern British Columbia showing the largest Skeena tributaries and the location of the Kitsumkalum River.

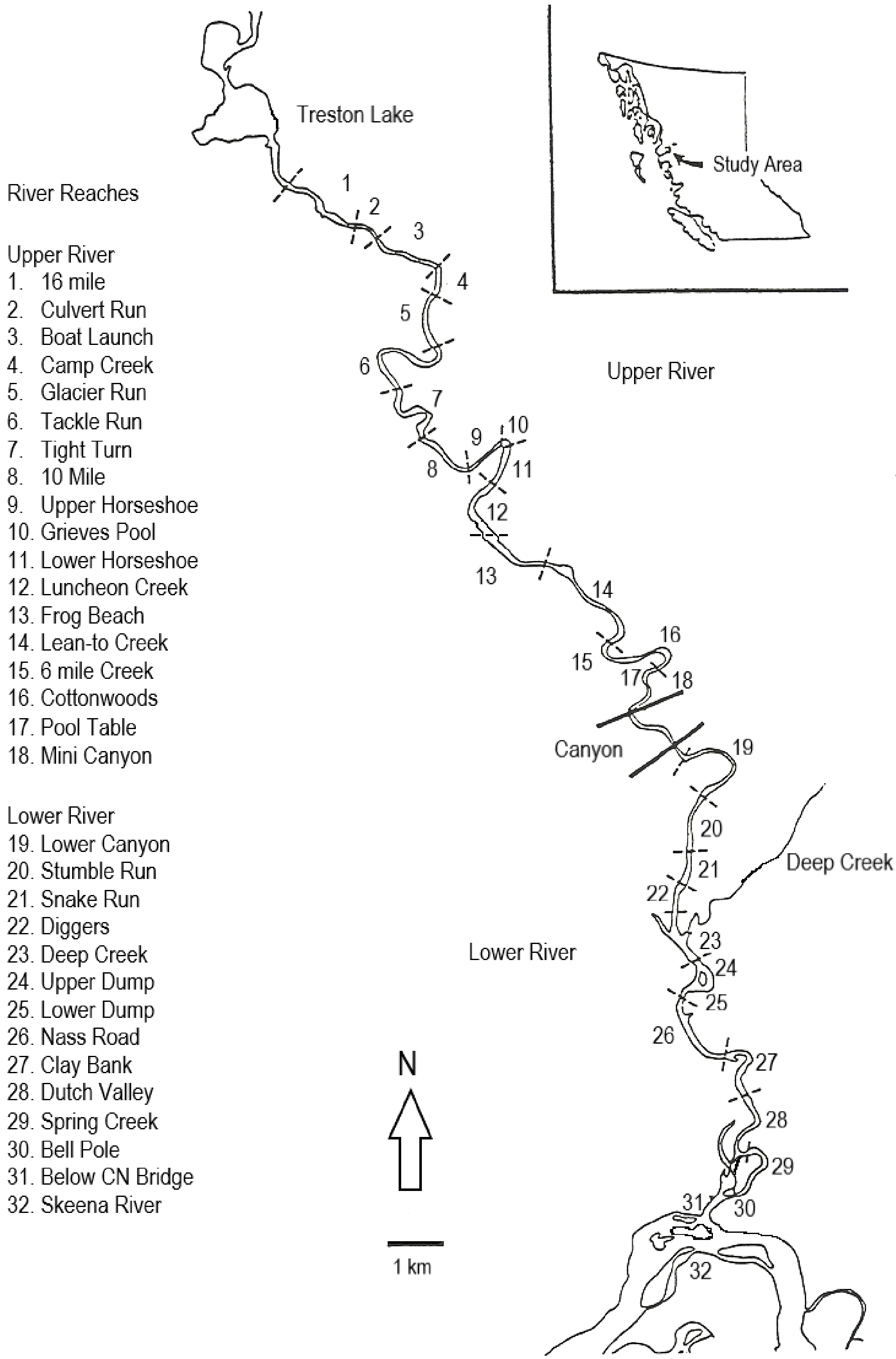

Figure 2. Kitsumkalum River study area with river reach breaks and local names of river sections (modified from Nelson, 1994).

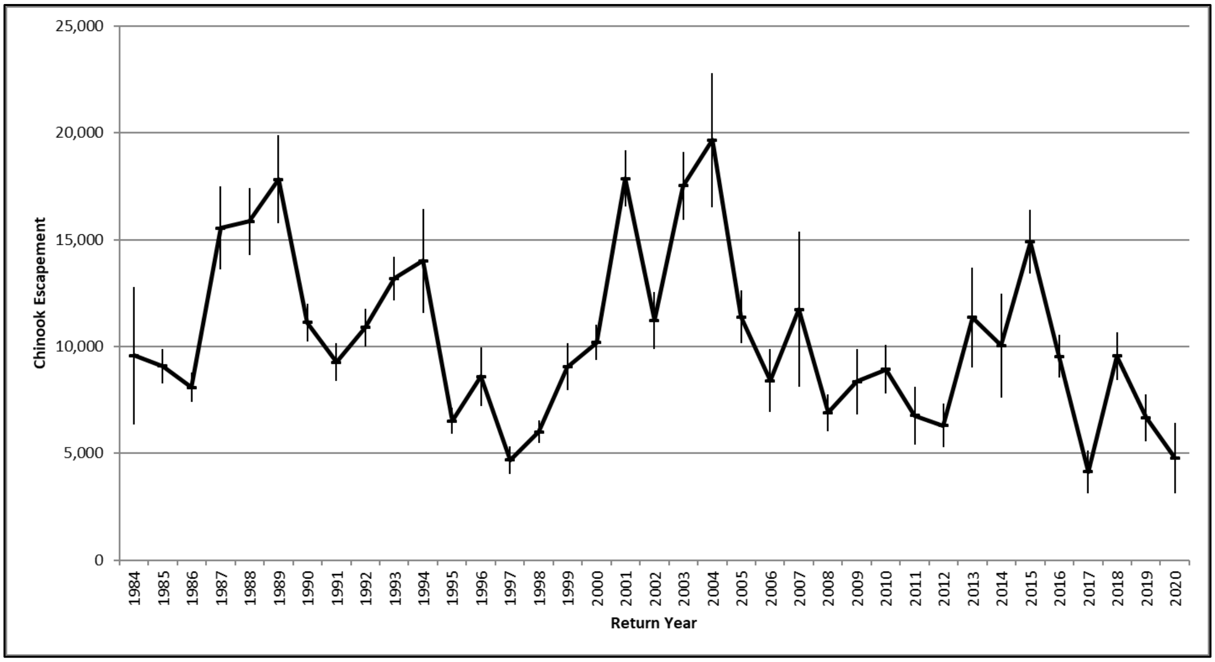

Figure 3. Escapement estimates of large Kitsumkalum Chinook salmon from open-population model (POPAN) analyses, 1984 to 2020.

Vertical lines represent +/- 1 standard error.

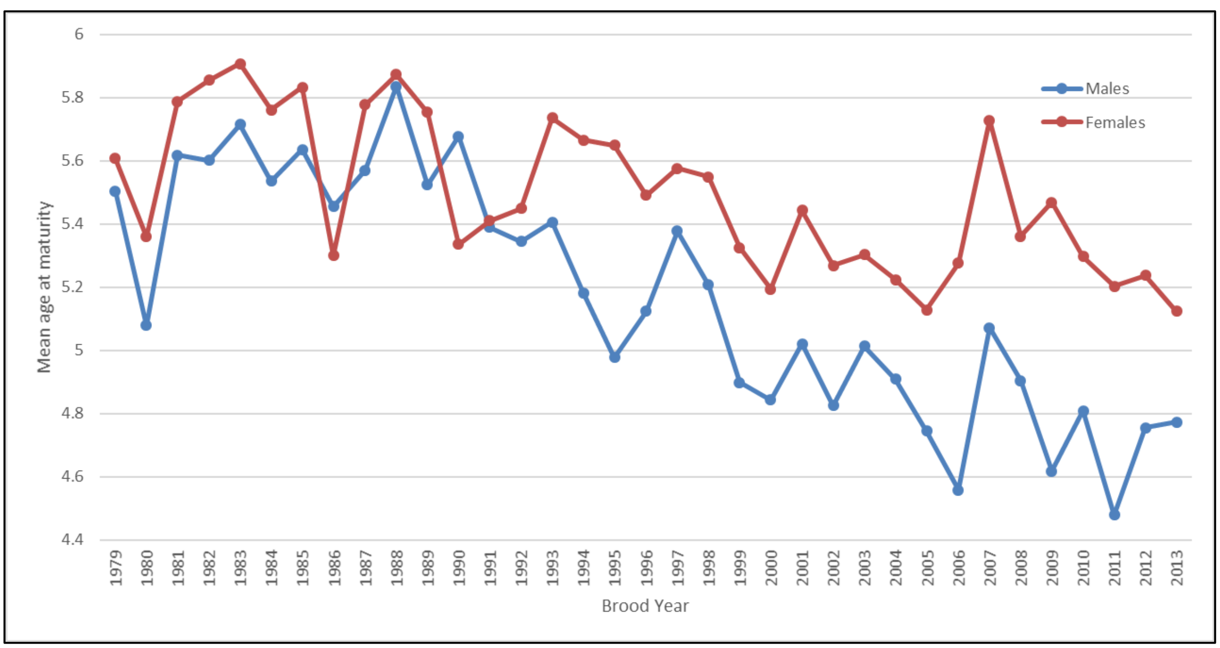

Figure 4. Mean age at maturity by brood year for male and female Kitsumkalum Chinook salmon, brood years 1979 to 2013.

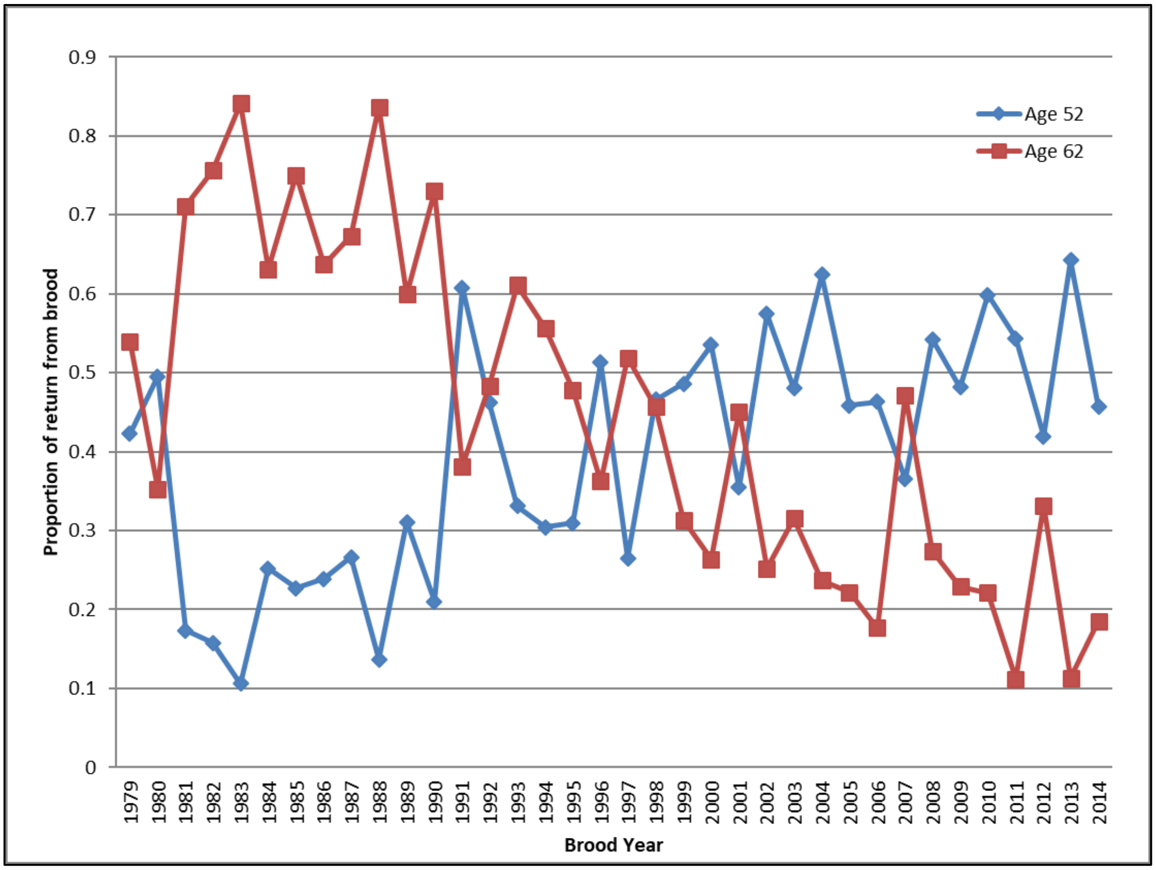

Figure 5. Proportions of age 5_2 and age 6_2 Chinook salmon by brood year in returns to the Kitsumkalum River.

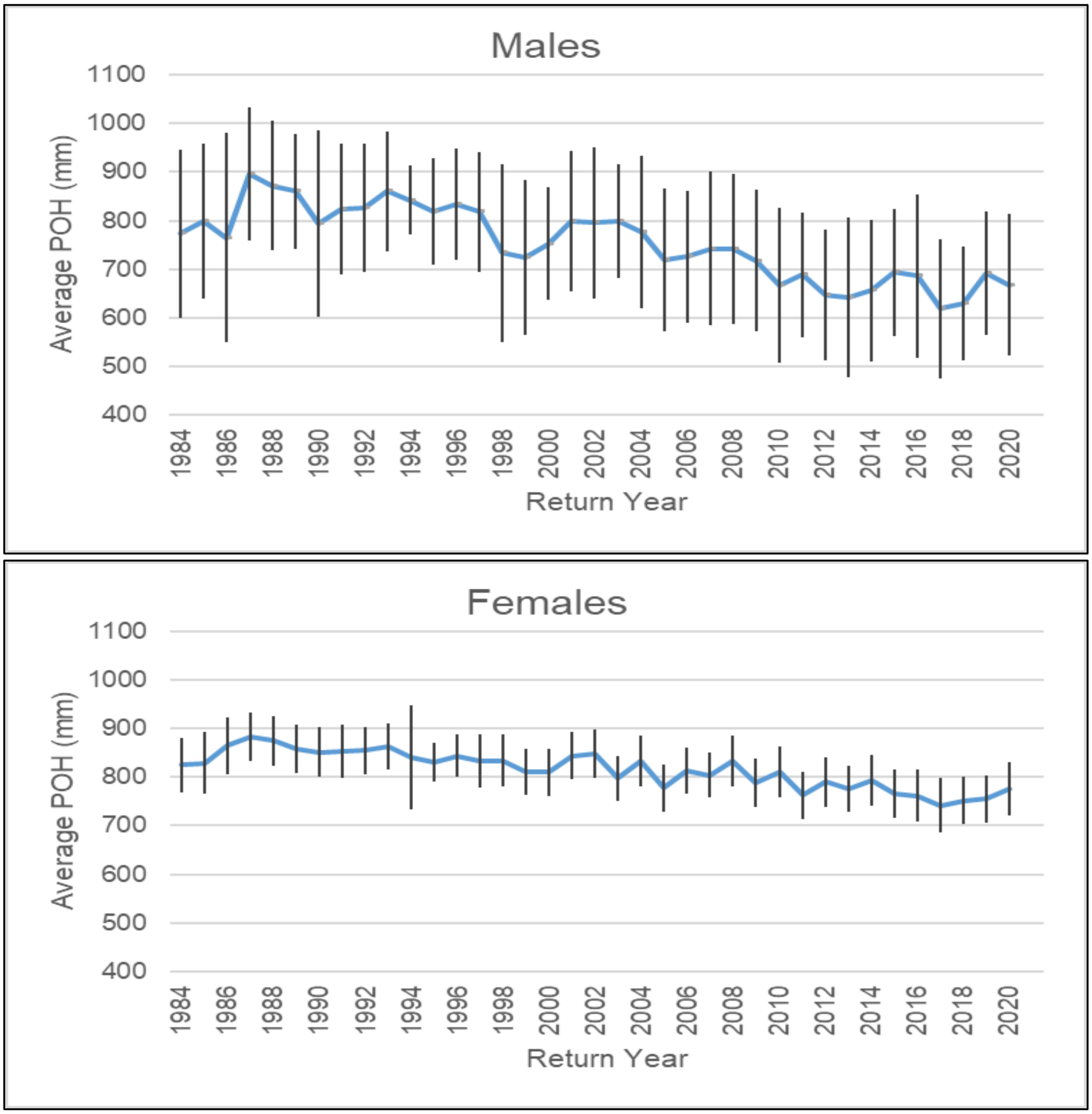

Figure 6. Mean size of male and female Kitsumkalum Chinook salmon 1984 to 2020. Vertical lines represent +/- 1 standard error.

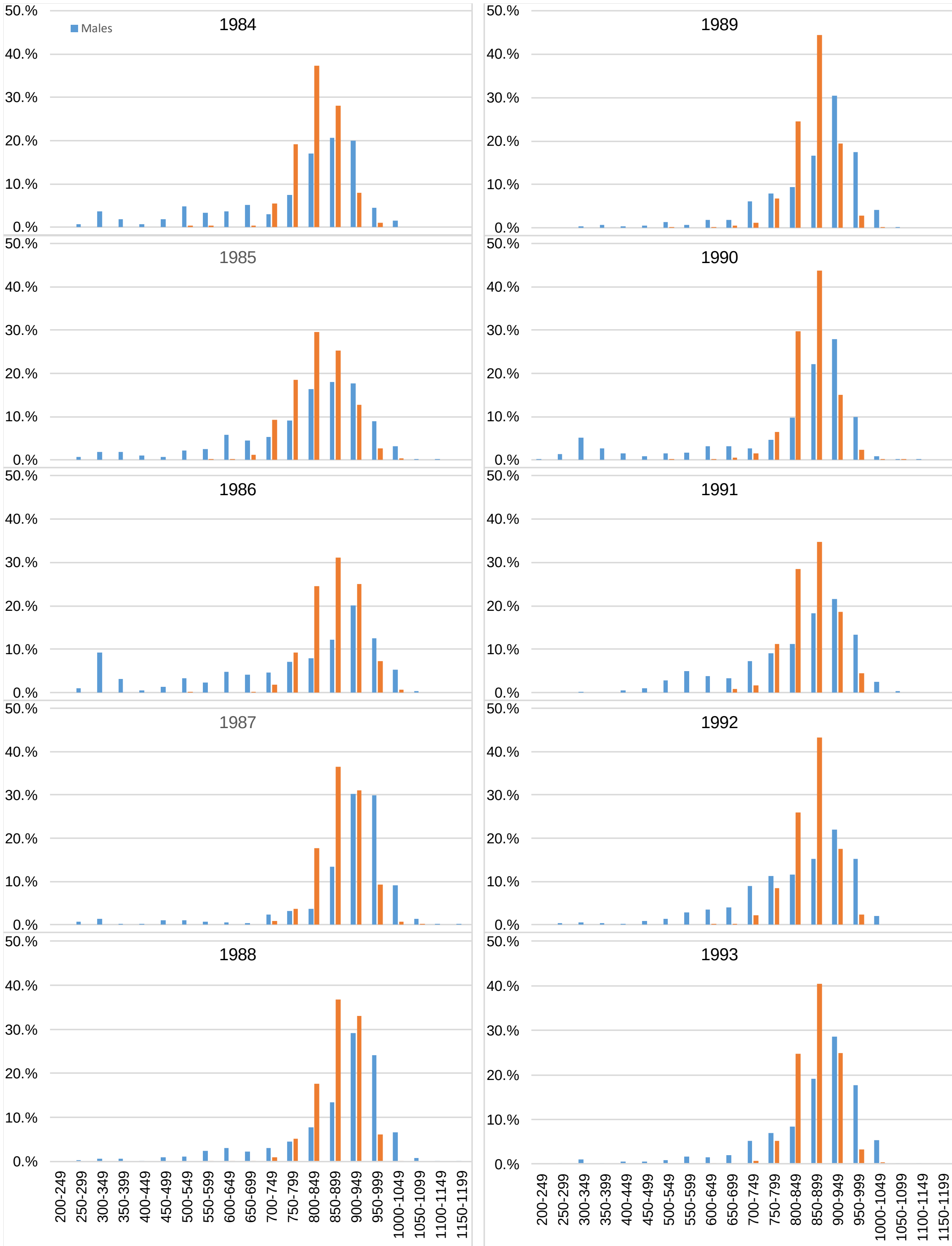

Figure 7. POH length frequency histograms of male and female Kitsumkalum Chinook salmon by year 1984 to 2020.
Blue columns are males and orange columns are females.

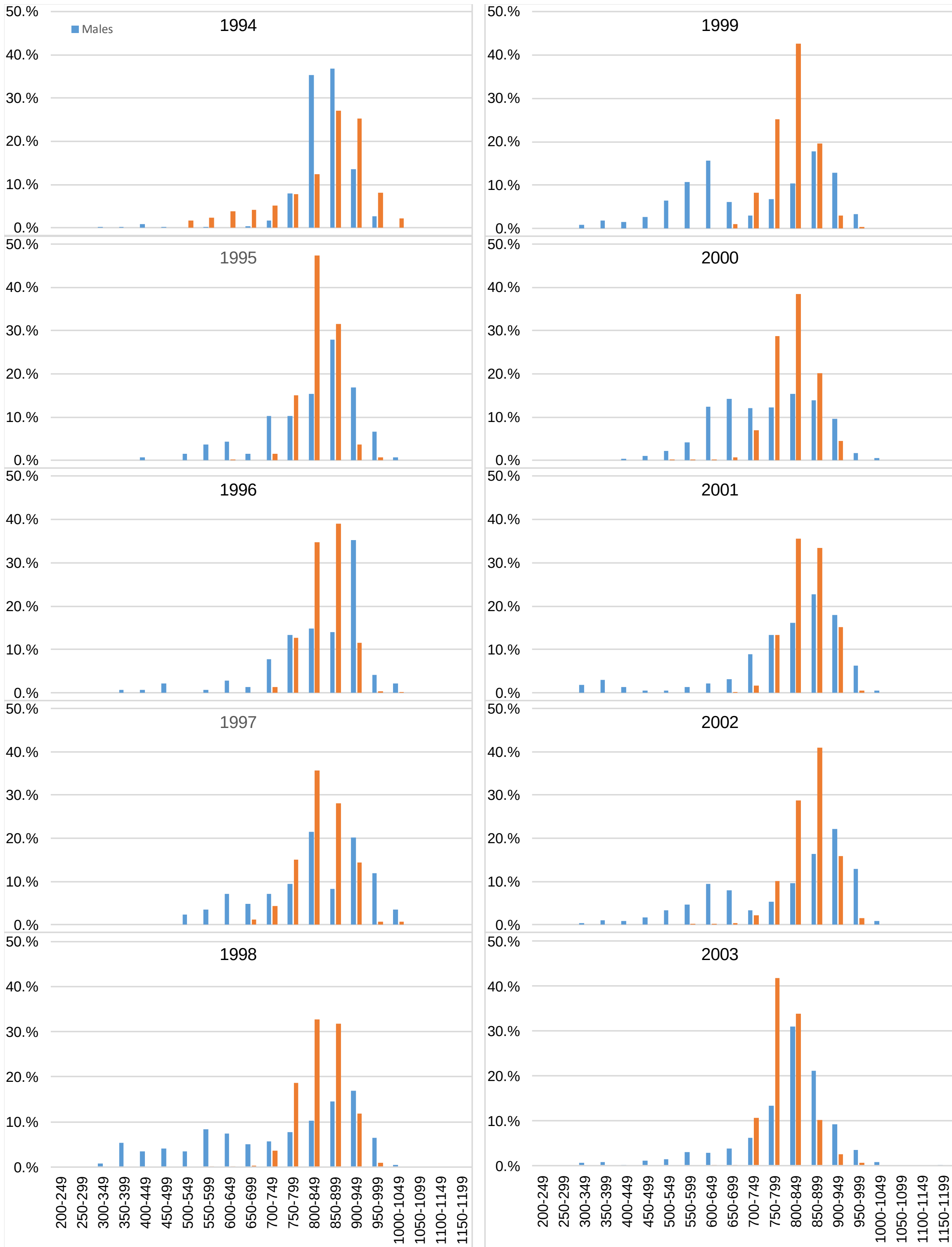

Figure 7 continued. POH length frequency histograms of male and female Kitsumkalum Chinook salmon by year 1984 to 2020. Blue columns are males and orange columns are females.

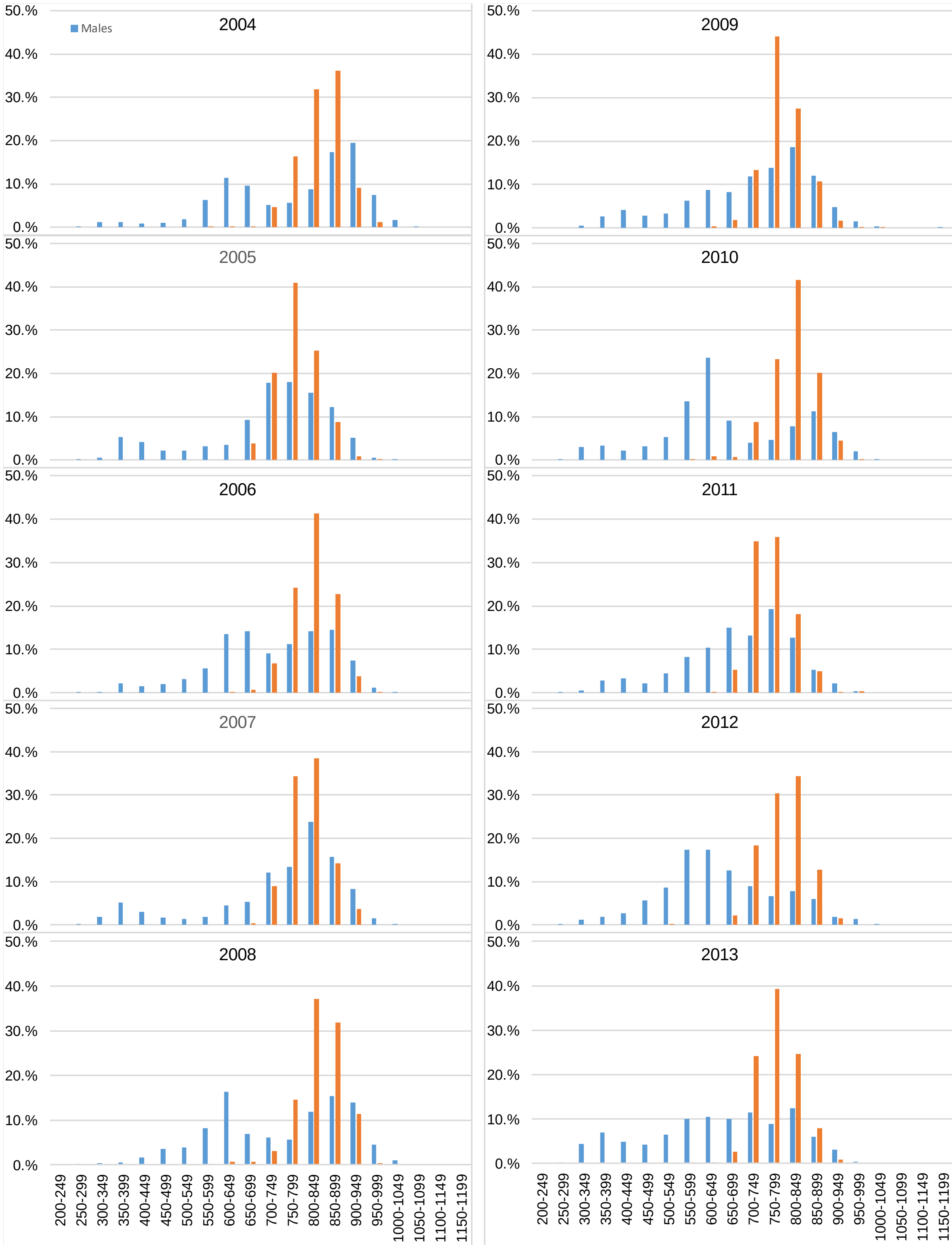

Figure 7 continued. POH length frequency histograms of male and female Kitsumkalum Chinook salmon by year 1984 to 2020. Blue columns are males and orange columns are females.

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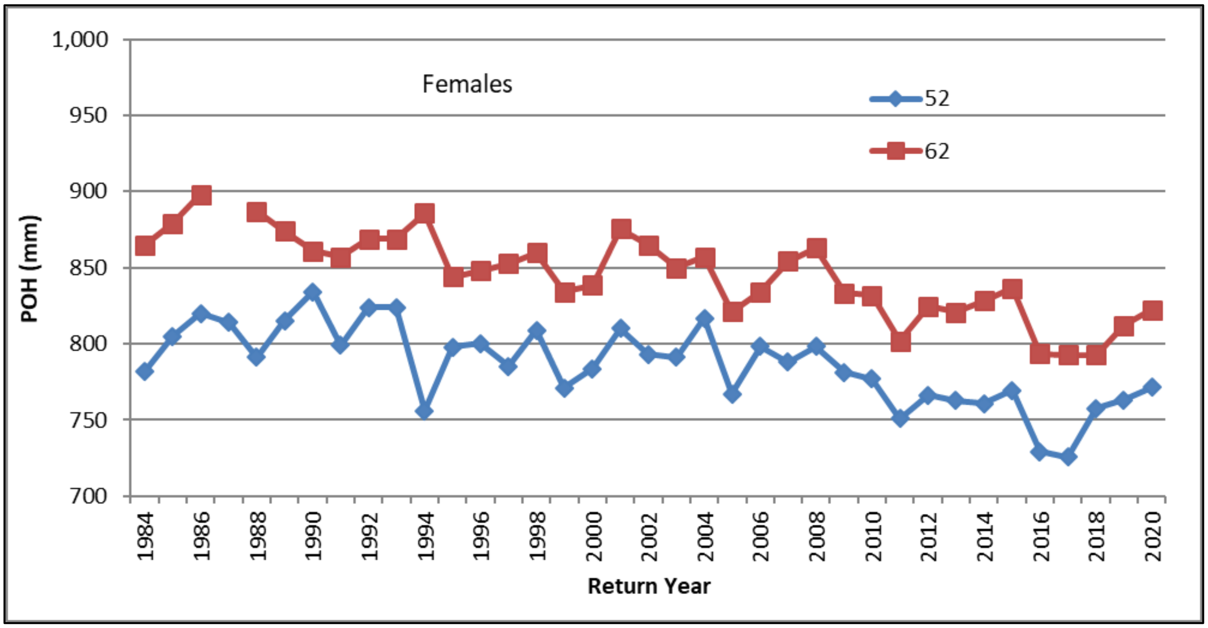

Figure 8. Mean size at age for female Kitsumkalum Chinook salmon by return year.

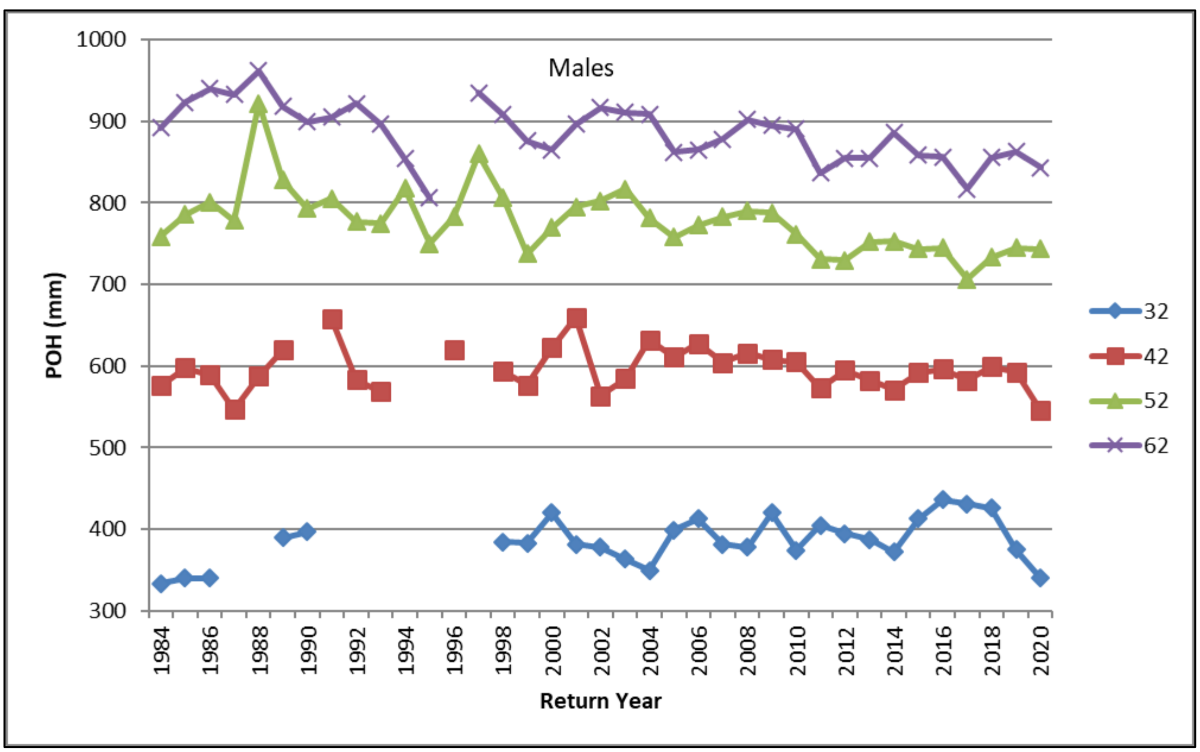

Figure 9. Mean size at age for male Kitsumkalum Chinook salmon by return year. See Table 12 for SE's of the annual mean size estimates at age.

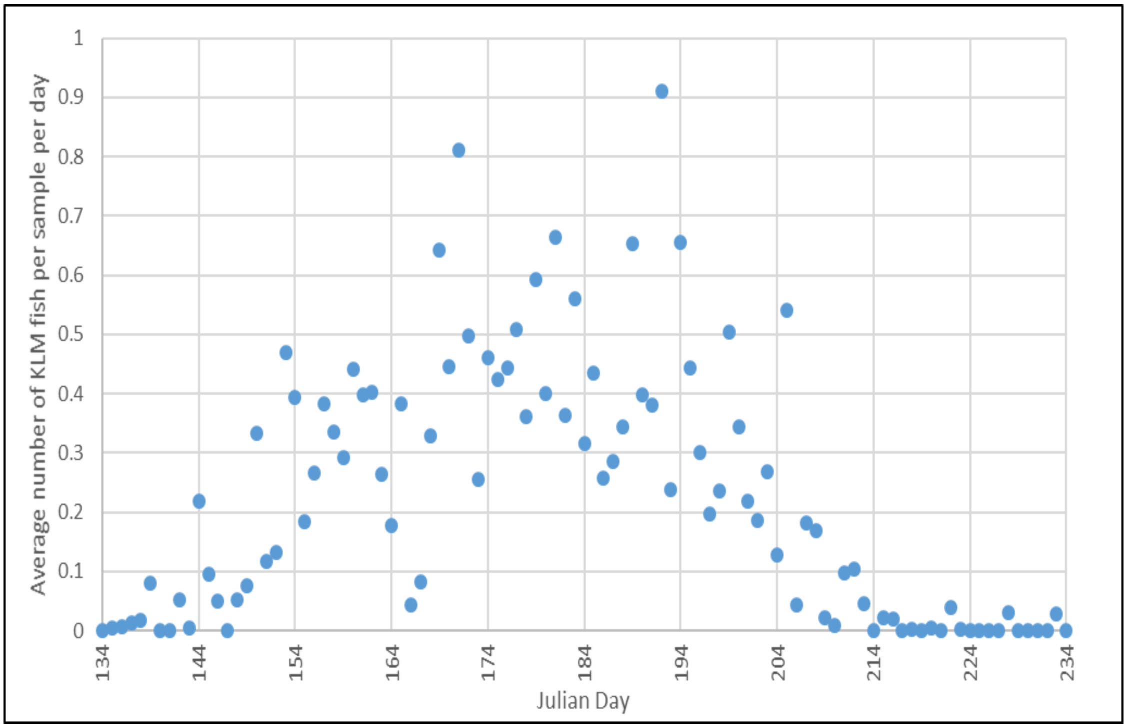

Figure 10. Timing of Kitsumkalum Chinook salmon caught in the sport fishery at Langara Island, Area 1, 2007 to 2016.

Mean = Jday 179 = 27 June, 10% = Jday 155 = 4 June, 90% = Jday 200 = 19 July

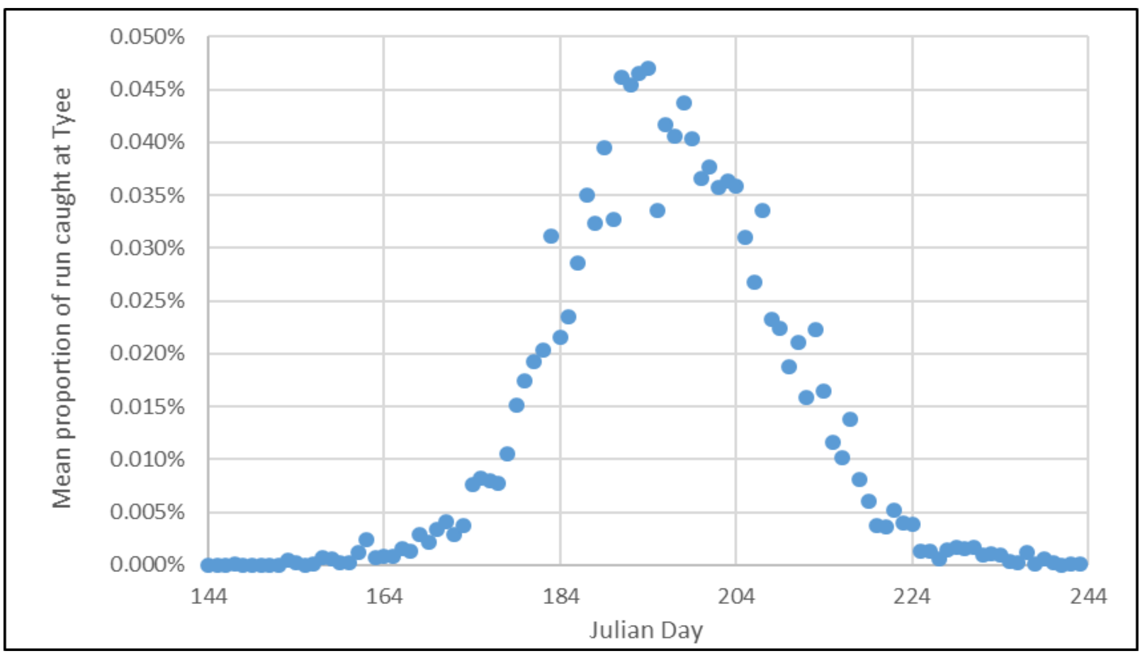

Figure 11. Average timing of Kitsumkalum Chinook salmon caught in the Skeena River Test fishery conducted at Tyee, 1984 to 2020.
Mean = Julian day 196 = 15 July, 10% = Jday 181 = 30 June, 90% = Jday 212 = 31 July

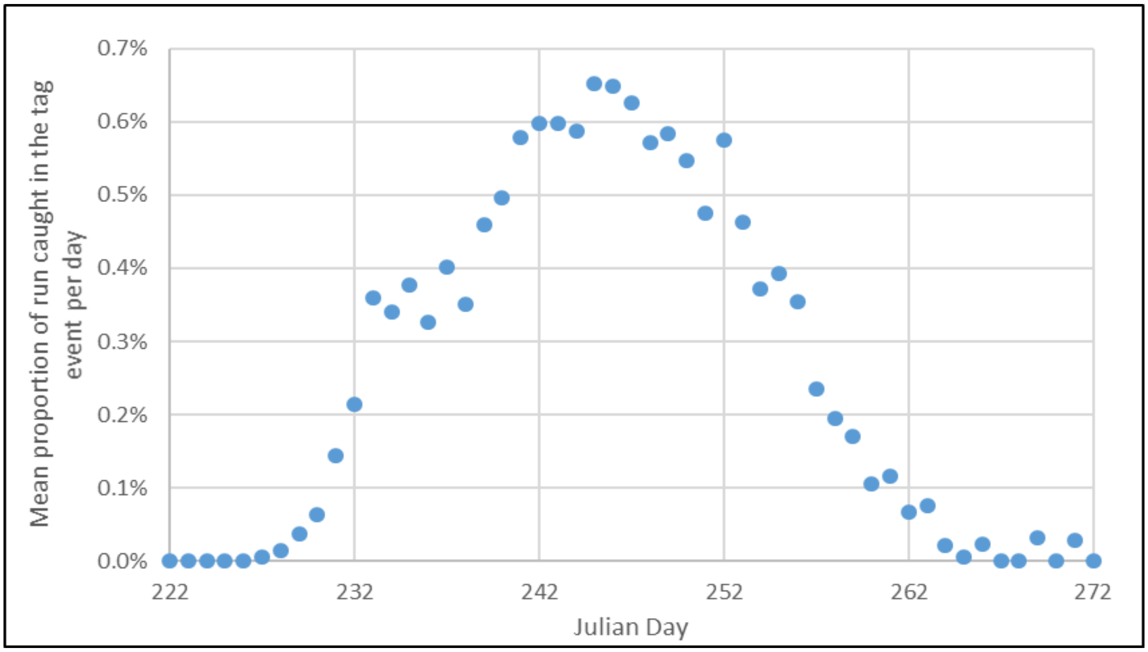

Figure 12. Average timing of Kitsumkalum Chinook salmon caught in the Kitsumkalum River during the tagging event of the mark-recapture study 1984 to 2020.
Mean = Jday 245 = 2 September, 10% = Jday 235 = 23 August, 90% = Jday 256 = 13 September

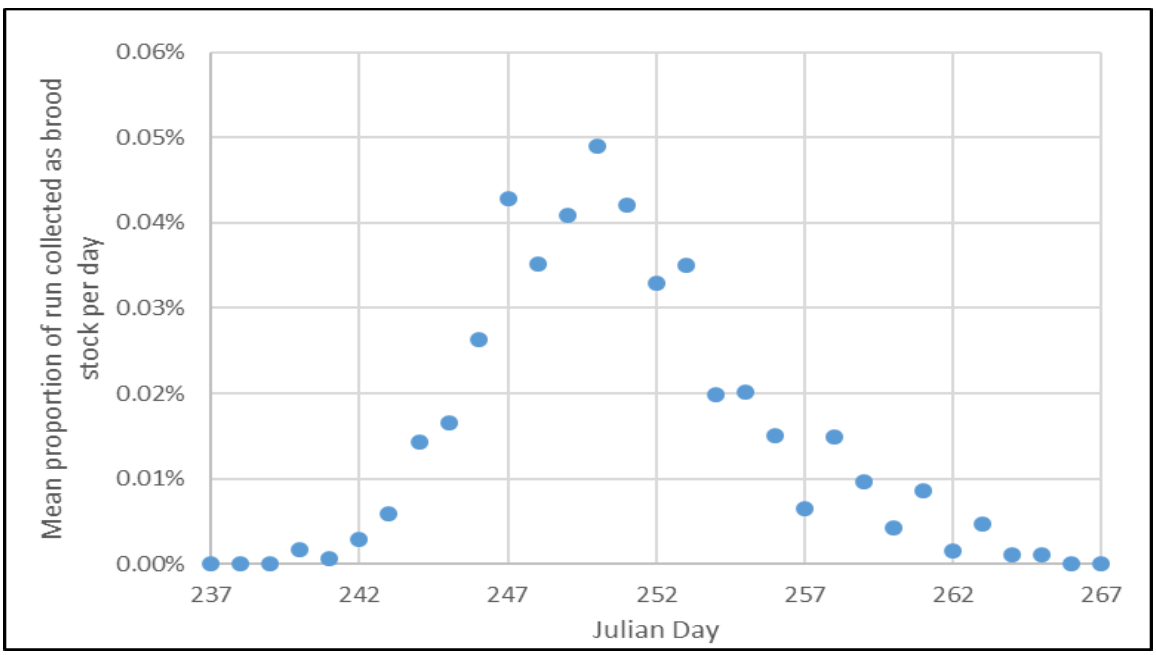

Figure 13. Average timing of Kitsumkalum Chinook salmon caught and retained for brood stock 1984 to 2020.
Mean = Jday 251 = 8 September, 10% = Jday 246 = 3 September, 90% = Jday 257 = 14 September.

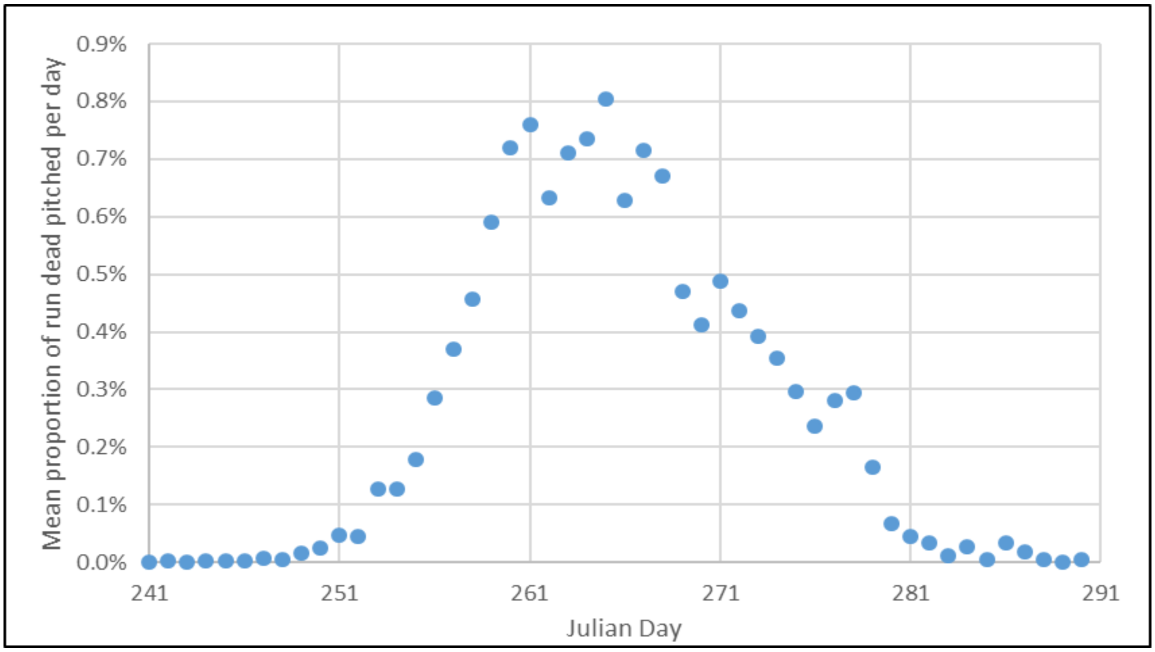

Figure 14. Average timing of Kitsumkalum Chinook salmon encountered in the dead pitch 1984 to 2020.
Mean = Jday 266 = 23 September, 10% = Jday 257 = 14 September, 90% = Jday 275 = 2 October.

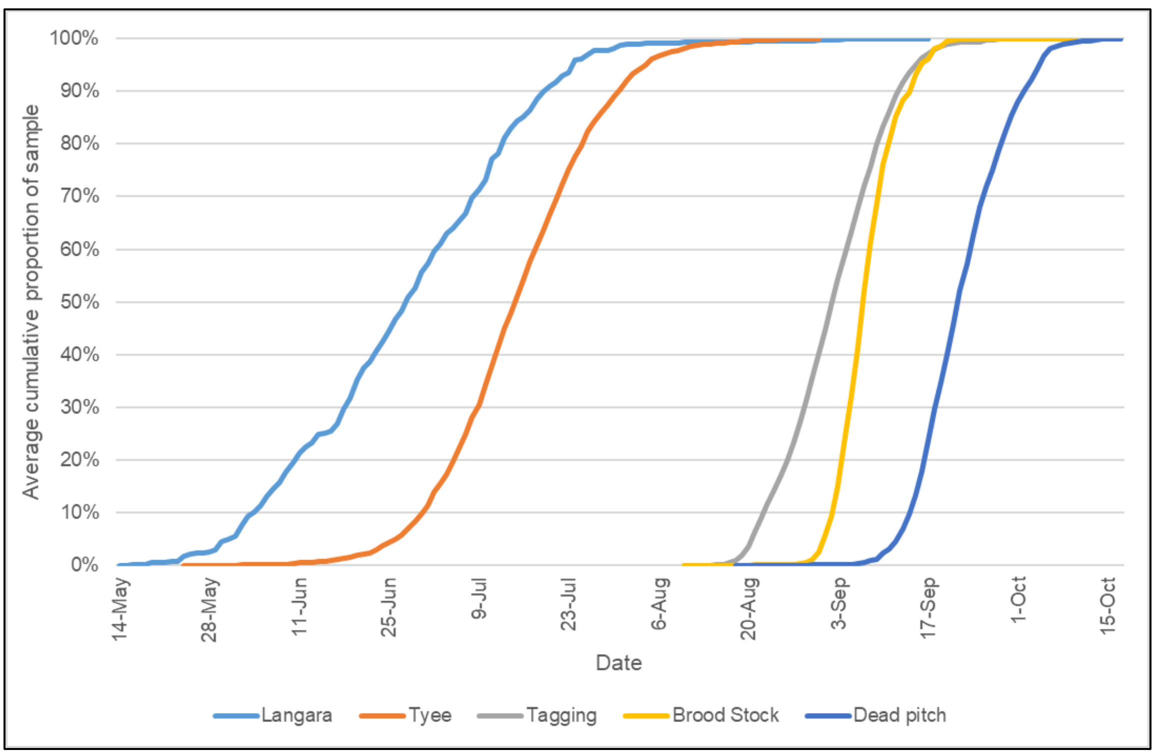

Figure 15. Average cumulative timing curves for Kitsumkalum Chinook salmon sampled at Langara, Tyee and in the Kitsumkalum River during tagging, brood stock and dead pitch encounters.

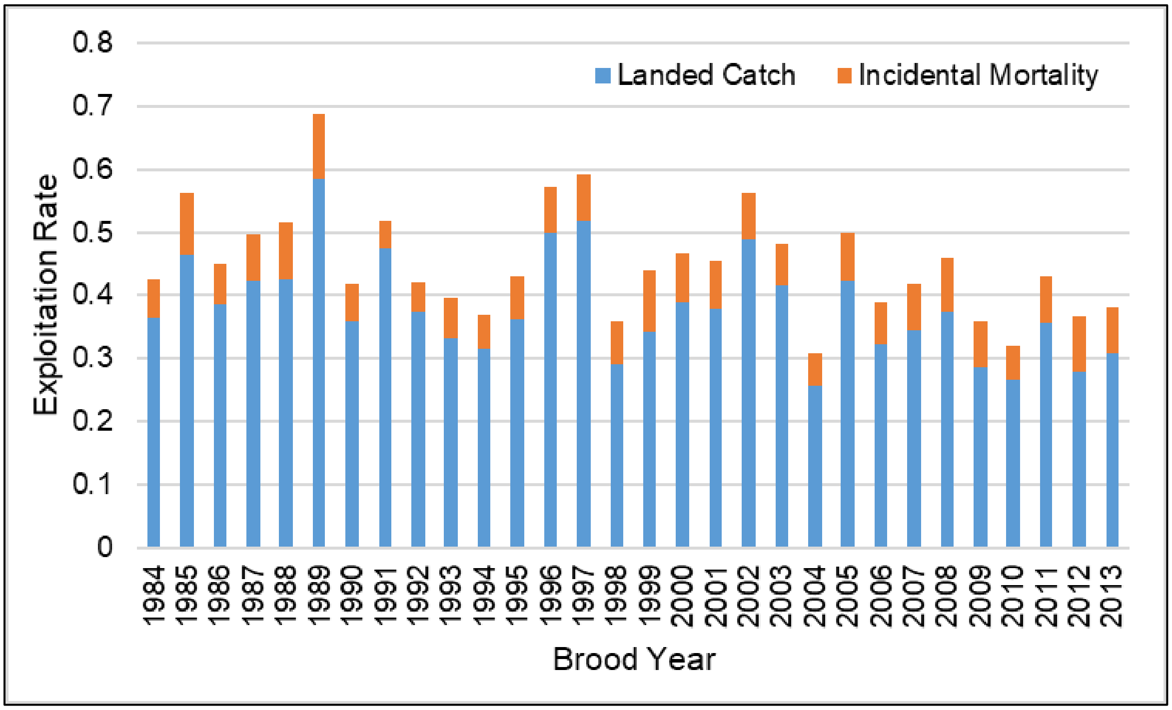

Figure 16. Brood year exploitation rates from landed catches and incidental mortalities for Kitsumkalum Chinook salmon 1984 to 2013.

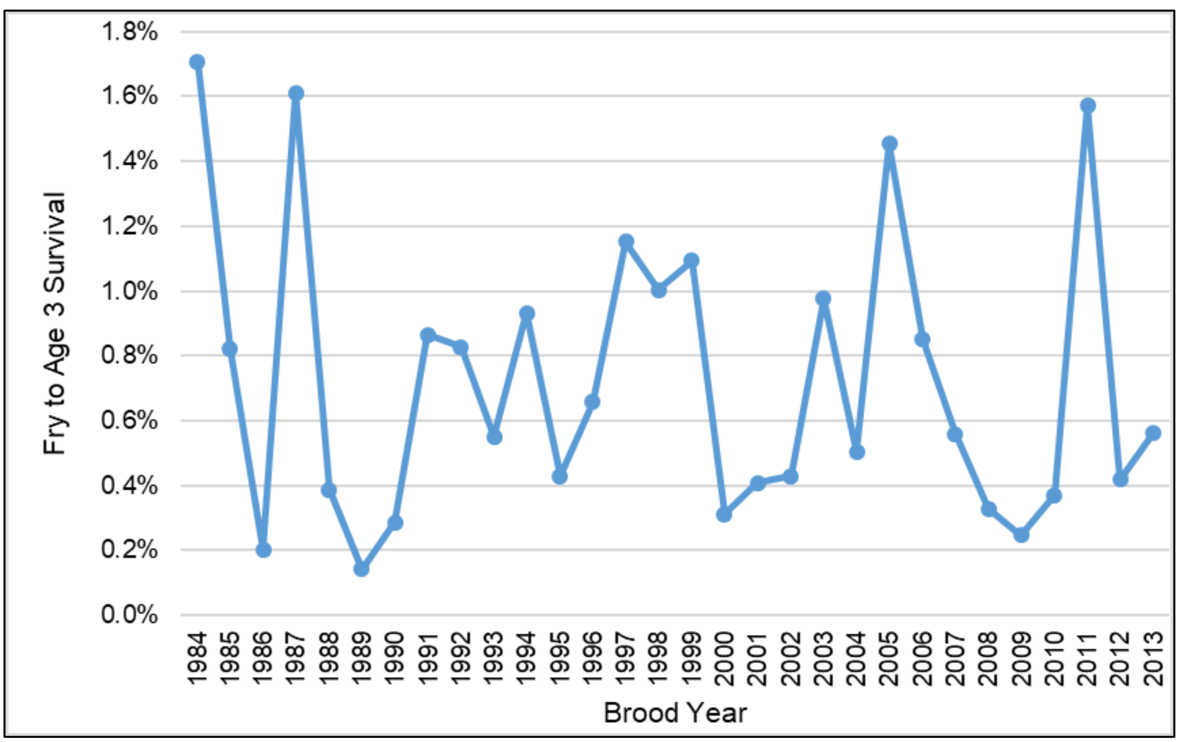

Figure 17. Estimated survival of Kitsumkalum Chinook salmon coded wire tagged fry releases to age 3.

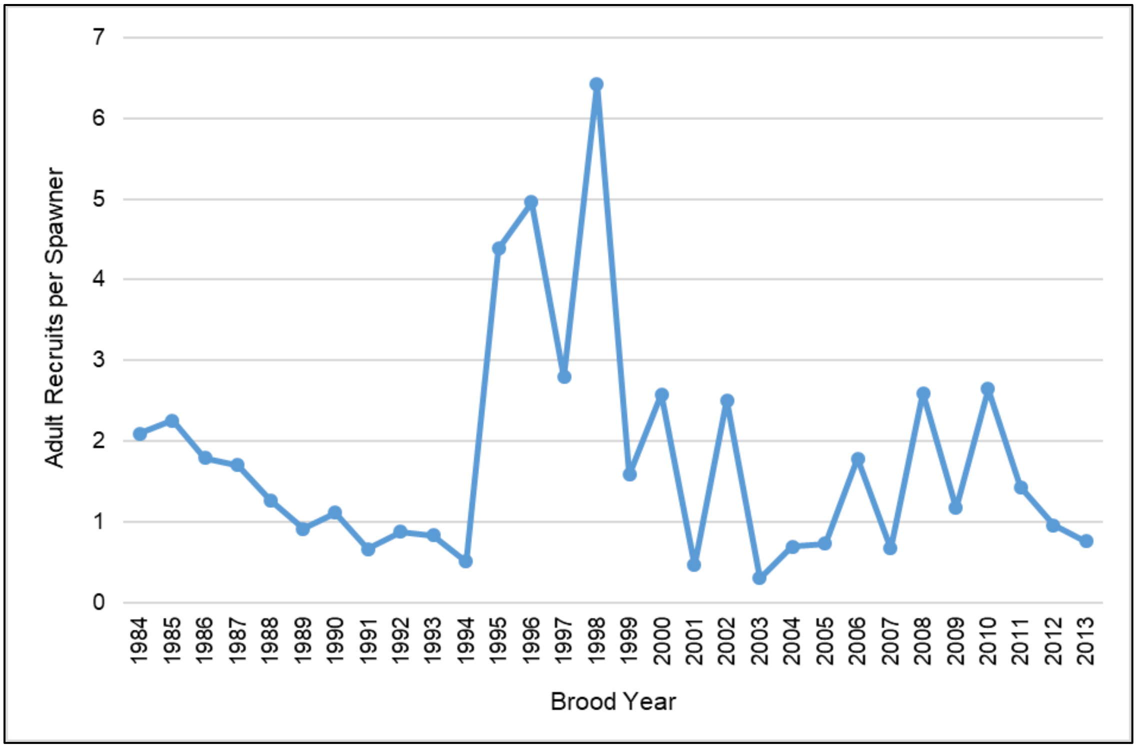

Figure 18. Adult recruits produced per spawning escapement of Kitsumkalum Chinook salmon in brood years 1984 to 2013.

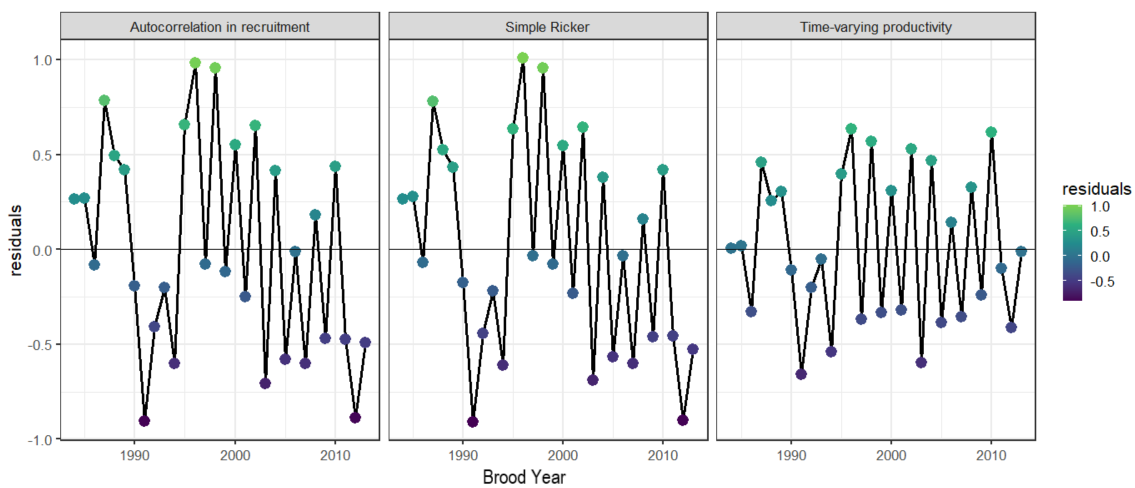

Figure 19. Recruitment residual patterns for the three models considered for Kitsumkalum Chinook salmon from brood years 1984 to 2013.

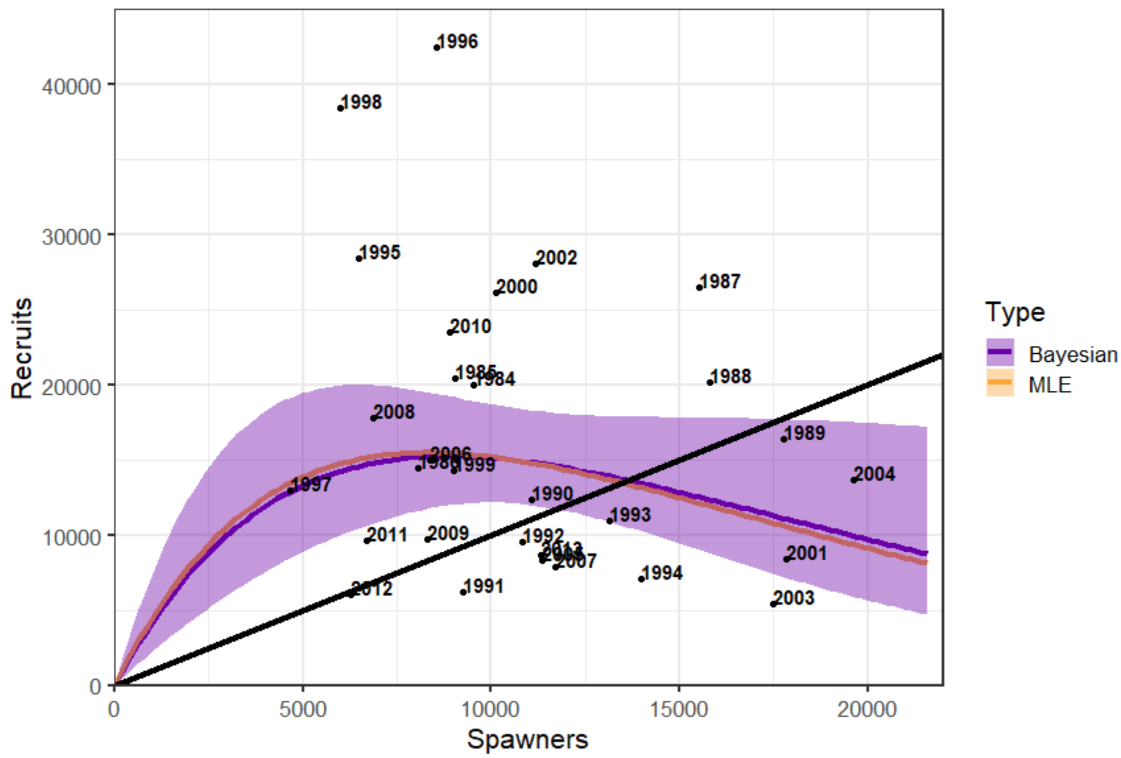

Figure 20. Ricker recruitment curve for Kitsumkalum Chinook salmon produced from brood years 1984 to 2013.

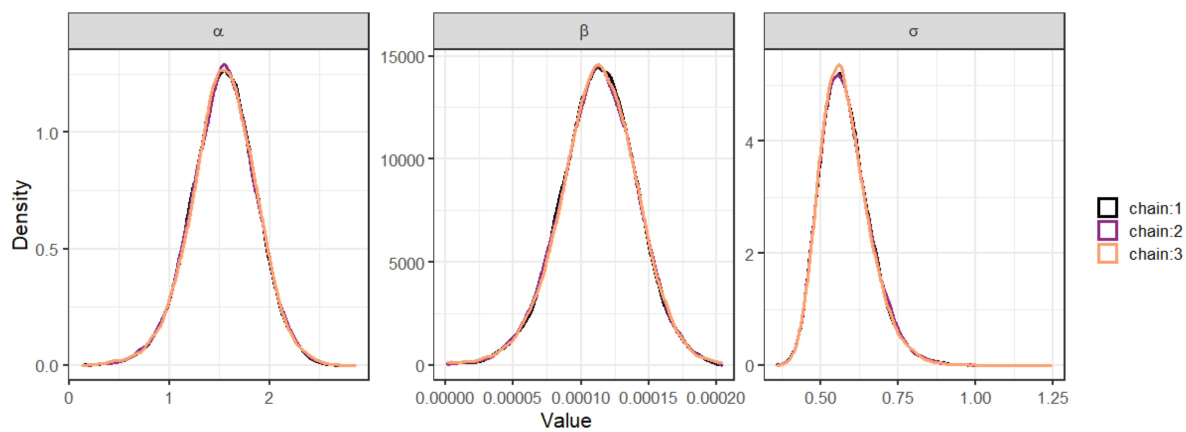

Figure 21. Posterior probability distributions for the simple Ricker model.

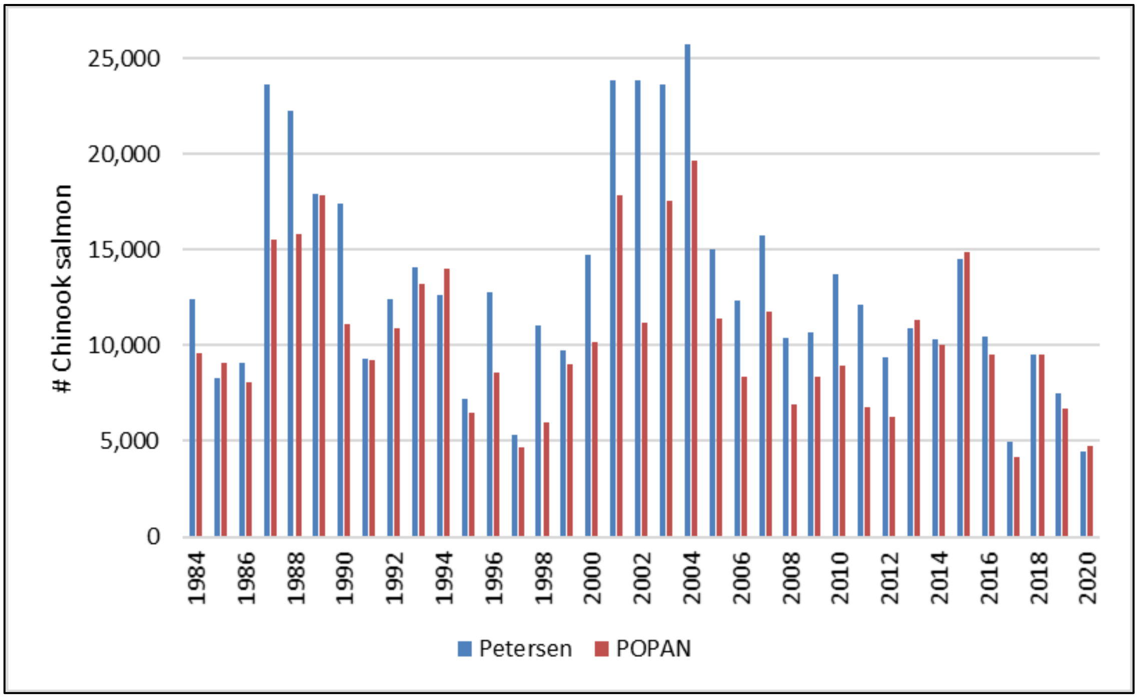

Figure 22. Comparison of Petersen and POPAN estimates of Kitsumkalum Chinook salmon escapement 1984-2020.

TABLES

Table 1. Kitsumkalum River Chinook salmon mark-recapture dates of tagging and dead pitch operations and staffing levels.

Year	Tagging				Dead Pitch				Total Experiment		
	Date start	Date end	Duration (d)	Days worked (d)	Date start	Date end	Duration (d)	Days worked (d)	Duration (d)	Events (d)	Staffing level
1984	16-Aug-84	6-Sep-84	22	17	30-Aug-84	28-Sep-84	29	20	43	32	1 crew
1985	21-Aug-85	9-Sep-85	20	19	12-Sep-85	7-Oct-85	25	22	47	46	2 crews
1986	20-Aug-86	10-Sep-86	22	21	30-Aug-86	6-Oct-86	37	28	48	46	2 crews
1987	20-Aug-87	8-Sep-87	20	19	24-Aug-87	15-Oct-87	52	27	57	40	2 crews
1988	17-Aug-88	9-Sep-88	24	23	20-Aug-88	7-Oct-88	48	31	52	34	2 crews
1989	21-Aug-89	7-Sep-89	18	17	6-Sep-89	25-Sep-89	19	15	36	31	2 crews
1990	20-Aug-90	6-Sep-90	18	16	27-Aug-90	5-Oct-90	39	27	47	37	2 crews
1991	19-Aug-91	17-Sep-91	30	24	30-Aug-91	4-Oct-91	35	28	47	40	2 crews
1992	20-Aug-92	8-Sep-92	20	17	22-Aug-92	8-Oct-92	47	27	50	38	2 crews
1993	20-Aug-93	10-Sep-93	22	18	31-Aug-93	4-Oct-93	34	24	46	36	2 crews
1994	23-Aug-94	15-Sep-94	24	20	10-Sep-94	8-Oct-94	28	19	47	34	1 crew
1995	22-Aug-95	20-Sep-95	30	21	16-Sep-95	5-Oct-95	19	14	45	35	1 crew
1996	19-Aug-96	18-Sep-96	31	26	3-Sep-96	4-Oct-96	31	15	47	32	1 crew
1997	19-Aug-97	30-Sep-97	43	29	6-Sep-97	2-Oct-97	26	22	45	39	1 crew
1998	20-Aug-98	12-Sep-98	24	20	10-Sep-98	5-Oct-98	25	21	47	38	1 crew
1999	19-Aug-99	21-Sep-99	34	26	13-Sep-99	12-Oct-99	29	21	55	39	1 crew
2000	18-Aug-00	12-Sep-00	26	22	8-Sep-00	5-Oct-00	27	14	49	34	1 crew
2001	20-Aug-01	12-Sep-01	24	10	13-Sep-01	21-Sep-01	8	8	33	29	1 crew
2002	23-Aug-02	9-Sep-02	18	17	10-Sep-02	10-Oct-02	30	14	49	33	1 crew
2003	18-Aug-03	13-Sep-03	27	24	15-Sep-03	3-Oct-03	18	14	47	38	1 crew
2004	18-Aug-04	13-Sep-04	27	22	13-Sep-04	5-Oct-04	22	16	49	37	1 crew
2005	19-Aug-05	13-Sep-05	26	21	12-Sep-05	5-Oct-05	23	18	48	37	1 crew
2006	18-Aug-06	14-Sep-06	28	24	14-Sep-06	3-Oct-06	19	14	47	37	1 crew
2007	20-Aug-07	18-Sep-07	30	27	15-Sep-07	5-Oct-07	20	15	47	39	1 crew
2008	14-Aug-08	17-Sep-08	35	25	15-Sep-08	8-Oct-08	23	14	56	37	1 crew
2009	17-Aug-09	15-Sep-09	30	26	14-Sep-09	8-Oct-09	24	17	53	42	1 crew
2010	18-Aug-10	16-Sep-10	30	25	7-Sep-10	5-Oct-10	28	14	49	36	1 crew
2011	10-Aug-11	22-Sep-11	44	26	14-Sep-11	17-Oct-11	33	22	69	40	1 crew
2012	15-Aug-12	15-Sep-12	32	28	10-Sep-12	11-Oct-12	31	20	58	42	1 crew of 3
2013	15-Aug-13	19-Sep-13	35	29	9-Sep-13	16-Oct-13	37	23	63	44	1 crew
2014	18-Aug-14	15-Sep-14	28	25	6-Sep-14	2-Oct-14	26	21	46	39	1 crew
2015	17-Aug-15	16-Sep-15	30	27	14-Sep-15	7-Oct-15	23	18	52	42	1 crew
2016	15-Aug-16	15-Sep-16	31	25	15-Sep-16	5-Oct-16	20	12	52	37	1 crew
2017	15-Aug-17	20-Sep-17	36	23	15-Sep-17	6-Oct-17	21	17	53	35	1 crew*
2018	17-Aug-18	17-Sep-18	31	27	10-Sep-18	4-Oct-18	24	23	49	41	1 crew
2019	19-Aug-19	14-Sep-19	26	24	9-Sep-19	4-Oct-19	25	22	47	40	1 crew
2020	25-Aug-20	15-Sep-20	21	20	12-Sep-20	5-Oct-20	23	17	42	30	1 crew of 3

* Crews consisted of 4 staff except in 2012 and 2020 when the crew consisted of 3 staff. In 2017 the tagging crew consisted of 4 staff and the dead pitch crew consisted of 3 staff. Events were equivalent to a day of work. Tagging and dead pitch sampling occasionally occurred on the same day.

Table 2. Sampling occasions and closure tests by strata for Kitsumkalum Chinook salmon 1984 to 2020.

A = additions, C = closure, ins = insufficient data, L = lower, U = upper, M = male, F = female, DP = Dead Pitch

Year	Events (d)	Total Occasions	Occasions Tagging	Occasions Tagging & DP combined	Occasions DP	# Spatial strata or river reaches (L/U)	# Group strata or gender (M/F)	Closure Tests				
								Lower Female (LF)	Lower Male (LM)	Upper Female (UF)	Upper Male (UM)	All Strata (L/U-M/F)
1984	32	7	3	1	3	1	2	A	C	ins	ins	A
1985	46	7	3	0	4	2	2	A	A	A	A	A
1986	46	7	2	2	3	2	2	A	A	A	A	A
1987	40	7	3	1	3	2	2	A	A	A	A	A
1989	31	5	2	1	2	2	2	A	A	A	A	A
1990	37	7	2	1	4	2	2	A	A	A	A	A
1991	40	7	2	2	3	2	2	A	A	A	A	A
1992	38	7	3	1	3	2	2	A	A	A	A	A
1993	36	7	3	1	3	2	2	A	A	A	A	A
1994	34	7	3	1	3	2	2	A	A	A	A	A
1995	35	7	4	1	2	2	2	A	A	A	C	A
1996	32	6	3	2	1	2	2	A	A	A	A	A
1997	39	7	3	4	0	2	2	A	A	A	A	A
1998	38	7	3	1	3	2	2	A	A	A	A	A
1999	39	7	3	1	3	2	2	A	A	A	A	A
2000	34	6	3	1	2	2	2	A	A	A	A	A
2001	29	6	4	0	2	2	2	A	A	A	A	A
2002	33	7	3	0	4	2	2	A	A	C	C	A
2003	38	7	4	0	3	2	2	A	A	A	A	A
2004	37	7	4	1	2	2	2	A	A	A	A	A
2005	37	7	3	1	3	2	2	A	A	A	A	A
2006	37	6	3	1	2	2	2	A	A	C	A	A
2007	39	7	4	1	2	2	2	A	A	A	C	A
2008	37	7	4	1	2	2	2	A	A	A	A	A
2009	42	8	4	1	3	2	2	C	A	A	A	A
2010	36	7	3	1	3	2	2	C	A	A	A	A
2011	40	9	4	2	3	2	2	C	A	C	C	A
2012	42	8	3	2	3	2	2	A	A	A	A	A
2013	44	8	4	2	2	2	2	A	A	A	A	A
2014	39	7	3	2	2	2	2	A	A	A	A	A
2015	42	7	4	1	2	2	2	A	A	A	A	A
2016	37	7	4	1	2	2	2	A	A	A	A	A
2017	35	6	3	1	2	2	2	C	A	C	C	A
2018	41	6	3	1	2	2	2	C	A	C	A	A
2019	40	7	3	1	3	2	2	A	A	A	A	A
2020	30	6	3	1	2	2	2	A	A	A	A	A

Table 3. Gender identification errors for Kitsumkalum Chinook salmon encountered in mark-recapture experiments 1984 to 2020.

Year	# Females sampled	Females incorrectly identified as male		# Males sampled	Males incorrectly identified as female		Total # Checked	Error: tagged M & dead pitched F	Error: tagged F & dead pitched M	# Absolute errors	% Absolute error	# Net errors	% Net error
		Tagging	Dead pitch		Tagging	Dead pitch							
1984	26	2	1	10	1	0	36	2	2	4	11%	0	0%
1985	147	3	0	118	6	0	265	3	6	9	3%	-3	-1%
1986	134	7	0	109	3	0	243	7	3	10	4%	4	2%
1987	64	0	0	59	0	0	123	0	0	0	0%	0	0%
1989	98	13	0	101	11	2	199	15	11	26	13%	4	2%
1990	110	16	0	125	8	0	235	16	8	24	10%	8	3%
1991	87	11	0	67	3	0	154	11	3	14	9%	8	5%
1992	83	5	0	74	5	0	157	5	5	10	6%	0	0%
1993	169	21	0	123	7	0	292	21	7	28	10%	14	5%
1994	73	2	2	64	3	2	137	4	5	9	7%	-1	-1%
1995	54	1	0	34	0	0	88	1	0	1	1%	1	1%
1996	52	4	1	12	2	1	64	5	3	8	13%	2	3%
1997	37	4	2	25	1	1	62	5	3	8	13%	2	3%
1998	76	7	0	64	6	1	140	8	6	14	10%	2	1%
1999	53	3	0	56	2	2	109	5	2	7	6%	3	3%
2000	75	1	0	73	2	0	148	1	2	3	2%	-1	-1%
2001	71	3	0	47	5	0	118	3	5	8	7%	-2	-2%
2002	52	9	0	33	2	0	85	9	2	11	13%	7	8%
2003	43	5	1	55	4	2	98	7	5	12	12%	2	2%
2004	50	3	0	56	0	1	106	4	0	4	4%	4	4%
2005	56	4	0	51	3	0	107	4	3	7	7%	1	1%
2006	26	2	1	25	1	1	51	3	2	5	10%	1	2%
2007	17	0	0	21	0	0	38	0	0	0	0%	0	0%
2008	26	2	0	33	1	1	59	3	1	4	7%	2	3%
2009	17	6	0	24	3	0	41	6	3	9	22%	3	7%
2010	57	15	0	60	1	1	117	16	1	17	15%	15	13%
2011	5	0	0	11	0	0	16	0	0	0	0%	0	0%
2012	42	11	0	24	0	0	66	11	0	11	17%	11	17%
2013	47	5	0	86	5	0	133	5	5	10	8%	0	0%
2014	23	0	0	56	0	1	79	1	0	1	1%	1	1%
2015	60	4	0	89	1	2	149	6	1	7	5%	5	3%
2016	40	0	1	49	0	1	89	1	1	2	2%	0	0%
2017	11	0	0	17	0	0	28	0	0	0	0%	0	0%
2018	28	0	1	65	1	0	93	0	2	2	2%	-2	-2%
2019	58	0	0	71	2	0	129	0	2	2	2%	-2	-2%
2020	11	0	1	17	0	0	28	0	1	1	4%	-1	-4%

M = Male, F = Female. Gender identification data were not available for 1988.

Table 4. Egg retention in female Kitsumkalum Chinook salmon sampled in the dead pitch program 1984 to 2020.

Year	Untagged females sampled in the dead pitch					Tagged females sampled in the dead pitch				
	Total sampled	# full of eggs	% full of eggs	# with partial and full egg loads	% partial & full	Total sampled	# full of eggs	% full of eggs	# with partial and full egg loads	% partial & full
1984	578	8	1.4%	11	1.9%	26	3	11.5%	3	11.5%
1985	939	3	0.3%	19	2.0%	147	1	0.7%	1	0.7%
1986	833	0	0.0%	19	2.3%	141	0	0.0%	2	1.4%
1987	962	4	0.4%	20	2.1%	65	0	0.0%	3	4.6%
1988	2008	7	0.3%	8	0.4%	109	0	0.0%	1	0.9%
1989	1481	2	0.1%	24	1.6%	99	0	0.0%	1	1.0%
1990	1604	0	0.0%	0	0.0%	111	0	0.0%	0	0.0%
1991	704	0	0.0%	0	0.0%	90	0	0.0%	0	0.0%
1992	838	1	0.1%	4	0.5%	84	0	0.0%	0	0.0%
1993	1674	7	0.4%	11	0.7%	171	0	0.0%	0	0.0%
1994	356	0	0.0%	20	5.6%	73	0	0.0%	2	2.7%
1995	558	0	0.0%	6	1.1%	54	0	0.0%	0	0.0%
1996	543	0	0.0%	3	0.6%	52	0	0.0%	0	0.0%
1997	187	0	0.0%	0	0.0%	37	0	0.0%	0	0.0%
1998	537	2	0.4%	7	1.3%	76	1	1.3%	1	1.3%
1999	472	2	0.4%	7	1.5%	51	0	0.0%	0	0.0%
2000	1032	2	0.2%	6	0.6%	73	0	0.0%	1	1.4%
2001	1058	1	0.1%	4	0.4%	71	0	0.0%	0	0.0%
2002	914	8	0.9%	15	1.6%	50	0	0.0%	1	2.0%
2003	1124	3	0.3%	8	0.7%	43	0	0.0%	0	0.0%
2004	1043	3	0.3%	6	0.6%	50	0	0.0%	0	0.0%
2005	872	2	0.2%	9	1.0%	53	0	0.0%	0	0.0%
2006	548	0	0.0%	4	0.7%	23	0	0.0%	0	0.0%
2007	431	1	0.2%	4	0.9%	17	0	0.0%	0	0.0%
2008	369	0	0.0%	0	0.0%	26	0	0.0%	0	0.0%
2009	465	1	0.2%	1	0.2%	22	0	0.0%	0	0.0%
2010	542	1	0.2%	2	0.4%	42	0	0.0%	0	0.0%
2011	336	1	0.3%	1	0.3%	9	0	0.0%	0	0.0%
2012	466	5	1.1%	5	1.1%	32	0	0.0%	0	0.0%
2013	648	1	0.2%	2	0.3%	48	0	0.0%	0	0.0%
2014	418	1	0.2%	1	0.2%	23	0	0.0%	0	0.0%
2015	858	1	0.1%	5	0.6%	60	2	3.3%	2	3.3%
2016	662	13	2.0%	13	2.0%	41	0	0.0%	0	0.0%
2017	178	0	0.0%	0	0.0%	11	0	0.0%	0	0.0%
2018	399	0	0.0%	0	0.0%	28	0	0.0%	0	0.0%
2019	697	2	0.3%	4	0.6%	58	0	0.0%	0	0.0%
2020	233	0	0.0%	3	1.3%	11	0	0.0%	0	0.0%

Table 5. Tag loss rates for male and female Kitsumkalum Chinook salmon 1984 to 2020.

Year	Females sampled	Males sampled	Total sampled	Female losses	Male losses	Total losses	Female unread-able	Male unread-able	Female tag loss %	Male tag loss %	Total tag loss %	Historic reference
1984	26	10	36	2	0	2	0	0	7.7%	0.0%	5.6%	Andrew & Webb 1988
1985	147	118	265	19	60	79	0	0	12.9%	50.8%	29.8%	Andrew & Webb 1988
1986	134	109	243	32	84	116	0	0	23.9%	77.1%	47.7%	Andrew & Webb 1988
1987	64	59	123	12	15	27	0	0	18.8%	25.4%	22.0%	Carolsfeld et al. 1990
1988									(4.2%)	(7.3%)	(5.5%)	Carolsfeld et al. 1990
1989	98	101	199	3	3	6	1	0	3.1%	3.0% (2.3%)	3.0% (2.7%)	Nass & Bocking 1992
1990	110	125	235	6	7	13	0	0	5.5% (8.1%)	5.6% (7.7%)	5.5% (7.9)	Nass & Bocking 1992
1991	87	67	154	6	11	17	0	0	6.9% (6.7%)	16.4% (24.4%)	11.0% (12.7%)	Nelson 1993
1992	83	74	157	9	14	23	0	0	10.8%	18.9%	14.6%	Nelson 1992
1993	169	123	292	8	14	22	0	0	4.7%	11.4%	7.5%	Nelson 1993
1994	73	64	137	23	31	54	0	0	31.5%	48.4%	39.4%	Nelson 1995a
1995	54	34	88	4	4	8	0	1	7.4%	11.8% (14.7%)	9.1% (10.2%)	Nelson 1995b
1996	52	12	64	0	0	0	0	0	0.0%	0.0%	0.0%	Blakely & Nelson 1998
1997	37	25	62	0	4	4	0	0	0.0%	16.0%	6.5%	
1998	76	64	140	1	1	2	0	0	1.3%	1.6%	1.4%	
1999	53	56	109	2	6	8	0	0	3.8%	10.7%	7.3%	
2000	75	73	148	7	14	21	2	0	9.3%	19.2%	14.2%	
2001	71	47	118	1	0	1	0	0	1.4%	0.0%	0.8%	
2002	52	33	85	4	4	8	2	2	7.7%	12.1%	9.4%	
2003	43	55	98	2	5	7	1	1	4.7%	9.1%	7.1%	
2004	50	56	106	7	6	13	0	0	14.0%	10.7%	12.3%	
2005	56	51	107	5	6	11	0	1	8.9%	11.8%	10.3%	
2006	26	25	51	0	3	3	0	0	0.0%	12.0%	5.9%	
2007	17	21	38	1	2	3	0	0	5.9%	9.5%	7.9%	
2008	26	33	59	0	0	0	0	0	0.0%	0.0%	0.0%	
2009	17	24	41	4	3	7	1	2	23.5%	12.5%	17.1%	
2010	57	60	117	0	3	3	0	0	0.0%	5.0%	2.6%	
2011	5	11	16	2	1	3	1	0	40.0%	9.1%	18.8%	
2012	42	24	66	1	2	3	2	1	2.4%	8.3%	4.5%	
2013	47	86	133	4	8	12	0	0	8.5%	9.3%	9.0%	
2014	23	56	79	0	0	0	0	0	0.0%	0.0%	0.0%	
2015	60	89	149	2	6	8	4	2	3.3%	6.7%	5.4%	
2016	40	49	89	4	1	5	1	1	10.0%	2.0%	5.6%	
2017	11	17	28	0	1	1	1	0	0.0%	5.9%	3.6%	
2018	28	65	93	2	5	7	1	0	7.1%	7.7%	7.5%	
2019	58	71	129	1	3	4	0	0	1.7%	4.2%	3.1%	
2020	11	17	28	0	1	1	0	0	0.0%	5.9%	3.6%	

Values published in references that were different from those derived here are presented in brackets.

Table 6. Descriptions, strata and parameters of the most parsimonious models selected in the analyses of Kitsumkalum Chinook salmon data 1984 to 2020.

Year	Best Model	temporal strata (t)	group strata (g)	reach strata (r)	Number of parameters
1984	{p(g) s(t) b(t g)}	7	2	1	22
1985	{p(fix-t r) s(g r) b(t g r)}	7	2	2	46
1986	{p(fix-t g r) s(t g) b(t r)}	7	2	2	56
1987	{p(fix-t g r) s(t r) b(t g)}	6	2	2	48
1989	{p(fix-t r) s(t g r) b(t g r)}	5	2	2	46
1990	{p(fix-t g r) s(t) b(t r)}	7	2	2	50
1991	{p(r) s(t r) b(t g r)}	7	2	2	42
1992	{p(fix-t) s(g r) b(t g r)}	7	2	2	39
1993	{p(fix-t r) s(g) b(t g r)}	7	2	2	44
1994	{p(fix-t g) s(t r) b(t g r)}	7	2	2	54
1995	{p(fix-t g) s(t) b(t r)}	7	2	2	36
1996	{p(r) s(t g) b(t g r)}	6	2	2	36
1997	{p(g r) s(t r) b(t g r)}	7	2	2	44
1998	{p(fix-t) s(t g r) b(t g r)}	7	2	2	59
1999	{p(fix-t r) s(g) b(t g r)}	7	2	2	44
2000	{p(fix-t r) s(t g) b(t g r)}	6	2	2	46
2001	{p(fix-t r) s(t g) b(t r)}	6	2	2	36
2002	{p(fix-t r) s(g r) b(t g r)}	7	2	2	46
2003	{p(fix-t r) s(t g) b(t g r)}	7	2	2	54
2004	{p(g r) s(t g) b(t g r)}	7	2	2	44
2005	{p(fix-t r) s(t g) b(t g r)}	7	2	2	54
2006	{p(fix-t r) s(t g) b(t g r)}	7	2	2	54
2007	{p(fix-t r) s(t r) b(t g r)}	7	2	2	54
2008	{p(fix-t) s(t r) b(t g r)}	7	2	2	47
2009	{p(fix-t g) s(t r) b(t g r)}	8	2	2	62
2010	{p(fix-t r) s(g r) b(t g r)}	7	2	2	46
2011	{p(r) s(r) b(t g r)}	9	2	2	40
2012	{p(g r) s(t g) b(t g r)}	8	2	2	50
2013	{p(g r) s(t g r) b(t g r)}	8	2	2	64
2014	{p(fix-t r) s(t r) b(t g r)}	7	2	2	54
2015	{p(*) s(t r) b(t g r)}	7	2	2	41
2016	{p(fix-t g) s(r) b(t g r)}	7	2	2	44
2017	{p(g r) s(g) b(t g r)}	6	2	2	30
2018	{p(fix-t g r) s(t g) b(t r)}	6	2	2	48
2019	{p(fix-t r) s(t g) b(t g)}	7	2	2	42
2020	{p(fix-t) s(t g r) b(t g r)}	6	2	2	50

1988 was not analyzed with program MARK because individual encounter histories could not be developed with the data available. Group is equivalent to gender for these analyses of large Chinook salmon.

Table 7. Gender specific and total Chinook salmon escapement estimates and standard errors for large Kitsumkalum Chinook salmon 1984 to 2020.
Est. = estimate, SE = standard error, CV = coefficient of variation.

Year	Male Est.	Male SE	Female Est.	Female SE	Total Est.	Total SE	CV%
1984	6,885	1,580	2,684	452	9,569	1,644	17.2%
1985	4,814	341	4,267	227	9,081	409	4.5%
1986	4,924	313	3,156	166	8,080	354	4.4%
1987	7,961	712	7,588	689	15,549	991	6.4%
1988	7,508	592	8,344	545	15,853	804	5.1%
1989	7,396	581	10,427	869	17,823	1,046	5.9%
1990	4,681	251	6,438	376	11,119	452	4.1%
1991	3,989	234	5,278	391	9,267	456	4.9%
1992	5,826	335	5,054	295	10,880	447	4.1%
1993	6,142	410	7,039	317	13,181	518	3.9%
1994	8,329	1,060	5,675	654	14,004	1,245	8.9%
1995	2,531	161	3,983	264	6,514	309	4.7%
1996	3,452	374	5,143	596	8,595	704	8.2%
1997	2,536	239	2,139	224	4,675	328	7.0%
1998	3,184	169	2,825	200	6,009	262	4.4%
1999	5,371	499	3,664	256	9,035	561	6.2%
2000	5,381	347	4,798	233	10,179	418	4.1%
2001	9,367	510	8,499	445	17,866	677	3.8%
2002	6,267	518	4,953	447	11,220	685	6.1%
2003	9,364	699	8,161	408	17,525	809	4.6%
2004	8,825	806	10,839	1,390	19,664	1,607	8.2%
2005	5,866	422	5,516	476	11,382	637	5.6%
2006	4,930	639	3,466	394	8,396	751	8.9%
2007	4,221	745	7,518	1,693	11,739	1,849	15.8%
2008	3,585	342	3,318	273	6,903	437	6.3%
2009	3,718	410	4,632	664	8,350	781	9.4%
2010	5,788	494	3,144	312	8,932	585	6.5%
2011	3,330	458	3,426	520	6,756	693	10.3%
2012	4,219	436	2,072	283	6,291	520	8.3%
2013	5,833	488	5,523	1,085	11,356	1,189	10.5%
2014	6,447	1,081	3,595	604	10,042	1,238	12.3%
2015	7,892	514	7,012	550	14,904	753	5.1%
2016	4,140	254	5,397	444	9,537	512	5.4%
2017	2,262	302	1,870	414	4,132	512	12.4%
2018	5,328	362	4,222	441	9,550	571	6.0%
2019	3,273	384	3,400	411	6,673	562	8.4%
2020	1,485	146	3,292	830	4,777	843	17.6%

Table 8. Gender and reach specific escapement estimates and standard errors for large Kitsumkalum Chinook salmon 1984 to 2020.
Est. = estimate, SE = standard error.

Year	Lower Male Est.	Lower Male SE	Lower Female Est.	Lower Female SE	Upper Male Est.	Upper Male SE	Upper Female Est.	Upper Female SE
1985	2,629	256	2,393	149	2,185	225	1,874	171
1986	2,383	218	1,622	143	2,542	226	1,534	83
1987	4,845	626	4,271	562	3,116	340	3,317	399
1988	4,451	507	5,084	447	3,057	305	3,261	311
1989	5,502	561	8,455	851	1,894	152	1,972	178
1990	2,942	231	4,334	346	1,739	98	2,104	146
1991	2,700	211	3,970	381	1,290	101	1,308	88
1992	3,182	244	2,226	164	2,644	230	2,828	245
1993	4,133	377	4,611	292	2,009	161	2,428	124
1994	6,702	1,029	4,504	646	1,626	252	1,171	103
1995	1,766	142	3,035	243	766	77	949	103
1996	2,857	367	4,604	592	595	77	539	64
1997	1,275	127	1,470	205	1,261	203	670	90
1998	1,871	109	1,415	90	1,313	130	1,411	179
1999	4,098	472	2,636	240	1,272	164	1,028	91
2000	4,228	336	3,901	225	1,152	83	897	61
2001	8,015	500	7,154	423	1,352	102	1,345	139
2002	5,106	398	3,924	303	1,160	332	1,029	329
2003	6,424	627	5,302	376	2,940	309	2,858	159
2004	6,584	780	6,654	1,173	2,241	202	4,185	746
2005	4,456	397	4,500	468	1,410	143	1,015	89
2006	3,601	589	2,659	339	1,329	248	807	202
2007	3,398	740	6,162	1,683	823	91	1,356	183
2008	2,579	335	2,493	261	1,006	65	825	79
2009	1,751	240	1,695	272	1,967	333	2,937	606
2010	3,692	455	2,104	298	2,096	194	1,040	92
2011	2,718	450	3,091	517	611	87	335	48
2012	2,631	345	1,503	252	1,588	266	569	130
2013	3,449	375	4,028	926	2,383	312	1,495	564
2014	3,476	984	2,026	563	2,971	447	1,569	217
2015	3,792	330	2,815	268	4,101	394	4,198	480
2016	1,941	172	2,380	338	2,200	187	3,017	288
2017	1,305	205	1,354	378	957	221	516	168
2018	1,840	167	2,365	365	3,488	321	1,857	248
2019	1,541	307	1,746	358	1,733	230	1,654	200
2020	538	98	2,763	824	947	108	529	101

1984 was not included because data were not separated by river reach. See Table 7 for estimates.

Table 9. Age data for samples collected from female Kitsumkalum Chinook salmon 1984 to 2020.

Year	Female Chinook salmon Age (Gilbert-Rich)											
	3_1	3_2	4_1	4_2	5_1	5_2	6_1	6_2	6_3	7_2	7_3	Total
1984				1	9	65		164		16	2	257
1985				4	6	197		77				284
1986		1			17	103		161		1		283
1987					8	28	1	145				182
1989			1		5	31	1	298		4		340
1990		1				30		176		4		211
1991	3			14		27		197				241
1992				1		44		100				145
1993						63		140				203
1994						20		227		1		248
1995				5		16		47				68
1996						15		81				96
1997				1	2	14		45		2		64
1998						26		18		1		45
1999					1	88		134		3		226
2000					6	55		163		1		225
2001			1	1		172		126		6		306
2002					1	109		146	1			257
2003				1	31	52		213		2		299
2004				2	3	224	2	67		4		302
2005				5	3	56		152	1			217
2006				8		243		127		1		379
2007	1		2	2	5	45		120				175
2008				2	2	182		63		1		250
2009				3	2	51		174		1		231
2010			5			166		29		2		202
2011				1	14	53		55		1	1	125
2012						108		36				144
2013				1	2	124		148	1	3	1	280
2014				1		140		90		1		232
2015				1		67		67		3		138
2016						70		17		1		88
2017			2	3	1	85		84		5		180
2018					3	70		40		1		114
2019			3	6	8	82		46				145
2020			9		5	99		14		1		128

Ocean type fish were combined with the stream type fish in the data for years 1991 through 1995 inclusive.

Table 10. Age data for samples collected from male Kitsumkalum Chinook salmon 1984 to 2020.

Year	Male Chinook salmon Age (Gilbert-Rich)													
	3_1	3_2	4_1	4_2	4_3	5_1	5_2	5_3	6_1	6_2	6_3	7_2	7_3	Total
1984		5		18		1	17			44				85
1985		6		22			64			42				134
1986		6	2	21		13	56			64				162
1987				6		1	16			66				89
1988	1		2	14		2	20		1	99		6		145
1989		1		2			30			95				128
1990		7		32			39			110		5		193
1991				11			14			38		12		75
1992				3			49			48		1		101
1993				5			20			78				103
1994							18			111		6		135
1995							6			8		1		15
1996							2					2		4
1997							5			2				7
1998		16		32		1	55			76				180
1999		7		79		1	19			33				139
2000	6	1	2	47			55			26				137
2001		14	1	6			81			39	1			142
2002		5	4	34		6	19			67		1		136
2003		9	1	26			111			30		2		179
2004		12	1	64		4	43			111	1	2		238
2005		20		27			126			33				206
2006		6	3	80		2	45			47				183
2007		11		17			96			28				152
2008	2	6		68		4	54			61		2		197
2009	3	6	7	39			98			22		1		176
2010	3	22	2	149		6	43	3		37			1	266
2011		4		39			103			15				161
2012	1	10		104		1	74			37	1	1		229
2013		17		91	1		133			41	2			285
2014		4		97			58	1		44		2		206
2015		3	1	57			104			8				173
2016		5	4	58		1	107			80				255
2017	2	38	6	71		1	79			18				215
2018	11	14	4	118		5	57			14				223
2019		4	10	23		2	94			14		1		148
2020		3		35		2	36		1	18				95

Ocean type fish were combined with the stream type fish in the data for years 1991 through 1995 inclusive (from McNicol, 1999).

Table 11. Mean size (POH length) of male and female Kitsumkalum Chinook salmon, all ages combined, 1984 to 2020.

Year	MALES			FEMALES		
	Average POH (mm)	SE (mm)	N	Average POH (mm)	SE (mm)	N
1984	773	173	270	825	56	570
1985	799	160	450	829	65	939
1986	765	217	605	864	58	832
1987	897	137	700	883	50	965
1988	872	132	1207	875	51	2330
1989	861	118	935	859	50	1503
1990	794	191	1108	852	51	1549
1991	823	134	653	853	54	908
1992	827	132	680	854	48	965
1993	860	124	819	863	47	1614
1994	842	72	803	840	107	581
1995	819	110	136	831	40	460
1996	834	115	142	844	44	451
1997	818	123	84	834	55	160
1998	734	184	481	834	53	582
1999	725	160	327	811	48	513
2000	753	116	573	810	49	1072
2001	799	145	586	844	48	1105
2002	796	155	456	849	49	949
2003	798	117	547	798	46	1140
2004	776	157	878	834	53	1098
2005	719	148	865	778	49	1096
2006	726	136	936	813	48	812
2007	742	158	812	804	46	877
2008	742	154	966	834	53	724
2009	717	146	1007	788	49	751
2010	666	160	1439	810	53	719
2011	688	128	615	762	49	459
2012	647	135	878	790	51	640
2013	641	165	1596	776	48	971
2014	656	146	1260	793	52	674
2015	693	131	1754	766	50	1294
2016	686	168	1203	762	55	1073
2017	618	142	670	742	56	349
2018	630	117	1399	752	48	791
2019	692	128	1088	755	48	1098
2020	668	145	495	777	54	369
Total	738	165	29423	821	65	32983

Table 12. Mean size (POH length) at age for female Kitsumkalum Chinook salmon 1984 to 2020.

Year	Age 5_2 Females			Age 6_2 Females		
	Average POH (mm)	Standard error (mm)	N	Average POH (mm)	Standard error (mm)	N
1984	782		65	865		164
1985	805		197	879		77
1986	820		103	898		161
1987	814		28	987		145
1988	791		31	887		298
1989	815		30	874		176
1990	834		27	861		197
1991	799		44	857		100
1992	824		63	869		140
1993	824		20	869		227
1994	756		16	886		47
1995	798		15	844		81
1996	799	42	14	848	35	45
1997	785	34	8	853	56	11
1998	809	47	88	860	40	134
1999	771	44	55	834	37	163
2000	784	39	172	838	40	126
2001	810	32	109	875	38	146
2002	793	54	52	865	34	213
2003	791	36	223	850	39	66
2004	817	54	50	857	41	145
2005	767	40	241	821	43	126
2006	798	41	45	834	45	120
2007	788	37	182	854	38	61
2008	798	35	48	863	41	170
2009	781	39	159	833	55	28
2010	777	39	53	832	49	55
2011	751	40	108	802	67	36
2012	766	40	124	825	37	148
2013	763	39	137	821	42	89
2014	761	47	66	828	48	65
2015	770	44	70	836	40	17
2016	729	42	85	794	50	84
2017	726	43	70	793	56	40
2018	758	41	82	793	46	46
2019	763	36	99	812	40	14
2020	771	32	16	822	48	25
1996 to 2020	776	45	2356	841	47	2173

SE could not be produced for data prior to 1996. 1984 to 1995 mean POH and N values from McNicol (1999).

Table 13. Mean size (POH length) at age for male Kitsumkalum Chinook salmon 1984 to 2020.

Year	Age 3_2 males			Age 4_2 males			Age 5_2 males			Age 6_2 males			Age 7_2 males	
	POH (mm)	SE (mm)	N	POH (mm)	SE (mm)	N	POH (mm)	SE (mm)	N	POH (mm)	SE (mm)	N	POH (mm)	N
1984	334		5	576		18	759		17	892		44		
1985	340		6	598		22	786		64	923		42		
1986	340		6	589		21	801		56	940		64		
1987				547		6	778		16	933		66		
1989				588		14	922		20	962		99	883	6
1990	390		1	620		2	828		30	918		95		
1991	397		7	817		32	793		39	899		110	932	5
1992				658		11	805		14	905		38	955	12
1993				583		3	777		49	922		48	1040	1
1994				569		5	775		20	896		78		
1995							818		18	854		111	882	6
1996							750		6	806		8	870	1
1997							770	42	2				960	2
1998							860	67	5	935	21	2		
1999	384	46	16	593	89	32	806	72	55	908	52	76		
2000	383	52	7	576	62	79	738	91	19	876	54	33		
2001	420		1	623	70	47	770	73	55	865	76	26		
2002	381	44	14	660	86	6	795	71	81	896	47	39		
2003	378	34	5	564	80	34	803	62	19	917	56	67	790	1
2004	363	42	9	585	107	26	817	68	111	911	49	30	956	2
2005	350	52	10	632	76	46	781	79	43	909	52	104	1040	2
2006	399	55	20	611	130	27	758	58	125	862	61	33		
2007	413	33	6	628	66	80	772	72	45	865	67	47		
2008	382	37	11	605	80	17	783	66	96	878	68	28		
2009	378	77	6	616	55	67	790	68	54	902	67	61	905	2
2010	420	26	6	608	89	39	788	81	97	895	51	21	870	1
2011	374	61	22	605	63	148	762	76	43	891	52	37		
2012	405	26	4	573	74	39	731	83	103	837	55	15		
2013	395	72	10	595	68	104	730	83	74	855	85	37	950	1
2014	388	74	17	583	78	91	752	74	133	855	63	41		
2015	373	93	4	571	55	97	753	75	58	886	49	43	935	2
2016	413	67	3	592	64	57	744	77	104	859	81	8		
2017	436	76	5	597	73	58	745	76	107	856	76	80		
2018	431	92	38	583	53	71	707	83	79	817	86	18		
2019	426	61	14	599	48	118	733	78	57	856	54	14		
2020	375	67	4	593	65	23	745	72	94	863	57	14	940	1
1996-2020	340	26	3	546	45	35	744	61	36	843	60	18		

SE could not be produced for data prior to 1996. 1984 to 1995 mean POH and N values at age are from McNicol (1999) and include ocean type fish.

Table 14. Gender and age specific escapements of Kitsumkalum Chinook salmon by return year.

Return Year	Females					Males				
	Age 4	Age 5	Age 6	Age 7	Total	Age 4	Age 5	Age 6	Age 7	Total
1984	10	773	1,713	188	2,684	1,549	1,549	3,787	0	6,885
1985	60	3,050	1,157	0	4,267	827	2,407	1,580	0	4,814
1986	0	1,343	1,802	11	3,156	726	2,178	2,020	0	4,924
1987	0	1,501	6,087	0	7,588	537	1,521	5,904	0	7,961
1988	25	884	7,339	98	8,345	834	1,147	5,214	313	7,509
1989	0	1,490	8,739	199	10,427	116	1,747	5,532	0	7,396
1990	379	730	5,329	0	6,438	805	981	2,768	126	4,681
1991	36	1,602	3,640	0	5,278	585	745	2,021	638	3,989
1992	0	1,568	3,485	0	5,054	173	2,826	2,769	58	5,826
1993	0	568	6,443	28	7,039	298	1,193	4,651	0	6,142
1994	417	1,335	3,922	0	5,675	0	1,110	6,848	370	8,329
1995	0	622	3,361	0	3,983	0	1,012	1,350	169	2,531
1996	72	1,376	3,549	145	5,143	266	797	2,124	266	3,452
1997	0	1,236	856	48	2,139	254	1,775	507	0	2,536
1998	0	1,113	1,675	38	2,825	621	1,087	1,475	0	3,184
1999	0	993	2,655	16	3,664	3,214	814	1,343	0	5,371
2000	31	2,697	1,975	94	4,798	2,028	2,276	1,076	0	5,381
2001	0	3,638	4,861	0	8,499	512	5,927	2,927	0	9,367
2002	17	1,375	3,528	33	4,953	1,818	1,196	3,205	48	6,267
2003	54	6,134	1,865	108	8,161	1,487	6,114	1,652	110	9,364
2004	250	2,947	7,642	0	10,839	2,538	1,835	4,374	78	8,825
2005	116	3,536	1,848	15	5,516	852	3,974	1,041	0	5,866
2006	80	996	2,390	0	3,466	2,312	1,309	1,309	0	4,930
2007	60	5,533	1,895	30	7,518	509	2,874	838	0	4,221
2008	43	761	2,499	14	3,318	1,290	1,100	1,157	38	3,585
2009	115	3,806	665	46	4,632	1,024	2,182	490	22	3,718
2010	25	1,685	1,383	50	3,144	3,627	1,249	889	24	5,788
2011	0	2,569	856	0	3,426	827	2,184	318	0	3,330
2012	7	932	1,103	30	2,072	2,013	1,451	735	19	4,219
2013	24	3,333	2,143	24	5,523	2,002	2,895	936	0	5,833
2014	26	1,746	1,746	78	3,595	3,096	1,883	1,404	64	6,447
2015	0	5,578	1,355	80	7,012	2,693	4,828	371	0	7,892
2016	150	2,579	2,519	150	5,397	1,027	1,789	1,325	0	4,140
2017	0	1,197	656	16	1,870	995	1,034	233	0	2,262
2018	262	2,620	1,339	0	4,222	3,283	1,668	377	0	5,328
2019	239	2,762	372	27	3,400	750	2,182	318	23	3,273
2020	0	1,514	1,646	132	3,292	565	613	307	0	1,485

Table 15. Gender and age specific escapements of wild Kitsumkalum Chinook salmon by brood year.

Brood Year	Females					Males					Sex Ratio
	Age 4	Age 5	Age 6	Age 7	Total	Age 4	Age 5	Age 6	Age 7	Total	
1977				188	188				0	0	
1978			1713	0	1713			3787	0	3787	
1979		773	1157	11	1941		1549	1580	0	3129	
1980	10	3050	1802	0	4862	1549	2407	2020	0	5976	1.23
1981	60	1343	6087	98	7588	827	2178	5904	313	9222	1.22
1982	0	1501	7339	199	9039	726	1521	5214	0	7461	0.83
1983	0	884	8739	0	9622	537	1147	5532	126	7342	0.76
1984	25	1490	5329	0	6843	834	1747	2768	638	5988	0.87
1985	0	730	3640	0	4370	116	981	2021	58	3177	0.73
1986	379	1602	3485	28	5494	805	745	2769	0	4319	0.79
1987	36	1568	6443	0	8048	585	2826	4651	370	8433	1.05
1988	0	568	3922	0	4490	173	1193	6848	169	8382	1.87
1989	0	1335	3361	145	4841	298	1110	1350	266	3024	0.62
1990	417	622	3549	48	4637	0	1012	2124	0	3137	0.68
1991	0	1376	856	38	2269	0	797	507	0	1304	0.57
1992	72	1236	1675	16	3000	266	1775	1475	0	3516	1.17
1993	0	1113	2655	94	3861	254	1087	1343	0	2683	0.69
1994	0	993	1975	0	2969	621	814	1076	0	2511	0.85
1995	0	2697	4861	33	7591	3214	2276	2927	48	8466	1.12
1996	31	3638	3528	108	7305	2028	5927	3205	110	11271	1.54
1997	0	1375	1865	0	3239	512	1196	1652	78	3439	1.06
1998	17	6134	7642	15	13807	1818	6114	4374	0	12306	0.89
1999	54	2947	1848	0	4849	1487	1835	1041	0	4363	0.90
2000	250	3536	2390	30	6206	2538	3974	1309	0	7821	1.26
2001	116	996	1895	14	3021	852	1309	838	38	3037	1.01
2002	80	5533	2499	46	8158	2312	2874	1157	22	6365	0.78
2003	60	761	665	50	1537	509	1100	490	24	2123	1.38
2004	43	3806	1383	0	5233	1290	2182	889	0	4360	0.83
2005	115	1685	856	30	2686	1024	1249	318	19	2610	0.97
2006	25	2569	1103	24	3721	3627	2184	735	0	6546	1.76
2007	0	932	2143	78	3153	827	1451	936	64	3278	1.04
2008	7	3333	1746	80	5166	2013	2895	1404	0	6311	1.22
2009	24	1746	1355	150	3274	2002	1883	371	0	4257	1.30
2010	26	5578	2519	16	8139	3096	4828	1325	0	9249	1.14
2011	0	2579	656	0	3235	2693	1789	233	0	4714	1.46
2012	150	1197	1339	27	2713	1027	1034	377	23	2460	0.91
2013	0	2620	372	132	3124	995	1668	318	0	2982	0.95
2014	262	2762	1646		4670	3283	2182	307		5772	
2015	239	1514			1753	750	613			1364	
2016	0				0	565				565	

1977 to 1979 and 2014 to 2016 brood years have incomplete sampling of returns.

Table 16. Adipose fin clip incidence and hatchery contributions to escapements by gender and river reach for Kitsumkalum Chinook salmon 1985 to 2020.

Year	Upper River Males							Upper River Females						
	Total fish Obs. tagging	Ad. Clips Obs. tagging	Clipped fish killed	Total fish Obs. DP	Ad. Clip Obs. DP	Escape-ment. Estimate	Ad. Clip Contrib-ution	Total fish Obs. tagging	Ad. Clips Obs. tagging	Clipped fish killed	Total fish Obs. DP	Ad. Clip Obs. DP	Escape-ment. Estimate	Ad. Clip Contrib-ution
1985	458	12		139	4	2,185	59	246	10		330	4	1,874	46
1986	464	12		322	5	2,542	55	300	7		480	11	1,534	35
1987	523	7		216	4	3,116	46	309	2	0	306	6	3,317	43
1989	449	1		214	2	3,057	14	332	1		378	0	3,261	5
1990	417	6		290	2	1,894	21	264	6	0	326	2	1,972	27
1991	527	uk		339	2	1,739	10	287	uk	0	486	7	2,104	30
1992	454	16		71	6	1,290	54	273	0	0	199	2	1,308	6
1993	390	14		254	11	2,644	103	277	13	0	451	20	2,828	128
1994	460	8		323	2	2,009	26	329	2	0	666	6	2,428	20
1995	217	2		218	0	1,626	7	445	8	0	95	4	1,171	26
1996	175	4		35	0	766	15	112	3	0	101	0	949	13
1997	160	5		25	3	595	26	130	3	0	105	2	539	11
1998	302	19		45	1	1,261	73	190	18		54	3	670	58
1999	412	21		172	6	1,313	61	286	6		273	6	1,411	30
2000	447	18		81	5	1,272	55	216	15		149	13	1,028	79
2001	298	16		85	1	1,152	51	214	7		143	6	897	33
2002	298	16		85	1	1,352	60	214	7		143	6	1,345	49
2003	364	11		425	2	1,160	19	157	1		147	2	1,029	10
2004	471	9		170	6	2,940	69	196	3		523	8	2,858	44
2005	482	38		320	33	2,241	198	181	8		589	29	4,185	201
2006	414	40		134	13	1,410	136	138	19		249	11	1,015	79
2007	282	25	7	65	8	1,329	126	75	9	6	115	6	807	64
2008	257	20	8	48	5	823	67	101	10	8	140	8	1,356	101
2009	345	20	6	112	8	1,006	62	139	6	6	142	7	825	38
2010	466	25	24	79	4	1,967	105	219	18	18	263	18	2,937	219
2011	448	40	38	239	20	2,096	183	187	16	16	296	15	1,040	67
2012	205	10	10	22	1	611	30	78	5	5	48	3	335	21
2013	219	19	19	98	5	1,588	120	66	6	6	124	2	569	24
2014	554	29	29	266	6	2,383	102	246	11	11	300	2	1,495	36
2015	427	32	31	330	1	2,971	130	144	9	9	234	2	1,569	46
2016	470	38	32	490	23	4,101	261	213	8	6	589	10	4,198	94
2017	293	17	17	281	6	2,200	88	210	13	0	452	17	3,017	137
2018	142	16	16	49	2	957	90	73	5	5	48	5	516	43
2019	520	63	63	314	20	3,488	347	180	25	25	137	16	1,857	240
2020	419	60	60	295	17	1,733	187	253	13	13	421	24	1,654	91

No adipose fin clips were recovered in 1984. Adipose fin clips were not recorded in the tagging event in 1991. Obs. = Observed, Ad. = Adipose, DP = Dead Pitch

Table 16 continued. Adipose fin clip incidences and hatchery contributions to escapements by gender and river reach for Kitsumkalum Chinook salmon 1985 to 2020.

Year	Lower River Males							Lower River Females						
	Total fish Obs. tagging	Ad. Clips Obs. tagging	Clipped fish killed	Total fish Obs. DP	Ad. Clip Obs. DP	Escape-ment. Estimate	Ad. Clip Contrib-ution	Total fish Obs. tagging	Ad. Clips Obs. tagging	Clipped fish killed	Total fish Obs. DP	Ad. Clip Obs. DP	Escape-ment. Estimate	Ad. Clip Contrib-ution
1985	0	0		401	2	2,629	13	0	0		760	3	2,393	9
1986	486	0		301	0	2,383	-	294	3		495	0	1,622	6
1987	442	1	0	517	0	4,845	5	325	1	0	721	0	4,271	4
1989	487	0		747	8	4,451	29	392	1		1724	6	5,084	17
1990	451	16	0	670	26	5,502	206	397	26	0	1254	39	8,455	333
1991	427	uk	0	791	25	2,942	93	384	uk	0	1229	41	4,334	145
1992	456	0	0	290	4	2,700	14	332	1	0	595	10	3,970	47
1993	503	7	0	273	5	3,182	49	293	7	0	471	18	2,226	73
1994	485	7	0	507	2	4,133	37	440	4	0	1179	8	4,611	34
1995	330	1	0	583	3	6,702	29	451	1	0	334	2	4,504	17
1996	337	7	0	174	1	1,766	28	319	6	0	511	6	3,035	44
1997	318	6	0	130	4	2,857	64	331	6	0	490	10	4,604	90
1998	382	24		84	3	1,275	74	229	21		170	21	1,470	155
1999	478	19		252	12	1,871	79	269	17		351	19	1,415	82
2000	540	8		245	11	4,098	99	281	13		394	27	2,636	156
2001	742	11		496	10	4,228	72	573	19		989	26	3,901	112
2002	742	11		496	10	8,015	136	573	19		989	26	7,154	206
2003	639	23		399	9	5,106	157	371	26		883	14	3,924	125
2004	527	16		376	5	6,424	149	333	8		682	16	5,302	125
2005	573	25		513	20	6,584	273	300	23		568	19	6,654	322
2006	581	11		366	7	4,456	85	323	5		735	9	4,500	60
2007	350	9	7	276	14	3,601	132	203	8	7	530	16	2,659	87
2008	321	19	5	145	8	3,398	197	305	20	7	389	17	6,162	329
2009	433	23	7	112	7	2,579	142	262	6	6	253	18	2,493	116
2010	303	31	31	129	16	1,751	190	158	27	27	168	19	1,695	239
2011	437	28	28	297	11	3,692	196	122	17	17	288	28	2,104	231
2012	238	15	15	159	15	2,718	205	168	8	8	293	3	3,091	74
2013	321	11	11	232	5	2,631	76	149	9	9	342	7	1,503	49
2014	306	40	40	370	8	3,449	245	134	5	4	396	11	4,028	122
2015	236	41	41	283	2	3,476	288	127	10	9	207	2	2,026	73
2016	438	97	86	383	18	3,792	531	209	38	35	383	15	2,815	252
2017	295	48	47	221	5	1,941	199	205	39	38	251	12	2,380	266
2018	249	67	67	145	22	1,305	295	104	15	15	141	10	1,354	138
2019	277	38	38	272	31	1,840	231	212	80	80	290	28	2,365	509
2020	162	29	29	223	16	1,541	180	148	35	35	334	30	1,746	235

No adipose fin clips were recovered in 1984. Adipose fin clips were not recorded in the tagging event in 1991.
Obs. = Observed, Ad. = Adipose, DP = Dead Pitch, Esc. = Escapement, Est. = Estimate

Table 17. Hatchery contribution (HC), pNOS, pNOB, pHOS and PNI for Kitsumkalum Chinook salmon 1984 to 2020.

Return Year	Total return year HC	HC as % of total Esc.	Un-marked HC	% Un-marked HC	pNOS	pNOB	pHOS	PNI
1984	0	0%	0	0	100%	100%	0	100.0%
1985	183	2.0%	56	0.62%	99.38%	100%	2.01%	97.4%
1986	169	2.1%	73	0.90%	99.10%	100%	2.09%	
1987	175	1.1%	82	0.53%	99.47%	100%	1.13%	98.4%
1988	74	0.5%	14	0.09%	99.91%	100%	0.47%	99.4%
1989	588	3.3%	1	0.01%	99.99%	100%	3.30%	96.8%
1990	285	2.6%	7	0.06%	99.94%	99.80%	2.56%	97.6%
1991	140	1.5%	24	0.26%	99.74%	99.37%	1.51%	98.9%
1992	412	3.8%	59	0.54%	99.46%	99.26%	3.78%	96.5%
1993	128	1.0%	11	0.08%	99.92%	99.55%	0.97%	99.4%
1994	81	0.6%	9	0.06%	99.94%	99.92%	0.58%	99.4%
1995	81	1.2%	9	0.14%	99.86%	99.98%	1.24%	98.7%
1996	193	2.2%	21	0.24%	99.76%	99.87%	2.24%	97.7%
1997	374	8.0%	15	0.32%	99.68%	99.57%	8.00%	92.7%
1998	255	4.3%	3	0.05%	99.95%	99.68%	4.25%	96.2%
1999	395	4.4%	6	0.06%	99.94%	99.90%	4.38%	95.8%
2000	271	2.7%	3	0.03%	99.97%	99.87%	2.66%	97.5%
2001	455	2.5%	4	0.02%	99.98%	99.80%	2.55%	97.7%
2002	318	2.8%	7	0.06%	99.94%	99.77%	2.84%	97.4%
2003	388	2.2%	1	0.01%	99.99%	99.89%	2.22%	97.9%
2004	999	5.1%	4	0.02%	99.98%	99.95%	5.08%	95.2%
2005	361	3.2%	2	0.02%	99.98%	99.96%	3.17%	96.9%
2006	411	4.9%	1	0.01%	99.99%	99.97%	4.89%	95.4%
2007	704	6.0%	10	0.09%	99.91%	99.95%	6.00%	94.3%
2008	370	5.4%	12	0.17%	99.83%	99.96%	5.35%	94.8%
2009	788	9.4%	34	0.41%	99.59%	99.98%	9.44%	91.0%
2010	700	7.8%	23	0.26%	99.74%	99.98%	7.84%	92.5%
2011	341	5.1%	11	0.17%	99.83%	99.98%	5.05%	95.1%
2012	274	4.4%	5	0.07%	99.93%	99.92%	4.35%	95.8%
2013	518	4.6%	14	0.13%	99.87%	99.81%	4.56%	95.7%
2014	549	5.5%	13	0.13%	99.87%	99.72%	5.47%	94.9%
2015	1197	8.0%	59	0.40%	99.60%	99.74%	8.03%	92.4%
2016	748	7.8%	57	0.60%	99.40%	99.80%	7.84%	92.3%
2017	634	15.3%	68	1.65%	98.35%	99.89%	15.34%	85.3%
2018	1471	15.4%	143	1.50%	98.50%	99.88%	15.40%	85.4%
2019	732	11.0%	39	0.59%	99.41%	99.83%	10.98%	89.7%
2020	509	10.7%	25	0.52%	99.48%	99.66%	10.66%	90.2%

Table 18. CWT and scale age data for samples collected from Kitsumkalum female hatchery Chinook salmon 1997 to 2020.

Year	Female Hatchery Chinook salmon Age (Gilbert-Rich)												
	3_1	3_2	$4_?$	4_1	4_2	$5_?$	5_1	5_2	$6_?$	6_1	6_2	7_3	Total
1997							1	7	6		25		39
1998			1	2		6	2	8	5		14	1	39
1999						14	13	11	3		12		53
2000					3	3	2	7		1	4		20
2001			1				2	29	1		2		35
2002						1	16	0	1		5		23
2003						1	6	24		1	2		34
2004					2	14	4	37	2		2		61
2005							1	24	1	1	6		33
2006					1		7	16	1		5		30
2007			1	3	2	2		25			9		42
2008					2		8	20			5		35
2009		2	1	4	2	3	2	47		1	17		79
2010			1		4	4	41	6			16		72
2011				2			4	10			2		18
2012						1	9	12		2	0		24
2013							1	20			4		25
2014							1	8			7		16
2015			1	8		2		55			2		68
2016	1					5	20	39	3		10		78
2017				1	2		1	13			12		29
2018				2	11		9	98			11		131
2019			3	20		10	4	37	2		16		92
2020						18	3	8			0		29
Total	1	2	9	42	29	84	157	561	25	6	188	1	1,105

Subscript ? indicates a CWT recovery where the total age was known from CWT's but the freshwater age could not be determined.

Table 19. CWT and scale age data for samples collected from Kitsumkalum male hatchery Chinook salmon 1984 to 2020.

Year	Male Hatchery Chinook salmon Age (Gilbert-Rich)													
	$3_?$	3_1	3_2	$4_?$	4_1	4_2	$5_?$	5_1	5_2	$6_?$	6_1	6_2	7_2	Total
1997	0	3	0	0	0	4	0	0	12	2	0	13	0	34
1998	0	0	0	1	5	0	1	5	11	1	0	3	0	27
1999	0	1	1	4	0	1	7	6	4	3	0	8	0	35
2000	1	0	1	2	1	19	2	0	4	3	0	1	1	35
2001	0	0	0	1	1	2	0	2	17	0	0	1	0	24
2002	0	0	0	0	0	4	0	11	3	1	0	4	0	23
2003	0	0	0	0	1	2	1	2	15	1	0	1	0	23
2004	0	0	0	0	0	33	14	3	15	1	0	2	0	68
2005	0	0	3	0	0	5	0	0	18	0	0	7	0	33
2006	0	4	1	0	0	6	0	4	13	0	0	7	0	35
2007	0	0	15	0	6	3	0	1	12	0	0	2	0	39
2008	0	2	0	0	1	10	1	11	4	0	0	2	0	31
2009	1	2	1	4	23	2	0	2	35	0	0	7	0	77
2010	2	4	1	2	4	48	3	19	9	0	0	7	0	99
2011	0	0	1	0	6	4	0	5	9	0	1	0	0	26
2012	0	3	6	0	1	17	0	6	11	0	0	0	0	44
2013	0	0	16	0	6	35	0	0	20	0	0	1	0	78
2014	1	9	5	1	1	48	0	2	9	0	0	1	0	77
2015	3	4	1	16	15	61	5	1	57	0	0	0	0	163
2016	3	3	25	0	4	13	2	7	36	0	0	6	0	99
2017	0	0	7	0	3	68	0	2	19	0	0	3	0	102
2018	0	22	18	0	4	34	0	3	47	0	0	1	0	129
2019	0	2	2	14	52	19	1	1	17	1	0	4	0	113
2020	11	2	3	2	2	14	5	4	2	0	0	1	0	46
Total	22	61	107	47	136	452	42	97	399	13	1	82	1	1,460

Subscript ? indicates a CWT recovery where the total age was known from CWT’s but the freshwater age could not be determined.

Table 20. Hatchery contribution by brood year and age for Kitsumkalum Chinook salmon 1979 to 2016.

Brood Year	Hatchery Chinook salmon				
	Age 4	Age 5	Age 6	Age 7	Total
1979			38		38
1980		109	43		153
1981	36	126	175	25	362
1982					0
1983		31	37		68
1984	14	502	164		680
1985	49	117	48		215
1986	4	29	20		52
1987	63	392	68		523
1988		60	60		120
1989			28		28
1990	22	53	62		136
1991		117	181		298
1992	33	178	86		296
1993	15	126	75		216
1994	44	305	51		400
1995	15	108	34		157
1996	112	375	89		575
1997	46	195	36		277
1998	35	323	68		425
1999	30	694	90		814
2000	238	240	91		568
2001	31	265	112		408
2002	55	419	21		495
2003	173	252	137		562
2004	96	479	96		671
2005	172	352			523
2006	253	262	7		522
2007	79	165	37		282
2008	102	307	53		462
2009	174	142	11		328
2010	354	620	85		1059
2011	566	591	76		1233
2012	71	186	75		333
2013	372	1065	106		1542
2014	331	244			574
2015	383	420			803
2016	89				89

There were no CWT releases of summer run Kitsumkalum Chinook salmon from the 1982 brood year.

Table 21. Kitsumkalum Chinook salmon CWT recoveries of fry releases (KLM) by major fishery group and escapement.

Brood Year	ALASKA						CANADA										TOTAL	
	COMMERCIAL TROLL		MARINE SPORT		OTHER		COMMERCIAL TROLL		COMMERCIAL NET		MARINE SPORT		FW SPORT		ESCAPEMENT			
	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.
1979	10	36	2	7	1	4	0	0	2	8	0	0	0	0	5	35	20	90
1980	10	45	0	0	0	0	8	38	13	56	0	0	1	5	20	107	52	252
1981	12	51	0	0	0	0	11	41	6	24	1	5	0	0	44	185	74	307
1983	6	17	1	3	0	0	0	0	5	18	1	6	0	0	11	68	24	112
1984	40	121	7	68	1	2	15	54	38	120	6	39	8	49	78	677	193	1131
1985	21	63	3	17	1	1	11	42	15	41	6	24	8	42	44	211	109	441
1986	5	15	0	0	0	0	0	0	6	15	0	0	1	5	7	47	19	82
1987	50	129	3	13	0	0	21	95	41	111	11	41	2	8	62	440	190	837
1988	10	24	1	5	1	2	6	20	14	42	3	10	0	0	11	111	46	214
1989	3	9	0	0	0	0	2	6	11	28	1	2	2	8	1	28	20	81
1990	10	24	1	5	0	0	2	7	10	22	3	10	2	7	8	112	36	188
1991	22	53	5	42	0	0	2	5	53	115	8	30	11	34	43	276	144	554
1992	30	74	5	50	0	0	0	0	24	49	4	11	3	11	64	291	130	486
1993	12	34	3	18	1	1	0	0	9	15	6	33	4	18	49	216	84	334
1994	31	86	11	57	0	0	0	0	9	12	7	42	2	7	80	393	140	597
1995	10	28	5	22	0	0	0	0	9	18	2	28	1	5	25	155	52	256
1996	18	42	12	46	0	0	0	0	22	41	5	31	6	28	42	250	105	439
1997	42	119	12	44	0	0	3	14	29	46	15	102	3	14	37	269	141	607
1998	30	95	2	8	1	1	5	39	5	8	3	32	4	18	52	424	102	626
1999	25	97	10	39	4	25	4	8	6	15	6	64	3	14	51	443	109	705
2000	11	37	5	17	0	0	4	8	3	4	2	13	2	9	20	118	47	205
2001	10	40	2	7	2	10	4	9	6	13	2	16	3	14	24	167	53	275
2002	18	52	4	21	2	3	4	10	8	18	5	37	1	5	13	125	55	270
2003	20	57	3	20	0	0	3	8	15	37	9	68	11	51	45	290	106	531
2004	8	19	2	4	0	0	1	3	3	9	3	32	1	5	34	183	52	255
2005	37	101	20	62	4	19	10	29	12	26	38	174	7	32	116	502	244	944
2006	13	42	4	7	0	0	2	7	3	12	8	42	3	14	38	233	71	357
2007	17	50	7	8	2	2	1	4	4	7	9	38	1	5	41	193	82	307
2008	8	23	1	1	1	2	3	9	4	20	5	23	3	15	21	134	46	228
2009	6	17	4	7	0	0	2	6	2	2	4	15	2	11	48	173	68	231
2010	9	26	2	2	1	8	0	0	0	0	4	21	3	16	34	187	53	260
2011	31	78	10	24	9	36	7	26	0	0	23	123	6	44	106	502	192	833
2012	4	8	0	0	1	3	1	4	0	0	5	30	1	6	21	94	33	145
2013	13	31	2	5	0	0	4	14	0	0	6	49	1	9	41	208	67	317
2014	2	6	1	4	1	1	1	3	0	0	2	9	0	0	21	96	28	119
2015	10	24	5	8	4	6	1	3	0	0	13	87	0	0	138	489	171	617

There were no CWT releases from the 1982 brood year. 2013 is the last complete brood year.
Obs. = observed, Est. = estimated.

Table 22. Kitsumkalum Chinook salmon CWT recoveries of yearling releases (KLY) by major fishery group and escapement.

Brood Year	ALASKA						CANADA										TOTAL	
	COMMERCIAL TROLL		MARINE SPORT		OTHER		COMMERCIAL TROLL		COMMERCIAL NET		MARINE SPORT		FW SPORT		ESCAPEMENT			
	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.
1996	22	50	6	26	0	0	3	7	42	89	12	67	4	18	40	322	129	580
1997																		
1998																		
1999	23	75	5	14	1	1	12	31	1	5	7	59	5	23	50	367	104	576
2000	65	236	17	67	1	6	15	29	8	19	11	82	9	42	68	448	194	930
2001	27	98	6	19	1	3	7	15	11	24	5	39	4	18	28	240	89	457
2002	35	108	4	19	2	26	5	12	17	41	11	94	4	18	34	367	112	684
2003	32	85	12	60	0	0	1	3	46	126	17	126	8	37	39	254	155	692
2004	48	124	19	48	0	0	3	9	30	90	20	83	10	46	90	456	220	857
2005																		
2006	24	74	4	4	1	3	5	16	7	20	10	48	1	5	45	272	97	442
2007	18	53	3	5	0	0	0	0	3	3	6	34	3	14	16	86	49	195
2008	18	49	2	3	0	0	1	3	5	5	12	48	3	14	39	316	80	439
2009	10	33	0	0	2	7	2	8	4	4	4	14	4	18	21	140	47	225
2010	52	154	33	51	4	10	5	19	0	0	38	110	21	117	157	863	310	1324
2011	18	53	11	19	9	38	5	19	0	0	12	52	4	24	112	624	171	831
2012	7	18	7	11	1	0	2	8	0	0	2	10	2	18	30	185	51	251
2013	16	38	9	19	8	1	6	21	0	0	30	158	5	44	226	1177	300	1459
2014	10	27	6	6	2	2	0	0	1	3	12	70	1	9	91	451	123	568
2015	3	8	2	2	2	3	0	0	0	0	3	39	0	0	29	273	39	325
2016	4	7	1	2	0	4	0	0	0	0	0	0	0	0	16	70	21	83

There were no CWT releases of yearlings from brood years 1997, 1998 or 2005. 2013 is the last complete brood year.
Obs. = observed, Est. = estimated.

Table 23. Percent distribution of Kitsumkalum River total fishing mortalities and escapement for fry releases (KLM) in adult equivalents.

Catch Year	Est # of CWT	Ages	AABM Fishery						ISBM Fishery			Terminal	
			SEAK			NBC		WCVI	NBC & CBC			S	Esc.
			T	N	S	T	S	T	T	N	S		
1982	8	3	Failed Criteria		-	-	-	-	-	-	-	-	-
1983	29	3,4	31.0	10.3	0.0	10.3	0.0	0.0	0.0	48.3	0.0	0.0	0.0
1984	82	3,4,5	57.3	0.0	0.0	18.3	0.0	0.0	0.0	24.4	0.0	0.0	0.0
1985	228	4,5,6	25.0	0.0	1.3	7.0	0.0	0.0	0.0	11.0	0.0	0.0	55.7
1986	173	3,5,6	12.7	0.0	0.0	17.3	0.0	0.0	0.0	11.0	0.0	2.9	56.1
1987	201	3,4,6	17.4	0.0	3.5	12.9	0.5	0.0	0.0	9.0	2.5	2.5	51.7
1988	177	3,4,5	27.7	1.7	5.1	8.5	0.6	0.0	0.0	20.9	3.4	3.4	28.8
1989	966	3,4,5,6	12.5	0.6	6.0	4.6	1.6	0.0	0.0	9.3	1.6	3.0	60.9
1990	520	3,4,5,6	14.2	0.0	3.8	9.6	1.0	0.0	0.4	8.3	1.3	7.9	53.5
1991	329	3,4,5,6	20.1	0.0	4.3	10.9	4.0	0.0	0.9	14.9	3.0	6.4	35.6
1992	639	3,4,5,6	16.4	0.0	2.0	8.5	3.9	0.5	0.0	9.9	2.0	1.4	55.4
1993	237	3,4,5,6	11.8	2.1	2.1	11.4	3.0	0.0	0.0	18.1	1.3	0.0	50.2
1994	131	3,4,5,6	13.7	0.0	0.0	6.1	3.8	0.0	0.0	18.3	2.3	0.0	55.7
1995	197	3,4,5,6	13.7	0.0	3.6	10.7	2.5	0.0	0.0	27.4	0.5	4.6	37.1
1996	404	3,4,5,6	13.9	0.2	8.7	0.2	0.5	0.0	0.0	23.3	1.7	4.0	47.5
1997	616	3,4,5,6	12.7	0.0	9.4	0.0	3.7	0.0	0.0	8.1	2.1	5.4	58.6
1998	359	3,4,5,6	15.3	0.0	4.7	0.0	0.6	0.0	0.0	1.7	2.2	5.0	70.5
1999	669	3,4,5,6	13.9	0.0	10.8	0.0	12.3	0.0	0.0	2.2	0.6	1.5	58.7
2000	309	3,4,5,6	10.4	0.0	11.3	0.0	9.1	0.0	0.0	8.1	0.0	3.9	57.3
2001	426	3,4,5,6	16.0	0.0	14.8	0.9	0.0	0.0	0.0	13.4	6.6	3.5	44.6
2002	654	3,4,5,6	23.1	0.6	8.4	2.4	9.5	0.0	0.0	5.0	9.0	3.2	38.7
2003	567	3,4,5,6	17.5	0.0	1.4	7.1	3.0	0.0	0.0	0.5	3.7	3.7	63.1
2004	766	3,4,5,6	9.9	4.0	5.7	1.0	13.1	0.0	0.0	1.6	0.0	1.3	63.3
2005	244	3,4,5,6	23.4	0.0	3.7	4.1	11.1	0.0	0.0	0.0	0.0	8.6	49.2
2006	258	3,4,5,6	17.1	4.7	5.0	3.5	7.8	0.0	0.0	7.4	0.0	6.2	48.4
2007	452	3,4,5,6	16.4	1.1	6.6	2.0	8.0	0.0	0.0	2.4	3.3	1.1	59.1
2008	439	3,4,5,6	8.7	0.2	5.0	3.2	8.2	0.0	0.0	14.4	11.6	13.7	35.1
2009	571	3,4,5,6	15.8	3.2	6.5	1.6	5.1	0.5	0.0	0.9	4.4	0.9	60.9
2010	769	3,4,5,6	7.0	0.7	5.3	3.1	7.3	0.0	0.0	1.2	11.3	6.0	58.1
2011	413	3,4,5,6	15.7	0.0	1.5	2.4	5.1	0.0	0.0	8.7	13.8	2.4	49.9
2012	224	3,4,5,6	19.2	1.3	2.7	1.3	5.8	0.0	0.0	1.8	8.9	0.0	57.6
2013	236	3,4,5,6	10.6	0.0	3.4	6.4	1.7	0.0	0.0	0.4	7.6	2.1	67.8
2014	248	3,4,5,6	11.7	0.4	2.0	1.6	5.2	0.0	0.0	0.0	6.0	9.7	63.3
2015	461	3,4,5,6	11.3	7.6	3.3	2.8	5.0	0.0	0.0	0.0	4.3	5.9	59.9
2016	605	3,4,5,6	8.9	5.6	2.1	1.3	5.0	0.0	0.0	0.0	13.6	4.8	58.7
2017	262	3,4,5,6	10.7	0.0	2.3	6.9	1.9	0.0	0.0	0.0	24.8	3.8	49.6
2018	228	3,4,5,6	6.1	0.0	0.0	3.1	3.5	0.0	0.0	0.0	0.0	0.0	87.3
2019	490	4,5,6	6.1	4.1	2.7	0.6	3.5	0.0	0.0	0.0	9.8	0.0	73.1

Est = Estimated, SEAK = Southeast Alaska, NBC = Northern British Columbia, WCVI = West Coast of Vancouver Island, T = Troll, N = Net, S = Sport, Esc. = Escapement

Table 24. Percent distribution of Kitsumkalum River total fishing mortalities and escapement for yearling releases (KLY) in adult equivalents.

Catch Year	Est # of CWT	Ages	AABM Fishery						ISBM Fishery		Terminal	
			SEAK			NBC		WCVI	NBC & CBC		S	Esc.
			T	N	S	T	S	T	N	S		
2002	13	3	Failed Criteria		-	-	-	-	-	-	-	
2003	87	3,4	34.5	1.1	13.8	12.6	3.4	0.0	0.0	0.0	0.0	34.5
2004	870	3,4,5	19.1	0.3	3.7	3.1	7.2	0.0	2.6	1.5	3.9	58.5
2005	608	3,4,5,6	28.8	0.0	9.7	4.8	3.0	0.0	0.0	6.6	7.4	39.8
2006	517	3,4,5,6	18.2	2.3	3.5	3.3	8.3	0.0	5.0	1.2	2.9	55.3
2007	831	3,4,5,6	19.9	7.2	3.2	1.6	6.5	0.2	7.6	1.8	0.6	51.4
2008	799	4,5,6	12.1	0.0	7.0	0.8	9.3	0.0	24.3	14.6	6.1	25.8
2009	648	3,5,6	14.5	0.0	7.7	1.2	4.9	0.0	0.3	4.9	3.7	62.3
2010	393	3,4,6	13.0	0.3	2.8	2.5	3.3	0.0	2.5	10.7	6.4	58.5
2011	261	3,4,5	21.8	1.1	1.9	3.4	4.6	0.0	4.2	11.1	3.8	47.9
2012	340	3,4,5,6	28.2	0.0	2.1	0.9	2.6	0.0	2.1	16.5	6.5	41.2
2013	450	3,4,5,6	9.1	0.2	0.7	0.7	2.9	0.0	0.9	4.4	5.3	75.8
2014	586	3,4,5,6	18.1	3.1	1.0	2.9	3.1	0.0	0.0	2.4	4.3	65.2
2015	1273	3,4,5,6	9.9	1.0	3.9	1.3	5.9	0.0	0.0	3.4	6.9	67.7
2016	592	3,4,5,6	5.2	6.8	4.2	3.4	5.9	0.0	0.0	6.8	10.8	56.9
2017	662	3,4,5,6	4.7	4.8	4.1	3.3	2.9	0.0	0.5	6.5	7.6	65.7
2018	1312	3,4,5,6	2.8	0.2	1.1	0.5	3.7	0.0	0.0	4.8	0.0	86.1
2019	477	4,5,6	4.2	8.0	0.8	0.0	4.4	0.0	0.0	11.7	0.0	70.9

Est = Estimated, SEAK = Southeast Alaska, NBC = Northern British Columbia, WCVI = West Coast of Vancouver Island, T = Troll, N = Net, S = Sport, Esc. = Escapement

Table 25. Spawning escapement (stock) and total production by age (recruits) for Kitsumkalum Chinook salmon 1984 to 2015.

Brood year	Spawning Escapement	Age 4 Recruits	Age 5 Recruits	Age 6 Recruits	Total Recruits	Recruits per spawner
1984	9,535	4,479	3,945	11,552	19,975	2.1
1985	9,048	74	3,160	17,187	20,421	2.3
1986	8,046	3,486	4,690	6,279	14,456	1.8
1987	15,516	1,631	6,604	18,286	26,521	1.7
1988	15,823	569	3,235	16,361	20,165	1.3
1989	17,782	711	5,732	9,946	16,389	0.9
1990	11,089	687	2,699	9,012	12,397	1.1
1991	9,237	0	4,217	1,977	6,194	0.7
1992	10,841	796	4,291	4,480	9,568	0.9
1993	13,148	404	2,523	8,059	10,985	0.8
1994	13,972	924	2,029	4,190	7,143	0.5
1995	6,476	6,606	7,954	13,831	28,391	4.4
1996	8,568	4,849	20,204	17,434	42,488	5.0
1997	4,647	1,310	5,600	6,094	13,003	2.8
1998	5,981	4,447	16,943	17,031	38,421	6.4
1999	9,000	3,079	5,818	5,380	14,276	1.6
2000	10,141	3,557	13,472	9,138	26,167	2.6
2001	17,830	2,199	3,475	2,724	8,397	0.5
2002	11,189	5,837	15,950	6,256	28,043	2.5
2003	17,492	388	3,559	1,482	5,429	0.3
2004	19,633	2,909	5,993	4,830	13,731	0.7
2005	11,340	1,818	4,127	2,391	8,336	0.7
2006	8,368	4,774	7,341	2,863	14,978	1.8
2007	11,709	1,338	3,339	3,258	7,935	0.7
2008	6,862	4,172	7,959	5,714	17,845	2.6
2009	8,307	2,775	4,475	2,507	9,756	1.2
2010	8,890	3,175	15,052	5,303	23,530	2.6
2011	6,706	2,899	5,844	875	9,619	1.4
2012	6,264	1,629	2,856	1,570	6,055	1.0
2013	11,311	1,306	6,249	1,105	8,660	0.8
2014*	9,994	3,267	6,288		9,555	2.1
2015*	14,854	1,636			1,636	2.3

* Incomplete broods.

Table 26. Akaike Information Criterion (AIC) estimates for the three Ricker models considered in the stock recruit analyses of Kitsumkalum Chinook salmon data.

Model	AIC	DeltaAIC
Ricker	54.46670	0
Time-varying productivity	59.19732	4.730617
Autocorrelation in recruitment	56.38529	1.918591

Table 27. Parameter estimates produced by the simple Ricker model for complete brood years of Kitsumkalum Chinook salmon stock-recruit data, 1984 to 2013.

MLE = maximum likelihood estimation

Parameters	MLE	Median	2.5% quantile	97.5% quantile
α	5.07	4.70	2.38	8.77
β	0.000120	0.000113	0.0000538	0.000168
σ	0.54	0.57	0.45	0.76
S_{MSY}	5,214	5,315	4,394	7,512
U_{MSY}	0.63	0.61	0.38	0.76
S_{eq}	13,492	13,658	11,750	17,710
S_{Gen}	1,187	1,321	570	3,569
$85\%\ S_{MSY}$	4,431	4,518	3,734	6,385
$U_{85\%Smsy}$	0.66	0.64	0.42	0.78
$25\%\ S_{MSY}$	1,303	1,328	1,098	1,878

APPENDICES

Appendix 1. Kitsumkalum Chinook salmon output from program MARK / POPAN analyses of mark-recapture data collected from 1984 to 2020.

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
--						
1984	1984 tg 72 F,M					
1984	{p(g) s(t) b(t g)}	622.394	0	0.86239	1	22
1984	{p(g) s(g) b(t g)}	626.104	3.71	0.13492	0.1564	18
1984	{p(g) s(t g) b(t g)}	633.957	11.56	0.00266	0.0031	28
1984	{p(*) s(t g) b(t g)}	642.766	20.37	0.00003	0	27
1984	{p(t g) s(t g) b(t g)}	654.884	32.49	0	0	40
1984	{p(fix-t) s(t g) b(t g)}	655.424	33.03	0	0	33
1984	{p(fix-t g) s(t g) b(t g)}	655.501	33.11	0	0	40
--						
1985	1985 tgr 722 LM,LF,UM,UF					
1985	{p(fix-t r) s(g r) b(t g r)}	2798.108	0	0.55591	1	46
1985	{p(fix-t r) s(g) b(t g r)}	2798.583	0.48	0.43832	0.7885	44
1985	{p(fix-t r) s(g r) b(t g)}	2807.757	9.65	0.00446	0.008	34
1985	{p(fix-t r) s(t g) b(t g r)}	2810.248	12.14	0.00128	0.0023	54
1985	{p(fix-t r) s(t g r) b(t g r)}	2818.729	20.62	0.00002	0	66
1985	{p(fix-t r) s(*) b(t g r)}	2828.649	30.54	0	0	43
1985	{p(fix-t) s(t g r) b(t g r)}	2843.15	45.04	0	0	59
1985	{p(fix-t g) s(t g r) b(t g r)}	2850.697	52.59	0	0	66
1985	{p(fix-t r) s(g r) b(t r)}	2850.908	52.8	0	0	34
1985	{p(t g r) s(t g r) b(t g r)}	2851.326	53.22	0	0	80
1985	{p(fix-t r) s(t) b(t g r)}	2851.983	53.88	0	0	48
1985	{p(fix-t g r) s(t g r) b(t g r)}	2852.661	54.55	0	0	80
1985	{p(fix-t r) s(t r) b(t g r)}	2860.898	62.79	0	0	54
1985	{p(g r) s(t g r) b(t g r)}	3044.705	246.6	0	0	56
1985	{p(*) s(t g r) b(t g r)}	3058.727	260.62	0	0	53
1985	{p(fix-t r) s(r) b(t g r)}	3218.135	420.03	0	0	44

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
----------						
1986	1986 tgr 722 LM,LF,UM,UF					
1986	{p(fix-t g r) s(t g) b(t r)}	3104.797	0	0.89899	1	56
1986	{p(fix-t g r) s(t g) b(t g)}	3109.424	4.63	0.08892	0.0989	56
1986	{p(fix-t g r) s(t r) b(t g)}	3114.983	10.19	0.00552	0.0061	56
1986	{p(fix-t g r) s(t g r) b(t)}	3115.954	11.16	0.0034	0.0038	62
1986	{p(t g r) s(t g r) b(t g r)}	3116.671	11.87	0.00237	0.0026	80
1986	{p(fix-t g r) s(t g r) b(t g)}	3119.627	14.83	0.00054	0.0006	68
1986	{p(fix-t g r) s(t g r) b(t g r)}	3121.218	16.42	0.00024	0.0003	80
1986	{p(fix-t g r) s(t g) b(t g r)}	3127.768	22.97	0.00001	0	68
1986	{p(fix-t r) s(t g r) b(t g r)}	3130.11	25.31	0	0	66
1986	{p(g r) s(t g r) b(t g r)}	3131.813	27.02	0	0	56
1986	{p(fix-t g) s(t g r) b(t g r)}	3134.578	29.78	0	0	66
1986	{p(*) s(t g r) b(t g r)}	3135.796	31	0	0	53
1986	{p(fix-t g r) s(t r) b(t g r)}	3137.367	32.57	0	0	68
1986	{p(fix-t g r) s(t) b(t g r)}	3138.516	33.72	0	0	62
1986	{p(fix-t) s(t g r) b(t g r)}	3142.873	38.08	0	0	59
1986	{p(fix-t g r) s(g r) b(t g r)}	3178.54	73.74	0	0	60
1986	{p(fix-t g r) s(t r) b(t r)}	3191.157	86.36	0	0	56

1987	1987 tgr 622 LM,LF,UM,UF					
1987	{p(fix-t g r) s(t r) b(t g)}	1959.039	0	0.83711	1	48
1987	{p(fix-t g r) s(t g) b(t r)}	1962.313	3.27	0.16289	0.1946	48
1987	{p(fix-t g r) s(t r) b(t g r)}	1991.544	32.5	0	0	58
1987	{p(fix-t g r) s(t g) b(t g r)}	1994.435	35.4	0	0	58
1987	{p(fix-t g r) s(t) b(t g r)}	1996.384	37.34	0	0	53
1987	{p(fix-t g r) s(t g r) b(t g r)}	2006.946	47.91	0	0	68
1987	{p(fix-t g) s(t r) b(t g r)}	2011.876	52.84	0	0	46
1987	{p(t g r) s(t g r) b(t g r)}	2014.498	55.46	0	0	68
1987	{p(g r) s(t g r) b(t g r)}	2020.182	61.14	0	0	48
1987	{p(fix-t r) s(t g r) b(t g r)}	2023.918	64.88	0	0	56

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
1987	{p(fix-t r) s(t g) b(t g r)}	2024.65	65.61	0	0	46
1987	{p(fix-t) s(t g r) b(t g r)}	2047.585	88.55	0	0	50
1987	{p(fix-t g) s(t g r) b(t g r)}	2050.029	90.99	0	0	56
1987	{p(fix-t g r) s(t r) b(t r)}	2057.324	98.28	0	0	48
1987	{p(fix-t g) s(t g) b(t g r)}	2059.383	100.34	0	0	46
1987	{p(fix-t r) s(t r) b(t g r)}	2090.548	131.51	0	0	46
1987	{p(*) s(t g r) b(t g r)}	2143.262	184.22	0	0	45
1987	{p(fix-t g r) s(t g) b(t g)}	2194.084	235.05	0	0	48

1989	1989 tgr 522 LM,LF,UM,UF					
1989	{p(fix-t r) s(t g r) b(t g r)}	2310.173	0	0.91527	1	46
1989	{p(t g r) s(t g r) b(t g r)}	2315.052	4.88	0.07984	0.0872	56
1989	{p(fix-t r) s(t g r) b(t g)}	2321.071	10.9	0.00394	0.0043	38
1989	{p(fix-t r) s(t g) b(t g r)}	2323.906	13.73	0.00095	0.001	38
1989	{p(fix-t g r) s(t g r) b(t g r)}	2341.84	31.67	0	0	56
1989	{p(fix-t r) s(t g r) b(t r)}	2352.722	42.55	0	0	38
1989	{p(*) s(t g r) b(t g r)}	2358.187	48.01	0	0	37
1989	{p(fix-t r) s(t r) b(t g r)}	2361.691	51.52	0	0	38
1989	{p(fix-t r) s(g r) b(t g r)}	2381.653	71.48	0	0	34
1989	{p(fix-t) s(t g r) b(t g r)}	2408.56	98.39	0	0	41
1989	{p(fix-t r) s(t) b(t g r)}	2421.78	111.61	0	0	34
1989	{p(fix-t g) s(t g r) b(t g r)}	2502.962	192.79	0	0	46

1990	1990 tgr 722 LM,LF,UM,UF					
1990	{p(fix-t g r) s(t) b(t r)}	3008.365	0	0.84543	1	50
1990	{p(fix-t g r) s(t) b(t g r)}	3012.409	4.04	0.1119	0.1324	62
1990	{p(fix-t g r) s(t) b(t)}	3014.342	5.98	0.04258	0.0504	44
1990	{p(fix-t g r) s(t r) b(t g r)}	3027.215	18.85	0.00007	0.0001	68
1990	{p(fix-t g r) s(t g r) b(t g r)}	3029.801	21.44	0.00002	0	80
1990	{p(fix-t g) s(t g r) b(t g r)}	3044.03	35.66	0	0	66
1990	{p(fix-t g r) s(g r) b(t g r)}	3047.43	39.07	0	0	60

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
1990	{p(fix-t r) s(t g r) b(t g r)}	3047.55	39.19	0	0	66
1990	{p(fix-t g r) s(*) b(t g r)}	3053.422	45.06	0	0	57
1990	{p(fix-t g r) s(t g) b(t g r)}	3076.303	67.94	0	0	68
1990	{p(fix-t) s(t g r) b(t g r)}	3097.036	88.67	0	0	59
1990	{p(g r) s(t g r) b(t g r)}	3130.405	122.04	0	0	56
1990	{p(fix-t g r) s(g) b(t g r)}	3139.688	131.32	0	0	58
1990	{p(fix-t g r) s(t) b(t g)}	3206.58	198.22	0	0	50
1990	{p(fix-t g r) s(r) b(t g r)}	3238.881	230.52	0	0	58
1990	{p(*) s(t g r) b(t g r)}	3346.715	338.35	0	0	53
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1991	1991 tgr 722 LM,LF,UM,UF					
1991	{p(r) s(t r) b(t g r)}	2674.898	0	0.96027	1	42
1991	{p(r) s(t g r) b(t g r)}	2681.302	6.4	0.03908	0.0407	54
1991	{p(fix-t r) s(t g r) b(t g r)}	2690.613	15.71	0.00037	0.0004	66
1991	{p(g) s(t g r) b(t g r)}	2692.951	18.05	0.00012	0.0001	54
1991	{p(fix-t g) s(t r) b(t g r)}	2694.039	19.14	0.00007	0.0001	54
1991	{p(*) s(t g r) b(t g r)}	2695.057	20.16	0.00004	0	53
1991	{p(fix-t r) s(t g) b(t g r)}	2696.645	21.75	0.00002	0	54
1991	{p(r) s(t) b(t g r)}	2697.203	22.3	0.00001	0	36
1991	{p(g r) s(t g r) b(t g r)}	2697.481	22.58	0.00001	0	56
1991	{p(t g r) s(t g r) b(t g r)}	2698.528	23.63	0.00001	0	80
1991	{p(fix-t g r) s(t g r) b(t g r)}	2699.602	24.7	0	0	80
1991	{p(r) s(g r) b(t g r)}	2705.962	31.06	0	0	34
1991	{p(r) s(t g) b(t g r)}	2706.009	31.11	0	0	42
1991	{p(fix-t r) s(t r) b(t g r)}	2714.599	39.7	0	0	54
1991	{p(r) s(r) b(t g r)}	2715.334	40.44	0	0	32
1991	{p(r) s(g) b(t g r)}	2715.503	40.6	0	0	32
1991	{p(fix-t) s(t g r) b(t g r)}	2722.141	47.24	0	0	59
1991	{p(fix-t g) s(t g r) b(t g r)}	2722.451	47.55	0	0	66
1991	{p(fix-t g) s(t g) b(t g r)}	2750.315	75.42	0	0	54
1991	{p(r) s(t r) b(t r)}	2925.848	250.95	0	0	30

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
1991	{p(r) s(t r) b(t g)}	3026.109	351.21	0	0	30
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1992	1992 tgr 722 LM,LF,UM,UF					
1992	{p(fix-t) s(g r) b(t g r)}	2324.258	0	0.67633	1	39
1992	{p(fix-t) s(g) b(t g r)}	2325.744	1.49	0.32157	0.4755	37
1992	{p(fix-t) s(t g r) b(t g r)}	2337.541	13.28	0.00088	0.0013	59
1992	{p(fix-t) s(*) b(t g r)}	2337.977	13.72	0.00071	0.001	36
1992	{p(fix-t) s(r) b(t g r)}	2339.272	15.01	0.00037	0.0005	37
1992	{p(fix-t) s(t r) b(t g r)}	2341.588	17.33	0.00012	0.0002	47
1992	{p(fix-t g) s(t g r) b(t g r)}	2346.426	22.17	0.00001	0	66
1992	{p(fix-t r) s(t g r) b(t g r)}	2347.764	23.51	0.00001	0	66
1992	{p(t g r) s(t g r) b(t g r)}	2374.515	50.26	0	0	80
1992	{p(fix-t g r) s(t g r) b(t g r)}	2374.82	50.56	0	0	80
1992	{p(fix-t) s(t g) b(t g r)}	2375.017	50.76	0	0	47
1992	{p(fix-t) s(t) b(t g r)}	2396.248	71.99	0	0	41
1992	{p(fix-t) s(g r) b(t r)}	2403.508	79.25	0	0	27
1992	{p(*) s(t g r) b(t g r)}	2460.065	135.81	0	0	53
1992	{p(g r) s(t g r) b(t g r)}	2462.251	137.99	0	0	56
1992	{p(fix-t) s(g r) b(t g)}	2593.961	269.7	0	0	27
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1993	1993 tgr 722 LM,LF,UM,UF					
1993	{p(fix-t r) s(g) b(t g r)}	3324.294	0	0.79995	1	44
1993	{p(fix-t r) s(t) b(t g r)}	3327.698	3.4	0.14589	0.1824	48
1993	{p(t g r) s(t g r) b(t g r)}	3330.904	6.61	0.02936	0.0367	80
1993	{p(fix-t r) s(g r) b(t g r)}	3331.269	6.97	0.02446	0.0306	46
1993	{p(fix-t r) s(*) b(t g r)}	3340.605	16.31	0.00023	0.0003	43
1993	{p(fix-t r) s(r) b(t g r)}	3343.203	18.91	0.00006	0.0001	44
1993	{p(fix-t) s(t g r) b(t g r)}	3344.279	19.98	0.00004	0.0001	59
1993	{p(fix-t r) s(t r) b(t g r)}	3346.703	22.41	0.00001	0	54
1993	{p(fix-t g r) s(t g r) b(t g r)}	3348.94	24.65	0	0	80
1993	{p(fix-t r) s(t g) b(t g r)}	3354.315	30.02	0	0	54

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
1993	{p(fix-t g) s(t g r) b(t g r)}	3356.762	32.47	0	0	66
1993	{p(fix-t g) s(t g) b(t g r)}	3371.18	46.89	0	0	54
1993	{p(fix-t g) s(t r) b(t g r)}	3385.008	60.71	0	0	54
1993	{p(fix-t r) s(t g r) b(t r)}	3388.354	64.06	0	0	54
1993	{p(fix-t r) s(g) b(t r)}	3436.997	112.7	0	0	32
1993	{p(fix-t r) s(g) b(t g)}	3462.594	138.3	0	0	32
1993	{p(*) s(t g r) b(t g r)}	3483.573	159.28	0	0	53
1993	{p(g r) s(t g r) b(t g r)}	3489.489	165.19	0	0	56
1993	{p(fix-t r) s(t g r) b(t g)}	3549.931	225.64	0	0	54
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1994	1994 tgr 722 LM,LF,UM,UF					
1994	{p(fix-t g) s(t r) b(t g r)}	3016.67	0	0.58189	1	54
1994	{p(fix-t g) s(t) b(t g r)}	3017.497	0.83	0.38484	0.6614	48
1994	{p(fix-t r) s(t g r) b(t g r)}	3022.526	5.86	0.03114	0.0535	66
1994	{p(fix-t r) s(t r) b(t g r)}	3029.648	12.98	0.00088	0.0015	54
1994	{p(fix-t g) s(t g) b(t g r)}	3029.796	13.13	0.00082	0.0014	54
1994	{p(fix-t) s(t g r) b(t g r)}	3031.908	15.24	0.00029	0.0005	59
1994	{p(t g r) s(t g r) b(t g r)}	3035.06	18.39	0.00006	0.0001	80
1994	{p(fix-t g r) s(t g r) b(t g r)}	3035.578	18.91	0.00005	0.0001	80
1994	{p(fix-t r) s(t g) b(t g r)}	3036.931	20.26	0.00002	0	54
1994	{p(fix-t g) s(t g r) b(t g r)}	3038.443	21.77	0.00001	0	66
1994	{p(fix-t g) s(*) b(t g r)}	3056.221	39.55	0	0	43
1994	{p(*) s(t g r) b(t g r)}	3062.474	45.8	0	0	53
1994	{p(fix-t g) s(g r) b(t g r)}	3063.58	46.91	0	0	46
1994	{p(r) s(t g r) b(t g r)}	3071.325	54.66	0	0	54
1994	{p(g r) s(t g r) b(t g r)}	3071.913	55.24	0	0	56
1994	{p(g) s(t g r) b(t g r)}	3076.695	60.03	0	0	54
1994	{p(fix-t g) s(t r) b(t r)}	3152.879	136.21	0	0	42
1994	{p(fix-t g) s(t r) b(t g)}	3189.441	172.77	0	0	42
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1995	1995 tgr 722 LM,LF,UM,UF					

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
1995	{p(fix-t g) s(t) b(t r)}	1729.387	0	0.45064	1	36
1995	{p(fix-t g) s(t) b(t g r)}	1729.434	0.05	0.44033	0.9771	48
1995	{p(fix-t g) s(t g) b(t g r)}	1732.238	2.85	0.10833	0.2404	54
1995	{p(fix-t g) s(t g r) b(t g r)}	1742.405	13.02	0.00067	0.0015	66
1995	{p(fix-t r) s(t g) b(t g r)}	1751.179	21.79	0.00001	0	54
1995	{p(fix-t g) s(t r) b(t g r)}	1751.491	22.1	0.00001	0	54
1995	{p(fix-t) s(t g r) b(t g r)}	1753.302	23.92	0	0	59
1995	{p(fix-t r) s(t) b(t g r)}	1758.046	28.66	0	0	48
1995	{p(fix-t g r) s(t g r) b(t g r)}	1759.453	30.07	0	0	80
1995	{p(fix-t r) s(t g r) b(t g r)}	1760.911	31.52	0	0	66
1995	{p(t g r) s(t g r) b(t g r)}	1761.381	31.99	0	0	80
1995	{p(fix-t r) s(t r) b(t g r)}	1773.298	43.91	0	0	54
1995	{p(*) s(t g r) b(t g r)}	1819.078	89.69	0	0	53
1995	{p(fix-t) s(t) b(t g)}	1848.781	119.39	0	0	29
1995	{p(fix-t g) s(t) b(t g)}	1852.319	122.93	0	0	36
1995	{p(fix-t r) s(t) b(t r)}	1858.003	128.62	0	0	36
1995	{p(fix-t) s(t) b(t r)}	1878.369	148.98	0	0	29
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1996	1996 tgr 622 LM,LF,UM,UF					
1996	{p(r) s(t g) b(t g r)}	1377.217	0	0.83168	1	36
1996	{p(r) s(t g r) b(t g r)}	1381.298	4.08	0.10813	0.13	46
1996	{p(g r) s(t g r) b(t g r)}	1382.495	5.28	0.05943	0.0715	48
1996	{p(r) s(t r) b(t g r)}	1392.249	15.03	0.00045	0.0005	36
1996	{p(fix-t) s(t g) b(t g r)}	1393.065	15.85	0.0003	0.0004	40
1996	{p(r) s(t g) b(t r)}	1399.936	22.72	0.00001	0	26
1996	{p(fix-t) s(t g r) b(t g r)}	1401.914	24.7	0	0	50
1996	{p(t g r) s(t g r) b(t g r)}	1409.093	31.88	0	0	68
1996	{p(g) s(t g r) b(t g r)}	1412.553	35.34	0	0	46
1996	{p(*) s(t g r) b(t g r)}	1413.411	36.19	0	0	45
1996	{p(fix-t g r) s(t g r) b(t g r)}	1416.74	39.52	0	0	68
1996	{p(fix-t g) s(t g r) b(t g r)}	1432.311	55.09	0	0	56

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
1996	{p(fix-t) s(t r) b(t g r)}	1447.988	70.77	0	0	40
1996	{p(fix-t r) s(t g r) b(t g r)}	1453.252	76.03	0	0	56
1996	{p(r) s(t g) b(t g)}	1688.378	311.16	0	0	26
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1997	1997 tgr 722 LM,LF,UM,UF					
1997	{p(g r) s(t r) b(t g r)}	1732.616	0	0.99818	1	44
1997	{p(g r) s(t r) b(t r)}	1745.335	12.72	0.00173	0.0017	32
1997	{p(g r) s(t g r) b(t g r)}	1752.662	20.05	0.00004	0	56
1997	{p(fix-t r) s(t r) b(t g r)}	1753.271	20.66	0.00003	0	54
1997	{p(fix-t r) s(t r) b(t g)}	1756.621	24	0.00001	0	42
1997	{p(*) s(t g r) b(t g r)}	1757.863	25.25	0	0	53
1997	{p(g) s(t g r) b(t g r)}	1758.766	26.15	0	0	54
1997	{p(fix-t) s(t r) b(t g r)}	1759.883	27.27	0	0	47
1997	{p(fix-t r) s(t g r) b(t g r)}	1766.306	33.69	0	0	66
1997	{p(fix-t r) s(t r) b(t r)}	1766.55	33.93	0	0	42
1997	{p(fix-t g) s(t g r) b(t g r)}	1776.309	43.69	0	0	66
1997	{p(t g r) s(t g r) b(t g r)}	1781.337	48.72	0	0	80
1997	{p(fix-t) s(t g r) b(t g r)}	1782.127	49.51	0	0	59
1997	{p(r) s(t g r) b(t g r)}	1801.101	68.48	0	0	54
1997	{p(fix-t g r) s(t g r) b(t g r)}	1804.65	72.03	0	0	80
1997	{p(g r) s(t) b(t g r)}	1810.172	77.56	0	0	38
1997	{p(g r) s(t r) b(t g)}	1811.574	78.96	0	0	32
1997	{p(g r) s(t g) b(t g r)}	1822.109	89.49	0	0	44
1997	{p(fix-t r) s(t) b(t g r)}	1842.237	109.62	0	0	48
1997	{p(fix-t) s(t g) b(t g r)}	1847.936	115.32	0	0	47
1997	{p(fix-t r) s(t g) b(t g r)}	1857.278	124.66	0	0	54
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1998	1998 tgr 722 LM,LF,UM,UF					
1998	{p(fix-t) s(t g r) b(t g r)}	2670.971	0	0.42781	1	59
1998	{p(fix-t r) s(t g r) b(t g r)}	2671.601	0.63	0.31223	0.7298	66
1998	{p(*) s(t g r) b(t g r)}	2673.022	2.05	0.1534	0.3586	53

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
1998	{p(fix-t g) s(t g r) b(t g r)}	2674.106	3.14	0.08921	0.2085	66
1998	{p(g r) s(t g r) b(t g r)}	2678.51	7.54	0.00987	0.0231	56
1998	{p(fix-t) s(t) b(t g r)}	2679.325	8.35	0.00656	0.0153	41
1998	{p(fix-t) s(t r) b(t g r)}	2683.758	12.79	0.00072	0.0017	47
1998	{p(r) s(t g r) b(t g r)}	2687.21	16.24	0.00013	0.0003	54
1998	{p(*) s(t) b(t g r)}	2689.788	18.82	0.00004	0.0001	35
1998	{p(t g r) s(t g r) b(t g r)}	2691.364	20.39	0.00002	0	80
1998	{p(*) s(t r) b(t g r)}	2691.787	20.82	0.00001	0	41
1998	{p(fix-t g r) s(t g r) b(t g r)}	2691.794	20.82	0.00001	0	80
1998	{p(*) s(t g) b(t g r)}	2696.122	25.15	0	0	41
1998	{p(fix-t) s(t r) b(t g)}	2698.662	27.69	0	0	35
1998	{p(fix-t) s(g) b(t g r)}	2706.108	35.14	0	0	37
1998	{p(g) s(t g r) b(t g r)}	2709.622	38.65	0	0	54
1998	{p(fix-t) s(g r) b(t g r)}	2710.027	39.06	0	0	39
1998	{p(fix-t) s(r) b(t g r)}	2713.378	42.41	0	0	37
1998	{p(fix-t) s(t g) b(t g r)}	2715.922	44.95	0	0	47
1998	{p(fix-t) s(t r) b(t r)}	2798.776	127.81	0	0	35
1998	{p(*) s(g) b(t g r)}	2817.107	146.14	0	0	31
1998	{p(*) s(g r) b(t g r)}	2820.967	150	0	0	33
1998	{p(*) s(r) b(t g r)}	2824.723	153.75	0	0	31
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1999	1999 tgr 722 LM,LF,UM,UF					
1999	{p(fix-t r) s(g) b(t g r)}	2272.374	0	0.65918	1	44
1999	{p(fix-t r) s(g r) b(t g r)}	2274.901	2.53	0.18631	0.2826	46
1999	{p(fix-t r) s(t g r) b(t g r)}	2275.677	3.3	0.12641	0.1918	66
1999	{p(fix-t r) s(t) b(t g r)}	2279.801	7.43	0.01608	0.0244	48
1999	{p(fix-t r) s(*) b(t g r)}	2281.539	9.17	0.00674	0.0102	43
1999	{p(fix-t r) s(t r) b(t g r)}	2282.95	10.58	0.00333	0.0051	54
1999	{p(fix-t r) s(r) b(t g r)}	2284.077	11.7	0.0019	0.0029	44
1999	{p(fix-t r) s(t g) b(t g r)}	2291.659	19.28	0.00004	0.0001	54
1999	{p(t g r) s(t g r) b(t g r)}	2295.235	22.86	0.00001	0	80

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
1999	{p(fix-t g) s(t g r) b(t g r)}	2317.173	44.8	0	0	66
1999	{p(*) s(t g r) b(t g r)}	2317.428	45.05	0	0	53
1999	{p(fix-t g) s(t r) b(t g r)}	2317.683	45.31	0	0	54
1999	{p(fix-t g r) s(t g r) b(t g r)}	2325.562	53.19	0	0	80
1999	{p(g r) s(t g r) b(t g r)}	2329.491	57.12	0	0	56
1999	{p(fix-t) s(t g r) b(t g r)}	2346.391	74.02	0	0	59
1999	{p(fix-t r) s(g) b(t r)}	2352.785	80.41	0	0	32
1999	{p(fix-t r) s(g) b(t g)}	2362.199	89.83	0	0	32
1999	{p(fix-t g) s(t g) b(t g r)}	2376.777	104.4	0	0	54
1999	{p(fix-t g) s(r) b(t g r)}	2384.986	112.61	0	0	44

2000	2000 tgr 622 LM,LF,UM,UF					
2000	{p(fix-t r) s(t g) b(t g r)}	2645.1	0	0.53501	1	46
2000	{p(fix-t g r) s(t g r) b(t g r)}	2645.673	0.57	0.40173	0.7509	68
2000	{p(fix-t r) s(t g r) b(t g r)}	2649.38	4.28	0.06295	0.1177	56
2000	{p(fix-t r) s(g) b(t g r)}	2660.082	14.98	0.0003	0.0006	38
2000	{p(g r) s(t g r) b(t g r)}	2682.804	37.7	0	0	48
2000	{p(fix-t r) s(g r) b(t g r)}	2689.673	44.57	0	0	40
2000	{p(fix-t r) s(t r) b(t g r)}	2699.14	54.04	0	0	46
2000	{p(fix-t g) s(t g r) b(t g r)}	2715.911	70.81	0	0	56
2000	{p(fix-t g) s(t r) b(t g r)}	2732.781	87.68	0	0	46
2000	{p(*) s(t g r) b(t g r)}	2746.639	101.54	0	0	45
2000	{p(fix-t r) s(r) b(t g r)}	2749.92	104.82	0	0	38
2000	{p(fix-t g) s(r) b(t g r)}	2818.322	173.22	0	0	38
2000	{p(fix-t r) s(t) b(t g r)}	2821.038	175.94	0	0	41
2000	{p(fix-t r) s(t g) b(t r)}	2862.41	217.31	0	0	36
2000	{p(fix-t r) s(t g) b(t g)}	2949.651	304.55	0	0	36
2000	{p(fix-t) s(t g r) b(t g r)}	3159.471	514.37	0	0	50

2001	2001 tgr 622 LM,LF,UM,UF					
2001	{p(fix-t r) s(t g) b(t r)}	2051.243	0	0.98318	1	36

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2001	{p(t g r) s(t g r) b(t g r)}	2059.407	8.16	0.01659	0.0169	68
2001	{p(fix-t r) s(t g) b(t g r)}	2067.929	16.69	0.00023	0.0002	46
2001	{p(fix-t r) s(g r) b(t g r)}	2090.332	39.09	0	0	40
2001	{p(fix-t g r) s(t g r) b(t g r)}	2091.24	40	0	0	68
2001	{p(fix-t r) s(t r) b(t g r)}	2120.14	68.9	0	0	46
2001	{p(fix-t r) s(t) b(t g r)}	2157.45	106.21	0	0	41
2001	{p(fix-t r) s(t g) b(t g)}	2171.163	119.92	0	0	36
2001	{p(fix-t r) s(t g r) b(t g)}	2174.921	123.68	0	0	46
2001	{p(g r) s(t g r) b(t g r)}	2292.698	241.46	0	0	48
2001	{p(*) s(t g r) b(t g r)}	2306.383	255.14	0	0	45
2001	{p(fix-t) s(t g r) b(t g r)}	2392.103	340.86	0	0	50
2001	{p(fix-t g) s(t g) b(t g r)}	2456.696	405.45	0	0	46
2001	{p(fix-t g) s(t) b(t g r)}	2522.453	471.21	0	0	41
2001	{p(fix-t g) s(t r) b(t g r)}	2556.295	505.05	0	0	46
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2002	2002 tgr 722 LM,LF,UM,UF					
2002	{p(fix-t r) s(g r) b(t g r)}	1626.413	0	0.98151	1	46
2002	{p(fix-t r) s(t g r) b(t g r)}	1634.504	8.09	0.01718	0.0175	66
2002	{p(fix-t r) s(g) b(t g r)}	1639.911	13.5	0.00115	0.0012	44
2002	{p(t g r) s(t g r) b(t g r)}	1643.952	17.54	0.00015	0.0002	80
2002	{p(fix-t r) s(r) b(t g r)}	1651.144	24.73	0	0	44
2002	{p(fix-t g) s(t g r) b(t g r)}	1652.205	25.79	0	0	66
2002	{p(fix-t g r) s(t g r) b(t g r)}	1652.653	26.24	0	0	80
2002	{p(fix-t r) s(t g) b(t g r)}	1663.756	37.34	0	0	54
2002	{p(fix-t) s(t g r) b(t g r)}	1671.721	45.31	0	0	59
2002	{p(fix-t g) s(t r) b(t g r)}	1693.228	66.82	0	0	54
2002	{p(fix-t r) s(t r) b(t g r)}	1711.286	84.87	0	0	54
2002	{p(fix-t g) s(g r) b(t g r)}	1719.01	92.6	0	0	46
2002	{p(fix-t r) s(g r) b(t r)}	1726.872	100.46	0	0	34
2002	{p(fix-t r) s(g r) b(t g)}	1738.375	111.96	0	0	34
2002	{p(fix-t r) s(t) b(t g r)}	1747.988	121.57	0	0	48

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2002	{p(fix-t g) s(g) b(t g r)}	1758.658	132.24	0	0	44
2002	{p(fix-t g) s(t g) b(t g r)}	1763.659	137.25	0	0	54
2002	{p(g r) s(t g r) b(t g r)}	1943.526	317.11	0	0	56
2002	{p(*) s(t g r) b(t g r)}	1999.396	372.98	0	0	53
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2003	2003 tgr 722 LM,LF,UM,UF					
2003	{p(fix-t r) s(t g) b(t g r)}	2175.846	0	0.59274	1	54
2003	{p(*) s(t g r) b(t g r)}	2178.575	2.73	0.15143	0.2555	53
2003	{p(g r) s(t r) b(t g r)}	2178.984	3.14	0.12343	0.2082	44
2003	{p(g) s(t g r) b(t g r)}	2180.396	4.55	0.06093	0.1028	54
2003	{p(fix-t r) s(t r) b(t g r)}	2182.027	6.18	0.02696	0.0455	54
2003	{p(g r) s(t g) b(t g r)}	2182.165	6.32	0.02516	0.0424	44
2003	{p(g r) s(t g r) b(t g r)}	2184.419	8.57	0.00815	0.0137	56
2003	{p(fix-t) s(t r) b(t g r)}	2184.64	8.79	0.0073	0.0123	47
2003	{p(r) s(t g r) b(t g r)}	2186.531	10.68	0.00284	0.0048	54
2003	{p(fix-t g) s(t r) b(t g r)}	2189.103	13.26	0.00078	0.0013	54
2003	{p(fix-t g) s(t g r) b(t g r)}	2191.897	16.05	0.00019	0.0003	66
2003	{p(t g r) s(t g r) b(t g r)}	2193.786	17.94	0.00008	0.0001	80
2003	{p(*) s(t g) b(t g r)}	2199.836	23.99	0	0	41
2003	{p(fix-t r) s(t) b(t g r)}	2201.708	25.86	0	0	48
2003	{p(fix-t g) s(t g) b(t g r)}	2203.193	27.35	0	0	54
2003	{p(fix-t g r) s(t g r) b(t g r)}	2214.33	38.48	0	0	80
2003	{p(fix-t r) s(t g r) b(t g r)}	2215.294	39.45	0	0	66
2003	{p(fix-t) s(t g) b(t g r)}	2229.265	53.42	0	0	47
2003	{p(fix-t r) s(t g) b(t r)}	2375.556	199.71	0	0	42
2003	{p(*) s(t r) b(t g)}	2507.246	331.4	0	0	29
2003	{p(fix-t r) s(t g) b(t g)}	2516.472	340.63	0	0	42
2003	{p(*) s(t r) b(t r)}	2608.56	432.71	0	0	29
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2004	2004 tgr 722 LM,LF,UM,UF					
2004	{p(g r) s(t g) b(t g r)}	2258.282	0	0.98006	1	44

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2004	{p(g r) s(t g r) b(t g r)}	2268.133	9.85	0.00712	0.0073	56
2004	{p(g r) s(t) b(t g r)}	2268.225	9.94	0.00679	0.0069	38
2004	{p(g r) s(t r) b(t g r)}	2268.71	10.43	0.00533	0.0054	44
2004	{p(r) s(t g r) b(t g r)}	2272.958	14.68	0.00064	0.0007	54
2004	{p(g) s(t g r) b(t g r)}	2277.896	19.61	0.00005	0.0001	54
2004	{p(*) s(t g r) b(t g r)}	2284.357	26.08	0	0	53
2004	{p(fix-t r) s(t g r) b(t g r)}	2286.222	27.94	0	0	66
2004	{p(t g r) s(t g r) b(t g r)}	2294.247	35.96	0	0	80
2004	{p(fix-t g r) s(t g r) b(t g r)}	2297.929	39.65	0	0	80
2004	{p(fix-t g) s(t g r) b(t g r)}	2355.453	97.17	0	0	66
2004	{p(fix-t r) s(t r) b(t g r)}	2382.775	124.49	0	0	54
2004	{p(g r) s(t g) b(t r)}	2463.364	205.08	0	0	32
2004	{p(g r) s(t) b(t g)}	2568.917	310.64	0	0	26
2004	{p(g r) s(t g) b(t g)}	2610.875	352.59	0	0	32
2004	{p(g r) s(t) b(t r)}	2621.974	363.69	0	0	26
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2005	2005 tgr 722 LM,LF,UM,UF					
2005	{p(fix-t r) s(t g) b(t g r)}	2132.404	0	0.99992	1	54
2005	{p(fix-t r) s(t g) b(t g)}	2151.363	18.96	0.00008	0.0001	42
2005	{p(t g r) s(t g r) b(t g r)}	2162.848	30.44	0	0	80
2005	{p(fix-t r) s(t g r) b(t g r)}	2178.148	45.74	0	0	66
2005	{p(fix-t r) s(t g) b(t r)}	2185.664	53.26	0	0	42
2005	{p(fix-t r) s(t r) b(t g r)}	2192.875	60.47	0	0	54
2005	{p(fix-t) s(t g r) b(t g r)}	2200.356	67.95	0	0	59
2005	{p(fix-t g r) s(t g r) b(t g r)}	2205.794	73.39	0	0	80
2005	{p(g r) s(t g r) b(t g r)}	2210.238	77.83	0	0	56
2005	{p(*) s(t g r) b(t g r)}	2238.459	106.05	0	0	53
2005	{p(fix-t g) s(t r) b(t g r)}	2253.661	121.26	0	0	54
2005	{p(fix-t) s(t r) b(t g r)}	2258.126	125.72	0	0	47
2005	{p(fix-t g) s(t g) b(t g r)}	2269.722	137.32	0	0	54
2005	{p(fix-t g) s(t g r) b(t g r)}	2307.692	175.29	0	0	66

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2005	{p(fix-t) s(t g) b(t g r)}	2376.229	243.82	0	0	47
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2006	2006 tgr 722 LM,LF,UM,UF					
2006	{p(fix-t r) s(t g) b(t g r)}	1260.956	0	0.99948	1	54
2006	{p(fix-t r) s(t r) b(t g r)}	1276.088	15.13	0.00052	0.0005	54
2006	{p(fix-t r) s(t g r) b(t g r)}	1284.811	23.86	0.00001	0	66
2006	{p(t g r) s(t g r) b(t g r)}	1309.911	48.96	0	0	80
2006	{p(fix-t g r) s(t g r) b(t g r)}	1310.145	49.19	0	0	80
2006	{p(fix-t g) s(t g r) b(t g r)}	1314.414	53.46	0	0	66
2006	{p(fix-t) s(t g r) b(t g r)}	1320.442	59.49	0	0	59
2006	{p(fix-t g) s(t r) b(t g r)}	1336.509	75.55	0	0	54
2006	{p(fix-t) s(t g) b(t g r)}	1344.009	83.05	0	0	47
2006	{p(fix-t g) s(t g) b(t g r)}	1357.055	96.1	0	0	54
2006	{p(fix-t) s(t r) b(t g r)}	1382.31	121.35	0	0	47
2006	{p(g r) s(t g r) b(t g r)}	1472.013	211.06	0	0	56
2006	{p(*) s(t g r) b(t g r)}	1504.131	243.17	0	0	53
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2007	2007 tgr 722 LM,LF,UM,UF					
2007	{p(fix-t r) s(t r) b(t g r)}	1241.073	0	0.78278	1	54
2007	{p(fix-t g) s(t r) b(t g r)}	1244.185	3.11	0.16514	0.211	54
2007	{p(fix-t) s(t r) b(t g r)}	1247.408	6.33	0.03297	0.0421	47
2007	{p(fix-t g) s(t) b(t g r)}	1249.631	8.56	0.01084	0.0138	48
2007	{p(fix-t g) s(g r) b(t g r)}	1250.519	9.45	0.00696	0.0089	46
2007	{p(fix-t g) s(t g) b(t g r)}	1255.002	13.93	0.00074	0.0009	54
2007	{p(fix-t g) s(t g r) b(t g r)}	1255.734	14.66	0.00051	0.0007	66
2007	{p(fix-t r) s(g r) b(t g r)}	1260.55	19.48	0.00005	0.0001	46
2007	{p(fix-t g) s(t r) b(t r)}	1262.967	21.89	0.00001	0	42
2007	{p(fix-t r) s(t g r) b(t g r)}	1267.579	26.51	0	0	66
2007	{p(fix-t) s(t g r) b(t g r)}	1273	31.93	0	0	59
2007	{p(fix-t) s(t g) b(t g r)}	1277.613	36.54	0	0	47
2007	{p(t g r) s(t g r) b(t g r)}	1279.248	38.17	0	0	80

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2007	{p(fix-t g r) s(t g r) b(t g r)}	1293.448	52.38	0	0	80
2007	{p(fix-t r) s(t r) b(t g)}	1296.067	54.99	0	0	42
2007	{p(fix-t g) s(t r) b(t g)}	1307.856	66.78	0	0	42
2007	{p(fix-t r) s(t g) b(t g r)}	1316.629	75.56	0	0	54
2007	{p(g r) s(t g r) b(t g r)}	1324.383	83.31	0	0	56
2007	{p(*) s(t g r) b(t g r)}	1339.767	98.69	0	0	53

2008	2008 tgr 722 LM,LF,UM,UF					
2008	{p(fix-t) s(t r) b(t g r)}	1681.973	0	0.99902	1	47
2008	{p(fix-t) s(t g r) b(t g r)}	1696.486	14.51	0.0007	0.0007	59
2008	{p(fix-t r) s(t g r) b(t g r)}	1698.666	16.69	0.00024	0.0002	66
2008	{p(fix-t g) s(t g r) b(t g r)}	1702.688	20.71	0.00003	0	66
2008	{p(fix-t) s(t g) b(t g r)}	1708.398	26.42	0	0	47
2008	{p(fix-t g r) s(t g r) b(t g r)}	1716.372	34.4	0	0	80
2008	{p(t g r) s(t g r) b(t g r)}	1717.853	35.88	0	0	80
2008	{p(fix-t) s(r) b(t g r)}	1745.191	63.22	0	0	37
2008	{p(fix-t) s(*) b(t g r)}	1750.055	68.08	0	0	36
2008	{p(fix-t) s(g) b(t g r)}	1751.216	69.24	0	0	37
2008	{p(fix-t) s(g r) b(t g r)}	1764.273	82.3	0	0	39
2008	{p(fix-t) s(t r) b(t g)}	1805.259	123.29	0	0	35
2008	{p(fix-t) s(t r) b(t r)}	1824.203	142.23	0	0	35
2008	{p(*) s(t g r) b(t g r)}	1916.934	234.96	0	0	53
2008	{p(fix-t) s(t) b(t g r)}	2042.348	360.37	0	0	41

2009	2009 tgr 822 LM,LF,UM,UF					
2009	{p(fix-t g) s(t r) b(t g r)}	1801.911	0	0.63105	1	62
2009	{p(fix-t) s(t r) b(t g r)}	1803.047	1.14	0.3577	0.5668	54
2009	{p(fix-t r) s(t r) b(t g r)}	1809.981	8.07	0.01116	0.0177	62
2009	{p(fix-t g) s(t g r) b(t g r)}	1821.375	19.46	0.00004	0.0001	76
2009	{p(fix-t) s(t g r) b(t g r)}	1821.379	19.47	0.00004	0.0001	68
2009	{p(fix-t r) s(t g r) b(t g r)}	1823.512	21.6	0.00001	0	76

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2009	{p(g r) s(t) b(t g r)}	1829.957	28.05	0	0	43
2009	{p(r) s(t) b(t g r)}	1830.02	28.11	0	0	41
2009	{p(fix-t g) s(t) b(t g r)}	1831.48	29.57	0	0	55
2009	{p(fix-t g) s(t r) b(t r)}	1838.813	36.9	0	0	48
2009	{p(t g r) s(t g r) b(t g r)}	1840.433	38.52	0	0	92
2009	{p(fix-t g) s(g r) b(t g r)}	1843.481	41.57	0	0	52
2009	{p(fix-t g) s(t g) b(t g r)}	1844.691	42.78	0	0	62
2009	{p(fix-t g r) s(t g r) b(t g r)}	1866.147	64.24	0	0	92
2009	{p(r) s(t g r) b(t g r)}	1910.58	108.67	0	0	62
2009	{p(*) s(t g r) b(t g r)}	1914.719	112.81	0	0	61
2009	{p(g) s(t g r) b(t g r)}	1917.27	115.36	0	0	62
2009	{p(g) s(t) b(t g r)}	1932.741	130.83	0	0	41
2009	{p(fix-t g) s(t r) b(t g)}	1964.496	162.58	0	0	48
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2010	2010 tgr 722 LM,LF,UM,UF					
2010	{p(fix-t r) s(g r) b(t g r)}	1669.917	0	0.84691	1	46
2010	{p(fix-t g) s(t g r) b(t g r)}	1674.122	4.21	0.10342	0.1221	66
2010	{p(fix-t g) s(t r) b(t g r)}	1675.81	5.89	0.04448	0.0525	54
2010	{p(fix-t r) s(*) b(t g r)}	1681.317	11.4	0.00283	0.0033	43
2010	{p(fix-t r) s(g) b(t g r)}	1681.829	11.91	0.00219	0.0026	44
2010	{p(t g r) s(t g r) b(t g r)}	1687.139	17.22	0.00015	0.0002	80
2010	{p(fix-t r) s(r) b(t g r)}	1693.181	23.26	0.00001	0	44
2010	{p(fix-t g) s(g r) b(t g r)}	1693.977	24.06	0.00001	0	46
2010	{p(fix-t g) s(t) b(t g r)}	1703.619	33.7	0	0	48
2010	{p(r) s(t g r) b(t g r)}	1710.632	40.72	0	0	54
2010	{p(fix-t r) s(g r) b(t g)}	1714.83	44.91	0	0	34
2010	{p(fix-t r) s(t g) b(t g r)}	1717.504	47.59	0	0	54
2010	{p(fix-t r) s(t g r) b(t g r)}	1718.257	48.34	0	0	66
2010	{p(fix-t) s(t g r) b(t g r)}	1720.155	50.24	0	0	59
2010	{p(r) s(t r) b(t g r)}	1723.119	53.2	0	0	42
2010	{p(r) s(t g) b(t g r)}	1725.534	55.62	0	0	42

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2010	{p(g r) s(t g r) b(t g r)}	1732.895	62.98	0	0	56
2010	{p(fix-t r) s(t r) b(t g r)}	1736.682	66.77	0	0	54
2010	{p(r) s(t) b(t g r)}	1741.473	71.56	0	0	36
2010	{p(fix-t g r) s(t g r) b(t g r)}	1746.686	76.77	0	0	80
2010	{p(*) s(t g r) b(t g r)}	1755.653	85.74	0	0	53
2010	{p(g) s(t g r) b(t g r)}	1756.795	86.88	0	0	54
2010	{p(fix-t g) s(t g) b(t g r)}	1757.735	87.82	0	0	54
2010	{p(fix-t r) s(g r) b(t r)}	1763.004	93.09	0	0	34
2010	{p(fix-t r) s(g r) b(t)}	1803.017	133.1	0	0	28
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2011	2011 tgr 922 LM,LF,UM,UF					
2011	{p(r) s(r) b(t g r)}	830.593	0	0.83732	1	40
2011	{p(g r) s(r) b(t g r)}	834.149	3.56	0.14149	0.169	42
2011	{p(g r) s(g r) b(t g r)}	838.005	7.41	0.02058	0.0246	44
2011	{p(r) s(g) b(t g r)}	846.148	15.55	0.00035	0.0004	40
2011	{p(g r) s(g) b(t g r)}	847.758	17.17	0.00016	0.0002	42
2011	{p(g r) s(t g) b(t g r)}	849.187	18.59	0.00008	0.0001	56
2011	{p(*) s(*) b(t g r)}	853.811	23.22	0.00001	0	38
2011	{p(g) s(r) b(t g r)}	853.867	23.27	0.00001	0	40
2011	{p(g) s(g) b(t g r)}	854.752	24.16	0	0	40
2011	{p(g r) s(t g r) b(t g r)}	854.842	24.25	0	0	72
2011	{p(fix-t) s(t r) b(t g r)}	855.027	24.43	0	0	61
2011	{p(r) s(t g r) b(t g r)}	855.264	24.67	0	0	70
2011	{p(fix-t) s(t g) b(t g r)}	862.483	31.89	0	0	61
2011	{p(fix-t) s(g) b(t g r)}	867.998	37.41	0	0	47
2011	{p(fix-t) s(r) b(t g r)}	868.141	37.55	0	0	47
2011	{p(*) s(t g r) b(t g r)}	874.059	43.47	0	0	69
2011	{p(fix-t) s(t g r) b(t g r)}	886.693	56.1	0	0	77
2011	{p(fix-t r) s(t g r) b(t g r)}	886.976	56.38	0	0	86
2011	{p(fix-t g) s(t g r) b(t g r)}	898.637	68.04	0	0	86
2011	{p(r) s(r) b(t r)}	904.467	73.87	0	0	24

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2011	{p(g r) s(t r) b(t g r)}	905.048	74.45	0	0	56
2011	{p(g) s(t g r) b(t g r)}	910.357	79.76	0	0	70
2011	{p(t g r) s(t g r) b(t g r)}	920.787	90.19	0	0	104
2011	{p(fix-t g r) s(t g r) b(t g r)}	921.103	90.51	0	0	104
2011	{p(r) s(r) b(t g)}	990.202	159.61	0	0	24
2011	{p(g) s(g) b(t g)}	1042.807	212.21	0	0	24
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2012	2012 tgr 822 LM,LF,UM,UF					
2012	{p(g r) s(t g) b(t g r)}	1367.963	0	0.93471	1	50
2012	{p(g r) s(t) b(t g r)}	1373.287	5.32	0.06525	0.0698	43
2012	{p(g r) s(t g r) b(t g r)}	1388.047	20.08	0.00004	0	64
2012	{p(fix-t) s(t g r) b(t g r)}	1401.757	33.79	0	0	68
2012	{p(fix-t g) s(t g r) b(t g r)}	1409.83	41.87	0	0	76
2012	{p(*) s(t g r) b(t g r)}	1412.943	44.98	0	0	61
2012	{p(fix-t r) s(t g r) b(t g r)}	1416.98	49.02	0	0	76
2012	{p(g) s(t g) b(t g r)}	1426.495	58.53	0	0	48
2012	{p(g r) s(t g) b(t r)}	1427.892	59.93	0	0	36
2012	{p(r) s(t g) b(t g r)}	1439.558	71.59	0	0	48
2012	{p(fix-t g r) s(t g r) b(t g r)}	1439.78	71.82	0	0	92
2012	{p(t g r) s(t g r) b(t g r)}	1445.789	77.83	0	0	92
2012	{p(g r) s(t r) b(t g r)}	1460.001	92.04	0	0	50
2012	{p(g r) s(t g) b(t g)}	1490.661	122.7	0	0	36
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2013	2013 tgr 822 LM,LF,UM,UF					
2013	{p(g r) s(t g r) b(t g r)}	2366.677	0	0.49212	1	64
2013	{p(fix-t g r) s(t r) b(t g r)}	2366.693	0.02	0.48834	0.9923	78
2013	{p(g r) s(t g) b(t g r)}	2373.168	6.49	0.01917	0.039	50
2013	{p(fix-t) s(t r) b(t g r)}	2381.166	14.49	0.00035	0.0007	54
2013	{p(fix-t g r) s(t g r) b(t g r)}	2387.955	21.28	0.00001	0	92
2013	{p(t g r) s(t g r) b(t g r)}	2388.527	21.85	0.00001	0	92
2013	{p(fix-t) s(t g r) b(t g r)}	2393.889	27.21	0	0	69

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2013	{p(fix-t g) s(t g r) b(t g r)}	2399.967	33.29	0	0	76
2013	{p(fix-t g r) s(t g) b(t g r)}	2400.891	34.21	0	0	78
2013	{p(g r) s(t) b(t g r)}	2409.25	42.57	0	0	43
2013	{p(*) s(t g r) b(t g r)}	2418.457	51.78	0	0	61
2013	{p(r) s(t r) b(t g r)}	2419.708	53.03	0	0	48
2013	{p(g) s(t r) b(t g r)}	2432.916	66.24	0	0	48
2013	{p(g r) s(t r) b(t r)}	2456.97	90.29	0	0	36
2013	{p(fix-t r) s(t r) b(t r)}	2457.289	90.61	0	0	48
2013	{p(g r) s(t r) b(t g)}	2560.314	193.64	0	0	36
2013	{p(g) s(t g) b(t g r)}	2564.679	198	0	0	48
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2014	2014 tgr 722 LM,LF,UM,UF					
2014	{p(fix-t r) s(t r) b(t g r)}	1305.483	0	0.99999	1	54
2014	{p(fix-t g r) s(t r) b(t g r)}	1330.502	25.02	0	0	68
2014	{p(fix-t r) s(t g) b(t r)}	1333.303	27.82	0	0	42
2014	{p(fix-t r) s(t g r) b(t r)}	1333.409	27.93	0	0	54
2014	{p(fix-t g r) s(t g r) b(t r)}	1334.659	29.18	0	0	68
2014	{p(fix-t g r) s(t g) b(t g r)}	1336.251	30.77	0	0	68
2014	{p(fix-t r) s(t g r) b(t g r)}	1339.974	34.49	0	0	66
2014	{p(fix-t r) s(t g r) b(t g)}	1340.048	34.56	0	0	54
2014	{p(fix-t g r) s(t g r) b(t g)}	1348.5	43.02	0	0	68
2014	{p(fix-t g r) s(t g r) b(t)}	1352.572	47.09	0	0	62
2014	{p(fix-t r) s(t r) b(t r)}	1353.161	47.68	0	0	42
2014	{p(fix-t g r) s(t g r) b(t g r)}	1354.113	48.63	0	0	80
2014	{p(t g r) s(t g r) b(t g r)}	1354.793	49.31	0	0	80
2014	{p(fix-t g) s(t g r) b(t g r)}	1355.568	50.08	0	0	66
2014	{p(fix-t r) s(t g) b(t g r)}	1355.73	50.25	0	0	54
2014	{p(fix-t) s(t g r) b(t g r)}	1358.551	53.07	0	0	59
2014	{p(fix-t r) s(t r) b(t g r)}	1359.76	54.28	0	0	54
2014	{p(fix-t r) s(t r) b(t g)}	1366.372	60.89	0	0	42
2014	{p(g r) s(t g r) b(t g r)}	1397.979	92.5	0	0	56

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2014	{p(*) s(t g r) b(t g r)}	5125.805	220.32	0	0	53
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2015	2015 tgr 722 LM,LF,UM,UF					
2015	{p(*) s(t r) b(t g r)}	2286.777	0	0.62854	1	41
2015	{p(r) s(t r) b(t g r)}	2287.935	1.16	0.35215	0.5603	42
2015	{p(g)) s(t r) b(t g r)}	2294.844	8.07	0.01113	0.0177	42
2015	{p(fix-t) s(t) b(t g r)}	2296.742	9.97	0.00431	0.0069	41
2015	{p(fix-t r) s(t r) b(t g r)}	2296.958	10.18	0.00387	0.0062	54
2015	{p(fix-t g r) s(t g) b(t g r)}	2310.49	23.71	0	0	68
2015	{p(fix-t g r) s(g r) b(t g r)}	2314.348	27.57	0	0	60
2015	{p(fix-t g) s(t r) b(t g r)}	2314.472	27.7	0	0	54
2015	{p(*) s(t g r) b(t g r)}	2317.679	30.9	0	0	53
2015	{p(fix-t) s(t r) b(t g r)}	2318.979	32.2	0	0	47
2015	{p(t g r) s(t g r) b(t g r)}	2322.017	35.24	0	0	80
2015	{p(fix-t g r) s(t g r) b(t g r)}	2323.262	36.49	0	0	80
2015	{p(fix-t r) s(t g r) b(t g r)}	2325.877	39.1	0	0	66
2015	{p(fix-t) s(t g) b(t g r)}	2327.035	40.26	0	0	47
2015	{p(fix-t g) s(t g r) b(t g r)}	2338.388	51.61	0	0	66
2015	{p(fix-t g r) s(t g) b(t g r)}	2346.664	59.89	0	0	68
2015	{p(fix-t) s(t r) b(t g)}	2358.91	72.13	0	0	35
2015	{p(fix-t) s(t g) b(t r)}	2359.807	73.03	0	0	35
2015	{p(fix-t g) s(t g) b(t g r)}	2363.693	76.92	0	0	54
2015	{p(fix-t) s(t r) b(t r)}	2411.594	124.82	0	0	35
2015	{p(fix-t) s(t r) b(t)}	2451.53	164.75	0	0	29
2015	{p(fix-t) s(t g) b(t g)}	2456.888	170.11	0	0	35
2015	{p(g r) s(t g r) b(t g r)}	456.626	1769.8	0	0	56
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2016	2016 tgr 722 LM,LF,UM,UF					
2016	{p(fix-t g) s(r) b(t g r)}	1565.322	0	0.73816	1	44
2016	{p(fix-t g) s(*) b(t g r)}	1567.526	2.2	0.24523	0.3322	43
2016	{p(fix-t) s(g r) b(t g r)}	1574.205	8.88	0.00869	0.0118	39

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2016	{p(fix-t) s(t g r) b(t g r)}	1576.02	10.7	0.00351	0.0048	59
2016	{p(fix-t g) s(r) b(t r)}	1576.482	11.16	0.00278	0.0038	32
2016	{p(fix-t g) s(g) b(t g r)}	1578.637	13.32	0.00095	0.0013	44
2016	{p(fix-t r) s(t g r) b(t g r)}	1580.209	14.89	0.00043	0.0006	66
2016	{p(fix-t g) s(t r) b(t g r)}	1582.474	17.15	0.00014	0.0002	54
2016	{p(fix-t g) s(g) b(t r)}	1583.147	17.83	0.0001	0.0001	32
2016	{p(fix-t g) s(t g r) b(t g r)}	1595.135	29.81	0	0	58
2016	{p(t g r) s(t g r) b(t g r)}	1596.408	31.09	0	0	80
2016	{p(fix-t g r) s(t g r) b(t g r)}	1596.558	31.24	0	0	80
2016	{p(*) s(t g r) b(t g r)}	1606.565	41.24	0	0	53
2016	{p(fix-t g) s(t g r) b(t g r)}	1613.531	48.21	0	0	66
2016	{p(fix-t g) s(g r) b(t g r)}	1614.182	48.86	0	0	46
2016	{p(g r) s(t g r) b(t g r)}	1625.908	60.59	0	0	56
2016	{p(fix-t g) s(t g) b(t g r)}	1668.169	102.85	0	0	54
2016	{p(fix-t g) s(r) b(t g)}	1762.114	196.79	0	0	32
2016	{p(fix-t g) s(g) b(t g)}	1792.542	227.22	0	0	32
2016	{p(fix-t g) s(t r) b(t g r)}	2177.825	612.5	0	0	54
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2017	2017 tgr 622 LM,LF,UM,UF					
2017	{p(g r) s(g) b(t g r)}	678.212	0	0.42169	1	30
2017	{p(g r) s(g r) b(t g r)}	679.498	1.29	0.22175	0.5259	32
2017	{p(g r) s(t) b(t g r)}	680.224	2.01	0.15421	0.3657	33
2017	{p(g r) s(r) b(t g r)}	680.899	2.69	0.11003	0.2609	30
2017	{p(g r) s(t r) b(t g r)}	682.111	3.9	0.06004	0.1424	38
2017	{p(g r) s(t g) b(t g r)}	683.363	5.15	0.03209	0.0761	38
2017	{p(g r) s(t g r) b(t g r)}	694.652	16.44	0.00011	0.0003	48
2017	{p(fix-t g) s(t g r) b(t g r)}	696.469	18.26	0.00005	0.0001	56
2017	{p(r) s(t g r) b(t g r)}	700.308	22.1	0.00001	0	46
2017	{p(g) s(t g r) b(t g r)}	700.36	22.15	0.00001	0	46
2017	{p(g r) s(g) b(t g)}	701.798	23.59	0	0	20
2017	{p(fix-t r) s(t g r) b(t g r)}	703.033	24.82	0	0	56

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2017	{p(g r) s(r) b(t g)}	703.246	25.03	0	0	20
2017	{p(*) s(t g r) b(t g r)}	703.825	25.61	0	0	45
2017	{p(t g r) s(t g r) b(t g r)}	718.777	40.56	0	0	68
2017	{p(fix-t g r) s(t g r) b(t g r)}	731.308	53.1	0	0	68
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2018	2018 tgr 622 LM,LF,UM,UF					
2018	{p(fix-t g,r),s(t,g),b(t,r)}	1563.232	0	0.99986	1	48
2018	{p(fix-t g,r),s(t,g,r),b(t,r)}	1581.787	18.56	0.00009	0.0001	58
2018	{p(fix-t g,r),s(t,g,r),b(t)}	1584.478	21.25	0.00002	0	53
2018	{p(fix-t g,r),s(g,r),b(t,g,r)}	1585.877	22.64	0.00001	0	52
2018	{p(t,g,r),s(t,g,r),b(t,g,r)}	1587.471	24.24	0.00001	0	68
2018	{p(fix-t r),s(g),b(t,r)}	1590.716	27.48	0	0	28
2018	{p(fix-t g,r),s(t,g,r),b(t,g,r)}	1596.455	33.22	0	0	68
2018	{p(fix-t g,r),s(t,r),b(t,g,r)}	1599.494	36.26	0	0	58
2018	{p(fix-t g,r),s(t,r),b(t,r)}	1599.494	36.26	0	0	58
2018	{p(fix-t ,r),s(t,g,r),b(t,g,r)}	1599.874	36.64	0	0	56
2018	{p(fix-t g),s(t,g),b(t,r)}	1601.243	38.01	0	0	29
2018	{p(fix-t r),s(t,g),b(t,r)}	1602.6	39.37	0	0	36
2018	{p(fix-t r),s(t,g,r),b(t,r)}	1605.961	42.73	0	0	46
2018	{p(fix-t g,r),s(t,g),b(t,g,r)}	1612.405	49.17	0	0	58
2018	{p(fix-t g),s(t,g,r),b(t,g,r)}	1614.268	51.04	0	0	56
2018	{p(fix-t g,r),s(t,g,r),b(t,g)}	1635.945	72.71	0	0	58
2018	{p(g,r),s(t,g,r),b(t,r)}	1636.479	73.25	0	0	28
2018	{p(*),s(t,g,r),b(t,g,r)}	1697.528	134.3	0	0	45
2018	{p(g,r),s(t,g,r),b(t,r)}	1708.78	145.55	0	0	48
2018	{p(fix-t r),s(g),b(t,r)}	1930.969	367.74	0	0	28
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2019	2019 tgr 722 LM,LF,UM,UF					
2019	{p(fix-t r) s(t g) b(t g)}	1760.829	0	0.58624	1	42
2019	{p(fix-t r) s(t g) b(t g r)}	1762.17	1.34	0.2998	0.5114	54
2019	{p(fix-t r) s(t r) b(t g r)}	1765.08	4.25	0.07	0.1194	54

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2019	{p(fix-t) s(t g) b(t g r)}	1766.039	5.21	0.04332	0.0739	47
2019	{p(fix-t g) s(t r) b(t g r)}	1774.757	13.93	0.00055	0.0009	54
2019	{p(fix-t) s(t r) b(t g r)}	1778.726	17.9	0.00008	0.0001	47
2019	{p(fix-t) s(t g r) b(t g r)}	1784.957	24.13	0	0	59
2019	{p(fix-t r) s(t g r) b(t g r)}	1785.112	24.28	0	0	66
2019	{p(fix-t g) s(t g) b(t g r)}	1787.755	26.93	0	0	54
2019	{p(fix-t g) s(t g r) b(t g r)}	1796.191	35.36	0	0	66
2019	{p(fix-t r) s(t g) b(t r)}	1804.998	44.17	0	0	42
2019	{p(*) s(t g r) b(t g r)}	1813.172	52.34	0	0	53
2019	{p(t g r) s(t g r) b(t g r)}	1814.446	53.62	0	0	80
2019	{p(fix-t) s(t g) b(t r)}	1814.447	53.62	0	0	35
2019	{p(fix-t g r) s(t g r) b(t g r)}	1835.516	74.69	0	0	80
2019	{p(fix-t) s(t g) b(t g)}	1886.187	125.36	0	0	35
--						
2020	2020 tgr 622 LM,LF,UM,UF					
2020	{p(fix-t) s (t g r) b (t g r)}	744.013	0	0.35104	1	50
2020	{p(r) s (t g r) b (t g r)}	745.138	1.13	0.2	0.5697	46
2020	{p(g) s (t g r) b (t g r)}	745.476	1.46	0.16892	0.4812	46
2020	{p(*) s (t g r) b (t g r)}	746.18	2.17	0.11878	0.3384	45
2020	{p(fix-t g r) s (t) b (t g r)}	746.815	2.8	0.08649	0.2464	53
2020	{p(fix-t g r) s (t r) b (t g r)}	749.138	5.13	0.02706	0.0771	58
2020	{p(fix-t r) s (t g r) b (t g r)}	749.316	5.3	0.02476	0.0705	56
2020	{p(fix-t g) s (t g) b (t g r)}	749.92	5.91	0.01831	0.0522	46
2020	{p(fix-t g r) s (t g) b (t g r)}	754.446	10.43	0.00191	0.0054	58
2020	{p(g) s (t r) b (t g r)}	754.71	10.7	0.00167	0.0048	36
2020	{p(r) s (t r) b (t g r)}	756.269	12.26	0.00077	0.0022	36
2020	{p(fix-t g) s (t g r) b (t g r)}	758.211	14.2	0.00029	0.0008	56
2020	{p(g r) s (*) b (t g r)}	765.991	21.98	0.00001	0	29
2020	{p(r) s (t g) b (t g r)}	769.855	25.84	0	0	36
2020	{p(fix-t g r) s (g r) b (t g r)}	770.338	26.33	0	0	52
2020	{p(fix-t) s (g r) b (t g r)}	772.464	28.45	0	0	34

Year	Model	AICc	Delta AICc	AICc Weight	Model Likelihood	# Parameters
2020	{p(g r) s (t) b (t r)}	772.718	28.7	0	0	23
2020	{p(t g r) s (t g r) b (t g r)}	772.818	28.81	0	0	68
2020	{p(fix-t g r) s (t g r) b (t g r)}	772.99	28.98	0	0	68
2020	{p(g r) s (t) b (t g)}	802.709	58.7	0	0	23

Appendix 2. POH length frequency data for male and female Kitsumkalum Chinook salmon 1984 to 2020.

Male POH (mm)	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
200-249							1			
250-299	2	3	6	5	3		16		2	1
300-349	10	8	56	10	7	3	58	1	4	8
350-399	5	8	19	2	6	7	29		2	1
400-449	2	5	3	2	1	3	17	3	1	4
450-499	5	3	8	7	10	5	10	7	6	4
500-549	13	10	20	7	12	13	17	19	9	7
550-599	9	11	14	5	28	6	19	32	19	14
600-649	10	26	29	4	36	17	35	25	24	13
650-699	14	20	25	3	27	17	35	22	27	16
700-749	8	24	28	16	37	58	30	47	61	43
750-799	20	41	43	22	54	74	52	59	77	57
800-849	46	74	48	26	94	88	109	73	79	69
850-899	56	81	74	94	161	156	246	119	103	157
900-949	54	80	122	212	351	285	310	141	149	234
950-999	12	40	76	209	291	163	110	87	103	145
1000-1049	4	14	32	64	79	39	10	16	14	44
1050-1099		1	2	9	8	1	2	2		1
1100-1149		1		1	1		2			1
1150-1199				2	1					
Total	270	450	605	700	1207	935	1108	653	680	819
Female POH (mm)	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
200-249										
250-299										
300-349										
350-399										
400-449										
450-499										
500-549	2		1			1	3			
550-599	2	1			1					
600-649		1			3	1	3		1	1
650-699	2	12	1		4	7	8	8	2	1
700-749	31	87	16	8	21	19	23	15	21	12
750-799	109	174	77	36	119	102	100	102	82	85
800-849	213	278	204	171	410	369	461	259	250	399
850-899	160	238	259	352	856	668	678	315	418	654
900-949	45	119	208	300	770	292	232	169	169	403
950-999	6	25	60	90	143	42	36	40	22	53
1000-1049		4	6	7	3	2	3			6
1050-1099				1			2			
1100-1149										
1150-1199										
Total	570	939	832	965	2330	1503	1549	908	965	1614

Appendix 2 continued. POH length frequency data for male and female Kitsumkalum Chinook salmon 1984 to 2020.

Male POH (mm)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
200-249										
250-299										
300-349	1				4	3		11	2	4
350-399	2		1		26	6		18	5	5
400-449	7	1	1		17	5	2	8	4	1
450-499	2		3		20	9	6	3	8	6
500-549		2		2	17	21	13	3	15	8
550-599	1	5	1	3	40	35	24	8	21	17
600-649		6	4	6	36	51	71	13	43	16
650-699	3	2	2	4	24	20	82	19	36	21
700-749	13	14	11	6	27	10	69	52	15	34
750-799	64	14	19	8	37	22	70	78	24	73
800-849	284	21	21	18	49	34	88	95	44	170
850-899	296	38	20	7	70	58	80	133	75	116
900-949	109	23	50	17	81	42	55	105	101	51
950-999	21	9	6	10	31	11	10	37	59	19
1000-1049		1	3	3	2		3	3	4	5
1050-1099										
1100-1149										
1150-1199										1
Total	803	136	142	84	481	327	573	586	456	547
Female POH (mm)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
200-249										
250-299										
300-349										
350-399										
400-449										
450-499										
500-549	10						1			
550-599	14				1		1		1	
600-649	22	1			1		2		1	1
650-699	24			2	2	5	7	2	4	3
700-749	30	7	6	7	21	42	74	19	20	121
750-799	45	69	57	24	108	129	309	147	96	477
800-849	72	218	157	57	190	219	413	393	273	386
850-899	157	145	176	45	185	101	217	370	389	116
900-949	147	17	52	23	69	15	48	168	150	29
950-999	47	3	2	1	5	2		6	15	7
1000-1049	13		1	1						
1050-1099										
1100-1149										
1150-1199										
Total	581	460	451	160	582	513	1072	1105	949	1140

Appendix 2 continued. POH length frequency data for male and female Kitsumkalum Chinook salmon 1984 to 2020.

Male POH (mm)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
200-249										
250-299	2	1	1	1	2		4	1	2	3
300-349	10	4	1	15	3	5	43	3	11	69
350-399	11	46	20	42	5	27	47	17	16	112
400-449	8	36	14	25	16	42	32	20	23	78
450-499	9	19	19	14	34	29	45	13	50	67
500-549	17	19	30	11	37	34	76	28	75	104
550-599	56	27	53	15	79	64	196	51	153	160
600-649	100	31	126	37	158	88	341	64	152	168
650-699	84	81	132	43	67	83	131	92	110	161
700-749	46	155	85	98	59	119	57	81	78	182
750-799	50	156	105	109	54	139	68	119	58	143
800-849	77	134	132	193	115	188	112	78	68	198
850-899	153	106	136	127	148	121	162	33	52	96
900-949	172	44	69	67	135	48	94	13	17	49
950-999	66	5	11	13	44	16	29	2	12	6
1000-1049	15	1	2	2	10	3	2		1	
1050-1099	2									
1100-1149										
1150-1199						1				
Total	878	865	936	812	966	1007	1439	615	878	1596
Female POH (mm)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
200-249										
250-299										
300-349										
350-399										
400-449										
450-499										
500-549									1	
550-599	1				1		1			1
600-649	3		2		5	3	6	1		2
650-699	3	42	6	4	5	14	5	24	14	25
700-749	51	221	55	78	22	100	63	160	118	235
750-799	180	448	197	301	106	331	167	165	195	382
800-849	350	278	335	337	269	207	299	83	220	240
850-899	397	97	184	125	231	80	145	23	82	77
900-949	100	9	31	32	82	13	32	1	10	9
950-999	13	1	2		3	2	1	2		
1000-1049						1				
1050-1099										
1100-1149										
1150-1199										
Total	1098	1096	812	877	724	751	719	459	640	971

Appendix 2 continued. POH length frequency data for male and female Kitsumkalum Chinook salmon 1984 to 2020.

Male POH (mm)	2014	2015	2016	2017	2018	2019	2020
200-249							
250-299	4	1	2	6	6	5	1
300-349	23	13	14	21	9	26	8
350-399	24	30	66	30	5	17	11
400-449	15	24	63	23	36	7	10
450-499	60	37	53	36	81	17	20
500-549	130	100	79	69	155	40	51
550-599	222	228	90	113	293	98	64
600-649	238	194	99	94	276	125	61
650-699	88	212	89	84	142	171	55
700-749	85	260	113	61	140	173	42
750-799	84	219	132	46	108	166	59
800-849	125	227	159	49	75	160	58
850-899	86	125	147	26	57	58	35
900-949	58	69	83	8	15	23	15
950-999	17	14	14	2	1	2	4
1000-1049	1	1		1			1
1050-1099				1			
1100-1149							
1150-1199							
Total	1260	1754	1203	670	1399	1088	495
Female POH (mm)	2014	2015	2016	2017	2018	2019	2020
200-249							
250-299							
300-349							
350-399							
400-449							
450-499							
500-549					1		
550-599		2	2	1	1	2	
600-649	5	8	12	8	9	10	3
650-699	10	71	103	61	76	83	22
700-749	112	369	296	118	258	380	66
750-799	209	518	344	99	307	419	139
800-849	237	242	249	47	115	160	110
850-899	88	74	64	13	22	40	21
900-949	11	8	3	2	2	4	8
950-999	2	2					
1000-1049							
1050-1099							
1100-1149							
1150-1199							
Total	674	1294	1073	349	791	1098	369

Appendix 3. Releases of coded wire tagged Kitsumkalum Chinook salmon.

Tagcode	Brood Year	Release Year	Release Site Name	Weight (g)	Stage	# CWT Adclip	Total Released	% Tagged
021951	1980	1981	Kitsumkalum R	2.1	F	44273	63115	70.2
022312	1981	1982	Kitsumkalum R	2.1	F	23234	30250	76.8
022313	1981	1982	Kitsumkalum R	2.1	F	29459	70400	41.9
022758	1983	1984	Kitsumkalum R	5.4	F	30716	30716	100.0
023347	1984	1985	Deep Cr/SKNA	2.5	F	26198	26409	99.2
023348	1984	1985	Deep Cr/SKNA	2.5	F	25978	26161	99.3
023352	1984	1985	Deep Cr/SKNA	2.5	F	26509	26509	100.0
023353	1984	1985	Deep Cr/SKNA	2.5	F	24512	26171	93.7
023346	1984	1985	Kitsumkalum R	3	F	25937	26146	99.2
023349	1984	1985	Kitsumkalum R	2.5	F	26373	26466	99.7
023350	1984	1985	Kitsumkalum R	3	F	25980	26071	99.7
023351	1984	1985	Kitsumkalum R	2.5	F	26376	26376	100.0
023704	1985	1986	Kitsumkalum R	2.5	F	44183	44446	99.4
023705	1985	1986	Kitsumkalum R	2.5	F	42264	42500	99.4
023706	1985	1986	Kitsumkalum R	3.3	F	43916	47422	92.6
023707	1985	1986	Kitsumkalum R	3	F	43892	47571	92.3
024410	1986	1987	Kitsumkalum R	3.43	F	24827	25230	98.4
024411	1986	1987	Kitsumkalum R	3.14	F	25221	29968	84.2
024412	1986	1987	Kitsumkalum R	2.85	F	26784	26784	100.0
024413	1986	1987	Kitsumkalum R	3.01	F	26783	26891	99.6
024414	1986	1987	Kitsumkalum R	2.5	F	26581	29715	89.5
024942	1987	1988	Below Canyon	3.66	F	26570	27030	98.3
024944	1987	1988	Below Canyon	3.35	F	26423	26785	98.7
025060	1987	1988	Below Canyon	3.44	F	27522	42516	64.7
025061	1987	1988	Below Canyon	3.07	F	27475	42468	64.7
024943	1987	1988	Lean-To Cr	2.88	F	25262	33817	74.7
024941	1987	1988	Lean-To Cr	2.94	F	27021	27154	99.5
026039	1988	1989	Kitsumkalum R	2.5	F	27131	29322	92.5
026040	1988	1989	Kitsumkalum R	2.5	F	27075	28992	93.4
026041	1988	1989	Kitsumkalum R	2.5	F	26543	28727	92.4
026042	1988	1989	Kitsumkalum R	2.5	F	24080	26488	90.9
026043	1988	1989	Kitsumkalum R	2.5	F	26794	28711	93.3
026044	1988	1989	Kitsumkalum R	2.5	F	26849	28766	93.3
026045	1988	1989	Kitsumkalum R	2.5	F	26299	28481	92.3
020940	1989	1990	Kitsumkalum R	1.29	F	29907	30209	99.0
020941	1989	1990	Kitsumkalum R	1.29	F	27486	27486	100.0
020942	1989	1990	Kitsumkalum R	1.29	F	26908	26908	100.0
020943	1989	1990	Kitsumkalum R	1.29	F	26583	26583	100.0
020944	1989	1990	Kitsumkalum R	1.29	F	27058	27058	100.0
020945	1989	1990	Kitsumkalum R	1.29	F	27053	32446	83.4

Tagcode	Brood Year	Release Year	Release Site Name	Weight (g)	Stage	# CWT Adclip	Total Released	% Tagged
020946	1989	1990	Kitsumkalum R	1.29	F	26553	31946	83.1
026137	1989	1990	Kitsumkalum R	1.29	F	4554	9947	45.8
026138	1989	1990	Kitsumkalum R	1.29	F	4553	9946	45.8
021133	1990	1991	Below Canyon	2.27	F	26376	31920	82.6
021134	1990	1991	Below Canyon	2.27	F	26720	32265	82.8
021135	1990	1991	Below Canyon	2.27	F	26736	32281	82.8
021136	1990	1991	Below Canyon	2.27	F	26783	32328	82.8
021137	1990	1991	Below Canyon	2.27	F	26599	32143	82.8
021138	1990	1991	Below Canyon	2.27	F	26722	32267	82.8
021139	1990	1991	Below Canyon	2.27	F	26624	32169	82.8
021140	1990	1991	Below Canyon	2.27	F	21952	27496	79.8
021010	1991	1992	Below Canyon	2.5	F	25634	28025	91.5
021011	1991	1992	Below Canyon	2.5	F	26679	28585	93.3
023116	1991	1992	Below Canyon	2.5	F	156630	168390	93.0
181046	1992	1993	Kitsumkalum R	1.84	F	25635	26513	96.7
181047	1992	1993	Kitsumkalum R	1.84	F	25811	26696	96.7
181048	1992	1993	Kitsumkalum R	1.84	F	26357	26849	98.2
181049	1992	1993	Kitsumkalum R	1.84	F	26134	26756	97.7
181050	1992	1993	Kitsumkalum R	1.84	F	26610	26971	98.7
181051	1992	1993	Kitsumkalum R	1.84	F	26772	27136	98.7
181052	1992	1993	Kitsumkalum R	1.84	F	25118	25716	97.7
021104	1993	1994	Kitsumkalum R	2.3	F	100060	100311	99.8
181423	1993	1994	Kitsumkalum R	2.3	F	49902	50067	99.7
181424	1993	1994	Kitsumkalum R	2.3	F	50119	50119	100.0
180608	1994	1995	Kitsumkalum R	2.2	F	10527	10711	98.3
180609	1994	1995	Kitsumkalum R	2.2	F	10700	10887	98.3
180640	1994	1995	Kitsumkalum R	2.2	F	30010	30534	98.3
180641	1994	1995	Kitsumkalum R	2.2	F	29946	30469	98.3
180642	1994	1995	Kitsumkalum R	2.2	F	30867	31406	98.3
182155	1994	1995	Kitsumkalum R	2.2	F	29252	29763	98.3
182156	1994	1995	Kitsumkalum R	2.2	F	30171	30698	98.3
182157	1994	1995	Kitsumkalum R	2.2	F	28943	29448	98.3
182345	1995	1996	Kitsumkalum R	2	F	28566	28860	99.0
182339	1995	1996	Kitsumkalum R	2	F	26105	26374	99.0
182340	1995	1996	Kitsumkalum R	2	F	25819	26085	99.0
182341	1995	1996	Kitsumkalum R	2	F	28193	28771	98.0
182342	1995	1996	Kitsumkalum R	2	F	28450	28743	99.0
182343	1995	1996	Kitsumkalum R	2	F	28561	28855	99.0
182344	1995	1996	Kitsumkalum R	2	F	28241	28532	99.0
182752	1996	1997	Kitsumkalum R	2.4	F	29096	29670	98.1
182753	1996	1997	Kitsumkalum R	2.4	F	29293	29871	98.1

Tagcode	Brood Year	Release Year	Release Site Name	Weight (g)	Stage	# CWT Adclip	Total Released	% Tagged
182754	1996	1997	Kitsumkalum R	2.4	F	29002	29574	98.1
182749	1996	1997	Kitsumkalum R	2.4	F	26622	27147	98.1
182750	1996	1997	Kitsumkalum R	2.4	F	28514	29076	98.1
182751	1996	1997	Kitsumkalum R	2.4	F	28609	29173	98.1
182755	1996	1998	Kitsumkalum R	24	Y	20403	20403	100.0
182809	1997	1998	Above Canyon	2.4	F	29066	29212	99.5
182810	1997	1998	Above Canyon	2.4	F	29301	29301	100.0
183308	1997	1998	Above Canyon	2.4	F	11481	11481	100.0
182806	1997	1998	Below Canyon	2.4	F	27399	28690	95.5
182807	1997	1998	Below Canyon	2.4	F	28803	29094	99.0
182808	1997	1998	Below Canyon	2.4	F	27132	27828	97.5
183307	1997	1998	Below Canyon	2.4	F	11447	11563	99.0
184212	1998	1999	Above Canyon	2.3	F	55085	55085	100.0
183063	1998	1999	Above Canyon	2.3	F	25149	25275	99.5
184213	1998	1999	Below Canyon	2.3	F	54684	54959	99.5
184214	1998	1999	Below Canyon	2.3	F	54591	54591	100.0
183516	1998	1999	Below Canyon	2.3	F	10890	10890	100.0
182959	1999	2000	Above Canyon	2.4	F	8001	8172	97.9
184601	1999	2000	Above Canyon	2.4	F	30531	31185	97.9
184602	1999	2000	Above Canyon	2.4	F	30246	30894	97.9
184603	1999	2000	Above Canyon	2.4	F	30639	31296	97.9
184604	1999	2000	Above Canyon	2.4	F	26727	27300	97.9
184560	1999	2000	Below Canyon	2.4	F	25338	25338	100.0
184561	1999	2000	Below Canyon	2.4	F	25301	25301	100.0
184563	1999	2000	Below Canyon	2.4	F	26879	26879	100.0
184562	1999	2001	Above Canyon	19.4	Y	30538	30538	100.0
184624	2000	2001	Above Canyon	2.3	F	28863	29488	97.9
184625	2000	2001	Above Canyon	2.3	F	28500	29118	97.9
184622	2000	2001	Above Canyon	2.3	F	29246	29880	97.9
184623	2000	2001	Above Canyon	2.3	F	29231	29864	97.9
184626	2000	2001	Below Canyon	2.3	F	27167	27517	98.7
184627	2000	2001	Below Canyon	2.3	F	26275	26613	98.7
184308	2000	2001	Below Canyon	2.3	F	40779	41512	98.2
184621	2000	2002	Above Canyon	16.7	Y	28028	28028	100.0
185048	2001	2002	Above Canyon	2.3	F	26815	27158	98.7
185049	2001	2002	Above Canyon	2.3	F	27119	27465	98.7
185050	2001	2002	Above Canyon	2.3	F	27123	27469	98.7
185051	2001	2002	Above Canyon	2.3	F	25482	25807	98.7
183506	2001	2002	Below Canyon	2.3	F	6477	6495	99.7
185045	2001	2002	Below Canyon	2.3	F	30165	30251	99.7
185046	2001	2002	Below Canyon	2.3	F	30358	30444	99.7

Tagcode	Brood Year	Release Year	Release Site Name	Weight (g)	Stage	# CWT Adclip	Total Released	% Tagged
185047	2001	2002	Below Canyon	2.3	F	30052	30137	99.7
180148	2001	2003	Above Canyon	17.3	Y	13487	13487	100.0
184302	2001	2003	Below Canyon	18.5	Y	12877	12877	100.0
185340	2002	2003	Above Canyon	2.27	F	50475	50860	99.2
185341	2002	2003	Above Canyon	2.27	F	48318	48946	98.7
184243	2002	2003	Below Canyon	2.27	F	11702	12009	97.4
185056	2002	2003	Below Canyon	2.27	F	30291	30598	99.0
185057	2002	2003	Below Canyon	2.27	F	30215	30674	98.5
185058	2002	2003	Below Canyon	2.27	F	27838	28145	98.9
184420	2002	2004	Above Canyon	14.26	Y	12267	12267	100.0
184827	2002	2004	Below Canyon	15.5	Y	10980	10980	100.0
185401	2003	2004	Above Canyon	2.2	F	30296	32103	94.4
185539	2003	2004	Above Canyon	2.2	F	53454	56643	94.4
185402	2003	2004	Below Canyon	2.2	F	27744	29558	93.9
185540	2003	2004	Below Canyon	2.2	F	53198	56960	93.4
184831	2003	2005	Above Canyon	16.5	Y	12456	12456	100.0
184830	2003	2005	Below Canyon	19.5	Y	12602	12602	100.0
185409	2004	2005	Above Canyon	2.3	F	29672	35387	83.8
185652	2004	2005	Above Canyon	2.3	F	24502	29221	83.8
185060	2004	2005	Above Canyon	2.3	F	27704	33039	83.8
185653	2004	2005	Below Canyon	2.5	F	29762	33784	88.1
185654	2004	2005	Below Canyon	2.5	F	28006	31790	88.1
185655	2004	2005	Below Canyon	2.5	F	25628	29091	88.1
184439	2004	2006	Above Canyon	14	Y	14227	14227	100.0
185629	2004	2006	Above Canyon	19	Y	8619	8619	100.0
185643	2004	2006	Below Canyon	16.5	Y	13995	13995	100.0
183530	2005	2006	Above Canyon	2	F	10238	11474	89.2
185254	2005	2006	Above Canyon	2	F	27867	29053	95.9
185251	2005	2006	Above Canyon	2	F	29223	30467	95.9
185252	2005	2006	Above Canyon	2	F	29217	30461	95.9
185253	2005	2006	Above Canyon	2	F	29043	30279	95.9
183531	2005	2006	Below Canyon	2	F	8629	8953	96.4
185255	2005	2006	Below Canyon	2	F	29199	30295	96.4
185256	2005	2006	Below Canyon	2	F	29022	30112	96.4
084325	2005	2007	Above Canyon	16.5	Y	225	225	100.0
084326	2005	2007	Below Canyon	16.5	Y	22	22	100.0
186005	2006	2007	Above Canyon	2.6	F	2995	3047	98.3
185927	2006	2007	Above Canyon	2.6	F	45790	46809	97.8
185554	2006	2007	Below Canyon	2.6	F	28880	31272	92.3
185555	2006	2007	Below Canyon	2.6	F	29569	32018	92.3
185645	2006	2007	Below Canyon	2.6	F	18705	20254	92.3

Tagcode	Brood Year	Release Year	Release Site Name	Weight (g)	Stage	# CWT Adclip	Total Released	% Tagged
020159	2006	2008	Above Canyon	17	Y	12002	12002	100.0
185642	2006	2008	Below Canyon	19	Y	13886	13886	100.0
186234	2007	2008	Above Canyon	2.4	F	29331	30018	97.7
183639	2007	2008	Above Canyon	2.4	F	10439	10684	97.7
186232	2007	2008	Above Canyon	2.4	F	29730	30429	97.7
186233	2007	2008	Above Canyon	2.4	F	29664	30363	97.7
180182	2007	2008	Below Canyon	2.4	F	54271	54716	99.2
186133	2007	2009	Above Canyon	17	Y	11209	11209	100.0
186135	2007	2009	Below Canyon	17	Y	10448	10448	100.0
186262	2008	2009	Above Canyon	3.3	F	24415	26309	92.8
186022	2008	2009	Above Canyon	3.3	F	4020	4198	95.8
186257	2008	2009	Above Canyon	3.3	F	33461	34441	97.2
186258	2008	2009	Above Canyon	3.3	F	25742	26367	97.6
186261	2008	2009	Above Canyon	3.3	F	25333	26201	96.7
186021	2008	2009	Above Canyon	3.3	F	2290	2392	95.7
186246	2008	2009	Below Canyon	3.3	F	2426	2517	96.4
180866	2008	2009	Below Canyon	3.3	F	24751	25973	95.3
180867	2008	2009	Below Canyon	3.3	F	25722	26941	95.5
180868	2008	2009	Below Canyon	3.3	F	26183	26638	98.3
180869	2008	2009	Below Canyon	3.3	F	14801	15354	96.4
186259	2008	2010	Above Canyon	16.5	Y	20215	20454	98.8
186245	2008	2010	Below Canyon	14.4	Y	527	542	97.2
180874	2008	2010	Below Canyon	14.4	Y	26257	27023	97.2
180781	2009	2010	Above Canyon	3	F	5450	5731	95.1
180782	2009	2010	Above Canyon	3	F	5179	5446	95.1
180783	2009	2010	Above Canyon	3	F	5583	5871	95.1
180786	2009	2010	Above Canyon	3	F	5514	5798	95.1
181286	2009	2010	Above Canyon	3	F	30545	32120	95.1
181287	2009	2010	Above Canyon	3	F	30354	31919	95.1
181288	2009	2010	Above Canyon	3	F	30436	32006	95.1
181289	2009	2010	Above Canyon	3	F	30774	32362	95.1
180790	2009	2010	Below Canyon	3	F	11462	11736	97.7
180791	2009	2010	Below Canyon	3	F	10705	10961	97.7
180792	2009	2010	Below Canyon	3	F	11426	11699	97.7
180793	2009	2010	Below Canyon	3	F	10187	10430	97.7
180794	2009	2010	Below Canyon	3	F	11133	11399	97.7
180789	2009	2010	Below Canyon	3	F	8910	12297	72.5
181285	2009	2011	Above Canyon	15.5	Y	31926	32030	99.7
181290	2009	2011	Below Canyon	16	Y	30794	32653	94.3
181595	2010	2011	Above Canyon	3	F	51578	54690	94.3
181596	2010	2011	Above Canyon	3	F	51541	54166	95.2

Tagcode	Brood Year	Release Year	Release Site Name	Weight (g)	Stage	# CWT Adclip	Total Released	% Tagged
181597	2010	2011	Above Canyon	3	F	51799	54521	95.0
180872	2010	2011	Above Canyon	3	F	25010	26492	94.4
181683	2010	2011	Above Canyon	3	F	3598	3735	96.3
181684	2010	2011	Above Canyon	3	F	5445	5709	95.4
180871	2010	2011	Below Canyon	3	F	19874	20916	95.0
182181	2010	2012	Above Canyon	19	Y	32130	32130	100.0
180784	2010	2012	Below Canyon	19	Y	5504	5504	100.0
180785	2010	2012	Below Canyon	19	Y	5148	5148	100.0
182182	2010	2012	Below Canyon	19	Y	21000	21000	100.0
182174	2011	2012	Above Canyon	3	F	9687	11108	87.2
182175	2011	2012	Above Canyon	3	F	7128	7596	93.8
181981	2011	2012	Above Canyon	3	F	53160	57486	92.5
181983	2011	2012	Above Canyon	3	F	52441	54434	96.3
182185	2011	2012	Below Canyon	3	F	13801	14702	93.9
181973	2011	2012	Below Canyon	3	F	19911	24328	81.8
182183	2011	2013	Above Canyon	20	Y	29262	32086	91.2
182184	2011	2013	Below Canyon	20	Y	24174	27163	89.0
183175	2012	2013	Above Canyon	3	F	38550	44351	86.9
180864	2012	2013	Above Canyon	3	F	11078	12595	88.0
183176	2012	2013	Below Canyon	3	F	38907	42769	91.0
180865	2012	2013	Below Canyon	3	F	10050	11316	88.8
181687	2012	2013	Below Canyon	3	F	2775	2967	93.5
186026	2012	2014	Above Canyon	16	Y	10211	11346	90.0
186028	2012	2014	Above Canyon	16	Y	5198	5776	90.0
186247	2012	2014	Below Canyon	16	Y	6657	9510	70.0
186248	2012	2014	Below Canyon	16	Y	4665	6665	70.0
183169	2013	2014	Above Canyon	3	F	370	378	97.9
183171	2013	2014	Above Canyon	3	F	30739	31102	98.8
183172	2013	2014	Above Canyon	3	F	32681	33145	98.6
183173	2013	2014	Above Canyon	3	F	32883	33148	99.2
183174	2013	2014	Above Canyon	3	F	14375	14820	97.0
182195	2013	2014	Below Canyon	3	F	54241	63201	85.8
183170	2013	2015	Above Canyon	17.5	Y	28860	32980	87.5
185614	2013	2015	Below Canyon	17.5	Y	10245	11307	90.6
185615	2013	2015	Below Canyon	17.5	Y	9904	10931	90.6
185616	2013	2015	Below Canyon	17.5	Y	10158	11211	90.6
183182	2014	2015	Above Canyon	2.5	F	72078	74644	96.6
183374	2014	2015	Above Canyon	2.5	F	4494	4654	96.6
180585	2014	2015	Above Canyon	2.5	F	11206	11605	96.6
180586	2014	2015	Above Canyon	2.5	F	11631	12045	96.6
183180	2014	2015	Below Canyon	2.5	F	53966	56069	96.3

Tagcode	Brood Year	Release Year	Release Site Name	Weight (g)	Stage	# CWT Adclip	Total Released	% Tagged
180588	2014	2015	Below Canyon	2.5	F	8411	8739	96.3
180589	2014	2015	Below Canyon	2.5	F	9551	9923	96.3
182187	2014	2016	Above Canyon	15	Y	29283	32186	91.0
185751	2014	2016	Below Canyon	15	Y	10891	10891	100.0
186027	2014	2016	Below Canyon	15	Y	10960	10960	100.0
185750	2014	2016	Below Canyon	15	Y	9469	9651	98.1
184269	2015	2016	Above Canyon	2.5	F	10745	11243	95.6
184270	2015	2016	Above Canyon	2.5	F	11537	12072	95.6
184271	2015	2016	Above Canyon	2.5	F	9350	9783	95.6
184278	2015	2016	Above Canyon	2.5	F	54110	56617	95.6
182893	2015	2016	Above Canyon	2.5	F	54008	56511	95.6
184268	2015	2016	Below Canyon	2.5	F	9558	10008	95.5
184277	2015	2016	Below Canyon	2.5	F	32573	34108	95.5
184081	2015	2016	Below Canyon	2.5	F	1612	1688	95.5
184267	2015	2016	Below Canyon	2.5	F	10518	11014	95.5
182875	2015	2017	Above Canyon	17.5	Y	24815	26366	94.1
184276	2015	2017	Below Canyon	17.5	Y	24958	27955	89.3
184371	2016	2017	Above Canyon	2.5	F	58246	58581	99.4
183499	2016	2017	Above Canyon	2.5	F	19816	19930	99.4
184084	2016	2017	Above Canyon	2.5	F	5848	5882	99.4
184370	2016	2017	Below Canyon	2.5	F	59002	59002	100.0
184272	2016	2017	Below Canyon	2.5	F	10875	10875	100.0
184083	2016	2017	Below Canyon	2.5	F	4782	4782	100.0
184287	2016	2018	Below Canyon	17.5	Y	27351	27561	99.2
181291	2016	2018	Below Canyon	17.5	Y	24849	24989	99.4
185167	2017	2018	Above Canyon	2.5	F	56991	57567	99.0
184172	2017	2018	Above Canyon	2.5	F	26979	27252	99.0
185166	2017	2018	Below Canyon	2	F	49665	49665	100.0
184997	2017	2019	Above Canyon	17.5	Y	19512	27264	71.6
184990	2017	2019	Below Canyon	17.5	Y	29183	29418	99.2
181681	2018	2019	Above Canyon	2.5	F	99914	101694	98.3
185191	2018	2019	Above Canyon	2.5	F	54039	55002	98.3
185192	2018	2019	Below Canyon	2.5	F	51984	52443	99.1
185384	2018	2020	Below Canyon	17.5	Y	10338	12446	83.1
185385	2018	2020	Below Canyon	17.5	Y	11586	13949	83.1
185268	2018	2020	Above Canyon	17.5	Y	20964	26176	80.1

Appendix 4. Kitsumkalum Chinook salmon hatchery contributions to escapement by tag code.
YY = yearling, FF = fry

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
1985	1979	21852	5	9,081	34.9	127	48,091	3,799	1.0790	37.7	183	FF
1985	1980	21951	9	9,081	76.8	127	44,273	18,842	1.4256	109.5	183	FF
1986	1980	21951	11	8,081	30.3	97	44,273	18,842	1.4256	43.2	169	FF
1985	1981	22313	2	9,081	15.0	127	29,459	40,941	2.3898	35.8	183	FF
1986	1981	22312	11	8,081	29.7	97	23,234	7,016	1.3020	38.6	169	FF
1986	1981	22313	13	8,081	36.5	97	29,459	40,941	2.3898	87.3	169	FF
1987	1981	22312	8	15,549	44.5	94	23,234	7,016	1.3020	58.0	175	FF
1987	1981	22313	8	15,549	49.1	94	29,459	40,941	2.3898	117.3	175	FF
1988	1981	22313	2	15,853	10.3	60	29,459	40,941	2.3898	24.6	74	FF
1988	1983	22758	9	15,853	31.5	60	30,716	0	1.0000	31.5	74	FF
1989	1983	22758	2	17,823	36.9	587	30,716	0	1.0000	36.9	588	FF
1987	1984	23347	1	15,549	jacks	0	26,198	211	1.0081	jacks	0	FF
1988	1984	23347	1	15,853	3.6	60	26,198	211	1.0081	3.6	74	FF
1988	1984	23350	2	15,853	10.5	60	25,980	91	1.0035	10.6	74	FF
1989	1984	23346	7	17,823	147.9	587	26,146	0	1.0000	147.9	588	FF
1989	1984	23347	2	17,823	29.4	587	26,409	0	1.0000	29.4	588	FF
1989	1984	23348	5	17,823	52.7	587	26,262	0	1.0000	52.7	588	FF
1989	1984	23349	4	17,823	81.3	587	26,479	0	1.0000	81.3	588	FF
1989	1984	23350	3	17,823	43.6	587	26,058	13	1.0005	43.6	588	FF
1989	1984	23351	6	17,823	90.9	587	26,376	0	1.0000	90.9	588	FF
1989	1984	23352	4	17,823	41.7	587	26,509	0	1.0000	41.7	588	FF
1989	1984	23353	4	17,823	13.8	587	24,512	1,659	1.0677	14.8	588	FF
1990	1984	23346	6	11,119	24.9	278	25,937	209	1.0081	25.1	285	FF
1990	1984	23347	5	11,119	20.3	278	26,198	211	1.0081	20.4	285	FF
1990	1984	23348	4	11,119	17.3	278	25,978	183	1.0070	17.4	285	FF
1990	1984	23349	3	11,119	12.5	278	26,373	93	1.0035	12.5	285	FF
1990	1984	23350	4	11,119	16.9	278	25,980	91	1.0035	16.9	285	FF
1990	1984	23351	8	11,119	33.0	278	26,376	0	1.0000	33.0	285	FF
1990	1984	23352	5	11,119	21.3	278	26,509	0	1.0000	21.3	285	FF
1990	1984	23353	4	11,119	15.8	278	24,512	1,659	1.0677	16.9	285	FF
1988	1985	23705	1	15,853	3.6	60	42,264	236	1.0056	3.6	74	FF
1989	1985	23704	3	17,823	31.8	587	44,360	86	1.0019	31.9	588	FF
1989	1985	23705	2	17,823	17.1	587	42,434	66	1.0016	17.1	588	FF
1990	1985	23704	7	11,119	28.9	278	44,183	263	1.0060	29.1	285	FF
1990	1985	23705	8	11,119	25.1	278	42,264	236	1.0056	25.3	285	FF
1990	1985	23706	13	11,119	46.1	278	43,916	3,506	1.0798	49.8	285	FF
1990	1985	23707	3	11,119	12.0	278	43,892	3,679	1.0838	13.1	285	FF

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
1991	1985	23704	5	9,267	27.2	116	44,183	263	1.0060	27.3	140	FF
1991	1985	23706	1	9,267	13.5	116	43,916	3,506	1.0798	14.6	140	FF
1991	1985	23707	1	9,267	5.9	116	43,892	3,679	1.0838	6.4	140	FF
1990	1986	24412	1	11,119	4.0	278	26,784	0	1.0000	4.0	285	FF
1991	1986	24411	1	9,267	13.5	116	25,221	4,747	1.1882	16.1	140	FF
1991	1986	24413	1	9,267	5.9	116	26,783	108	1.0040	5.9	140	FF
1991	1986	24414	1	9,267	5.9	116	26,581	3,134	1.1179	6.6	140	FF
1992	1986	24411	2	10,880	12.0	353	25,221	4,747	1.1882	14.3	412	FF
1992	1986	24412	1	10,880	5.6	353	26,784	0	1.0000	5.6	412	FF
1990	1987	24944	2	11,119	jacks	0	26,423	362	1.0137	jacks	0	FF
1991	1987	24941	2	9,267	7.2	116	27,021	133	1.0049	7.3	140	FF
1991	1987	24943	1	9,267	3.6	116	25,262	8,555	1.3387	4.8	140	FF
1991	1987	25060	1	9,267	13.5	116	27,522	14,994	1.5448	20.9	140	FF
1991	1987	25061	2	9,267	19.4	116	27,475	14,993	1.5457	30.0	140	FF
1992	1987	24941	5	10,880	39.8	353	27,021	133	1.0049	40.0	412	FF
1992	1987	24942	17	10,880	111.7	353	26,570	460	1.0173	113.6	412	FF
1992	1987	24943	2	10,880	12.8	353	25,262	8,555	1.3387	17.2	412	FF
1992	1987	24944	12	10,880	81.2	353	26,423	362	1.0137	82.3	412	FF
1992	1987	25060	5	10,880	35.9	353	27,522	14,994	1.5448	55.5	412	FF
1992	1987	25061	6	10,880	53.9	353	27,475	14,993	1.5457	83.3	412	FF
1993	1987	24941	2	13,181	19.3	117	27,157	0	1.0000	19.3	128	FF
1993	1987	24942	1	13,181	4.9	117	27,030	0	1.0000	4.9	128	FF
1993	1987	24944	2	13,181	23.6	117	26,798	0	1.0000	23.6	128	FF
1993	1987	25060	1	13,181	6.5	117	27,522	14,994	1.5448	10.1	128	FF
1993	1987	25061	1	13,181	6.5	117	27,475	14,993	1.5457	10.1	128	FF
1993	1988	26039	2	13,181	9.8	117	27,405	1,917	1.0700	10.4	128	FF
1993	1988	26040	2	13,181	9.8	117	27,075	1,917	1.0708	10.5	128	FF
1993	1988	26041	2	13,181	23.6	117	26,811	1,916	1.0715	25.3	128	FF
1993	1988	26042	1	13,181	12.8	117	24,571	1,917	1.0780	13.8	128	FF
1994	1988	26043	2	14,003	27.7	73	26,849	1,917	1.0714	29.7	81	FF
1994	1988	26044	1	14,003	13.0	73	26,299	1,917	1.0729	14.0	81	FF
1994	1988	26045	1	14,003	14.7	73	21,952	2,182	1.0994	16.1	81	FF
1995	1989	20942	1	6,515	27.6	72	26,908	0	1.0000	27.6	81	FF
1994	1990	21140	1	14,003	17.2	73	21,952	5,544	1.2526	21.6	81	FF
1995	1990	21136	1	6,515	14.6	72	26,783	5,545	1.2070	17.7	81	FF
1995	1990	21137	1	6,515	14.6	72	26,599	5,544	1.2084	17.7	81	FF
1995	1990	21138	1	6,515	14.6	72	26,722	5,545	1.2075	17.7	81	FF
1996	1990	21135	1	8,595	12.8	191	26,736	5,545	1.2074	15.5	211	FF
1996	1990	21136	1	8,595	12.8	191	26,783	5,545	1.2070	15.5	211	FF
1996	1990	21137	1	8,595	12.8	191	26,599	5,545	1.2085	15.5	211	FF

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
1996	1990	21139	1	8,595	12.8	72	26,624	5,545	1.2083	15.5	81	FF
1996	1991	21010	2	8,595	57.6	191	25,634	2,391	1.0933	63.0	211	FF
1996	1991	23116	4	8,595	49.9	191	156,630	11,760	1.0751	53.7	211	FF
1997	1991	21010	3	4,675	14.8	359	25,634	1,868	1.0729	15.9	374	FF
1997	1991	21011	1	4,675	5.6	359	26,679	1,906	1.0714	6.0	374	FF
1997	1991	23116	33	4,675	148.4	359	156,630	11,226	1.0717	159.1	374	FF
1996	1992	181049	1	8,595	31.9	191	26,134	622	1.0238	32.6	211	FF
1997	1992	181046	1	4,675	5.2	359	25,635	355	1.0138	5.2	374	FF
1997	1992	181047	4	4,675	20.6	359	25,811	885	1.0343	21.3	374	FF
1997	1992	181048	6	4,675	25.9	359	26,357	360	1.0137	26.2	374	FF
1997	1992	181049	4	4,675	19.4	359	26,134	358	1.0137	19.6	374	FF
1997	1992	181050	6	4,675	25.9	359	26,610	361	1.0136	26.2	374	FF
1997	1992	181051	9	4,675	41.6	359	26,772	364	1.0136	42.2	374	FF
1997	1992	181052	8	4,675	36.5	359	25,118	344	1.0137	37.0	374	FF
1998	1992	181046	2	6,009	5.5	253	25,635	878	1.0343	5.7	255	FF
1998	1992	181047	1	6,009	3.2	253	25,811	885	1.0343	3.3	255	FF
1998	1992	181048	4	6,009	14.3	253	26,357	492	1.0187	14.6	255	FF
1998	1992	181049	11	6,009	42.0	253	26,134	622	1.0238	43.0	255	FF
1998	1992	181050	2	6,009	5.5	253	26,610	361	1.0136	5.6	255	FF
1998	1992	181051	4	6,009	11.0	253	26,772	364	1.0136	11.1	255	FF
1998	1992	181052	1	6,009	2.3	253	25,118	598	1.0238	2.4	255	FF
1997	1993	21104	1	4,675	5.6	359	100,060	251	1.0025	5.6	374	FF
1997	1993	181423	1	4,675	5.6	359	49,902	165	1.0033	5.6	374	FF
1997	1993	191424	1	4,675	3.9	359	50,119	0	1.0000	3.9	374	FF
1998	1993	21104	16	6,009	66.1	253	100,060	251	1.0025	66.2	255	FF
1998	1993	181423	6	6,009	22.2	253	49,902	165	1.0033	22.2	255	FF
1998	1993	181424	8	6,009	37.5	253	50,119	0	1.0000	37.5	255	FF
1999	1993	21104	7	9,035	31.0	390	100,060	251	1.0025	31.1	395	FF
1999	1993	181423	6	9,035	30.8	390	49,902	165	1.0033	30.9	395	FF
1999	1993	181424	3	9,035	12.9	390	50,119	0	1.0000	12.9	395	FF
1997	1994	180640	1	4,675	jacks	0	30,009	524	1.0175	jacks	0	FF
1997	1994	180641	2	4,675	jacks	0	29,945	523	1.0175	jacks	0	FF
1998	1994	180640	2	6,009	11.3	253	30,009	524	1.0175	11.5	255	FF
1998	1994	180641	1	6,009	5.5	253	29,945	523	1.0175	5.6	255	FF
1998	1994	182155	4	6,009	17.4	253	29,251	511	1.0175	17.7	255	FF
1998	1994	182156	2	6,009	8.8	253	30,170	527	1.0175	9.0	255	FF
1999	1994	180608	11	9,035	52.6	390	10,527	184	1.0175	53.5	395	FF
1999	1994	180609	9	9,035	49.1	390	10,700	187	1.0175	50.0	395	FF
1999	1994	180640	4	9,035	19.7	390	30,010	524	1.0175	20.1	395	FF
1999	1994	180641	5	9,035	25.9	390	29,946	523	1.0175	26.4	395	FF

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
1999	1994	180642	7	9,035	36.5	390	30,867	539	1.0175	37.1	395	FF
1999	1994	182155	4	9,035	21.6	390	29,252	511	1.0175	22.0	395	FF
1999	1994	182156	16	9,035	74.2	390	30,171	527	1.0175	75.5	395	FF
1999	1994	182157	4	9,035	20.6	390	28,943	505	1.0174	21.0	395	FF
2000	1994	180608	1	10,178	3.4	268	10,527	184	1.0175	3.5	271	FF
2000	1994	180609	1	10,178	5.7	268	10,700	187	1.0175	5.8	271	FF
2000	1994	180640	3	10,178	28.2	268	30,010	524	1.0175	28.7	271	FF
2000	1994	182155	1	10,178	3.4	268	29,252	511	1.0175	3.5	271	FF
2000	1994	182156	1	10,178	4.7	268	30,171	527	1.0175	4.7	271	FF
2000	1994	182157	1	10,178	4.7	268	28,943	505	1.0174	4.7	271	FF
1999	1995	182339	1	9,035	3.7	390	26,105	269	1.0103	3.7	395	FF
1999	1995	182340	1	9,035	3.7	390	25,819	266	1.0103	3.7	395	FF
1999	1995	182342	1	9,035	3.7	390	28,450	293	1.0103	3.7	395	FF
1999	1995	182344	1	9,035	3.7	390	28,241	291	1.0103	3.7	395	FF
2000	1995	182340	1	10,178	3.4	268	25,819	266	1.0103	3.5	271	FF
2000	1995	182341	6	10,178	30.8	268	28,193	578	1.0205	31.4	271	FF
2000	1995	182342	3	10,178	27.1	268	28,450	293	1.0103	27.4	271	FF
2000	1995	182344	1	10,178	11.2	268	28,241	291	1.0103	11.4	271	FF
2000	1995	182345	5	10,178	34.0	268	28,566	294	1.0103	34.3	271	FF
2001	1995	182340	1	17,866	3.8	451	25,819	266	1.0103	3.8	455	FF
2001	1995	182341	2	17,866	11.3	451	28,193	578	1.0205	11.5	455	FF
2001	1995	182343	1	17,866	8.5	451	28,561	294	1.0103	8.6	455	FF
2001	1995	182344	1	17,866	10.3	451	28,241	291	1.0103	10.4	455	FF
1999	1996	182752	1	9,035	jacks	0	29,096	574	1.0197	jacks	0	FF
1999	1996	182755	1	9,035	jacks	0	20,403	0	1.0000	jacks	0	FF
2000	1996	182749	1	10,178	4.7	268	26,622	525	1.0197	4.8	271	FF
2000	1996	182750	1	10,178	3.4	268	28,514	562	1.0197	3.5	271	FF
2000	1996	182753	2	10,178	6.8	268	29,293	578	1.0197	7.0	271	FF
2000	1996	182754	1	10,178	5.7	268	29,002	572	1.0197	5.8	271	FF
2000	1996	182755	18	10,178	90.7	268	20,403	0	1.0000	90.7	271	FF
2001	1996	182749	1	17,866	8.5	451	26,622	525	1.0197	8.7	455	FF
2001	1996	182752	2	17,866	17.8	451	29,096	574	1.0197	18.2	455	FF
2001	1996	182753	7	17,866	55.4	451	29,293	578	1.0197	56.5	455	FF
2001	1996	182754	4	17,866	29.1	451	29,002	572	1.0197	29.6	455	FF
2001	1996	182755	33	17,866	262.2	451	20,403	0	1.0000	262.2	455	YE
2002	1996	182750	2	11,220	22.0	312	28,514	562	1.0197	22.4	318	FF
2002	1996	182752	1	11,220	6.3	312	29,096	574	1.0197	6.4	318	FF
2002	1996	182755	7	11,220	59.7	312	20,403	0	1.0000	59.7	318	YE
2000	1997	182806	2	10,178	jacks	0	27,399	1,291	1.0471	jacks	0	FF
2001	1997	182806	3	17,866	27.3	451	27,399	1,291	1.0471	28.6	455	FF

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
2001	1997	182808	1	17,866	8.5	451	27,132	696	1.0257	8.7	455	FF
2001	1997	184213	1	17,866	8.5	451	54,684	275	1.0050	8.5	455	FF
2002	1997	182806	12	11,220	103.6	312	27,399	1,291	1.0471	108.4	318	FF
2002	1997	182807	3	11,220	28.3	312	28,803	291	1.0101	28.5	318	FF
2002	1997	182808	2	11,220	22.0	312	27,132	696	1.0257	22.6	318	FF
2002	1997	182809	3	11,220	9.8	312	29,066	146	1.0050	9.8	318	FF
2002	1997	182810	3	11,220	10.0	312	29,301	0	1.0000	10.0	318	FF
2002	1997	183307	2	11,220	12.5	312	11,447	116	1.0101	12.6	318	FF
2002	1997	183308	1	11,220	3.2	312	11,481	0	1.0000	3.2	318	FF
2003	1997	182807	1	17,525	14.9	387	28,803	291	1.0101	15.1	388	FF
2003	1997	182810	1	17,525	8.6	387	29,301	0	1.0000	8.6	388	FF
2003	1997	183307	2	17,525	11.9	387	11,447	116	1.0101	12.1	388	FF
2002	1998	184213	2	11,220	18.9	312	54,684	275	1.0050	19.0	318	FF
2002	1998	184214	1	11,220	15.7	312	54,591	0	1.0000	15.7	318	FF
2003	1998	183063	10	17,525	63.1	387	25,149	126	1.0050	63.5	388	FF
2003	1998	184212	10	17,525	74.7	387	55,085	0	1.0000	74.7	388	FF
2003	1998	184213	13	17,525	103.4	387	54,684	275	1.0050	103.9	388	FF
2003	1998	184214	9	17,525	80.6	387	54,591	0	1.0000	80.6	388	FF
2004	1998	184212	2	19,664	11.3	994	55,085	0	1.0000	11.3	999	FF
2004	1998	184213	4	19,664	46.6	994	54,684	275	1.0050	46.8	999	FF
2004	1998	184214	1	19,664	9.4	994	54,591	0	1.0000	9.4	999	FF
2003	1999	184562	2	17,525	29.9	387	30,538	0	1.0000	29.9	388	FF
2004	1999	184560	3	19,664	34.2	994	25,338	0	1.0000	34.2	999	FF
2004	1999	184561	10	19,664	103.0	994	25,301	0	1.0000	103.0	999	FF
2004	1999	184562	40	19,664	303.3	994	30,538	0	1.0000	303.3	999	YE
2004	1999	184563	8	19,664	93.1	994	26,879	0	1.0000	93.1	999	FF
2004	1999	184601	4	19,664	22.6	994	30,531	654	1.0214	23.1	999	FF
2004	1999	184602	7	19,664	51.7	994	30,246	648	1.0214	52.8	999	FF
2004	1999	184603	10	19,664	70.9	994	30,639	657	1.0214	72.4	999	FF
2004	1999	184604	2	19,664	11.3	994	26,727	573	1.0214	11.6	999	FF
2005	1999	184561	2	11,382	9.2	359	25,301	0	1.0000	9.2	361	FF
2005	1999	184562	10	11,382	63.9	359	30,538	0	1.0000	63.9	361	YE
2005	1999	184563	1	11,382	4.6	359	26,879	0	1.0000	4.6	361	FF
2005	1999	184602	1	11,382	7.6	359	30,246	648	1.0214	7.7	361	FF
2005	1999	184603	1	11,382	4.6	359	30,639	657	1.0214	4.7	361	FF
2004	2000	184621	29	19,664	205.5	994	28,028	0	1.0000	205.5	999	YE
2004	2000	184622	3	19,664	15.7	994	29,246	634	1.0217	16.0	999	FF
2004	2000	184623	1	19,664	5.2	994	29,231	633	1.0217	5.3	999	FF
2004	2000	184625	2	19,664	10.4	994	28,500	618	1.0217	10.7	999	FF
2005	2000	184308	1	11,382	7.7	359	40,779	733	1.0180	7.8	361	FF

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
2005	2000	184621	28	11,382	162.4	359	28,028	0	1.0000	162.4	361	YE
2005	2000	184622	1	11,382	7.7	359	29,246	634	1.0217	7.9	361	FF
2005	2000	184623	3	11,382	22.7	359	29,231	633	1.0217	23.2	361	FF
2005	2000	184625	2	11,382	12.2	359	28,500	618	1.0217	12.5	361	FF
2005	2000	184626	1	11,382	4.6	359	27,167	350	1.0129	4.6	361	FF
2005	2000	184627	4	11,382	21.4	359	26,275	338	1.0129	21.7	361	FF
2006	2000	184621	11	8,396	80.5	409	28,028	0	1.0000	80.5	411	YE
2006	2000	184625	2	8,396	9.9	409	28,500	618	1.0217	10.1	411	FF
2005	2001	180148	1	11,382	7.7	359	26,357	492	1.0187	7.8	361	FF
2005	2001	184302	1	11,382	7.7	359	12,877	0	1.0000	7.7	361	FF
2005	2001	185045	1	11,382	7.7	359	30,165	86	1.0029	7.7	361	FF
2005	2001	185051	1	11,382	7.6	359	25,482	325	1.0128	7.7	361	FF
2006	2001	180148	11	8,396	82.7	409	13,487	0	1.0000	82.7	411	YE
2006	2001	183506	1	8,396	4.6	409	6,477	18	1.0028	4.6	411	FF
2006	2001	184302	12	8,396	74.9	409	12,877	0	1.0000	74.9	411	YE
2006	2001	185045	3	8,396	17.4	409	30,165	86	1.0029	17.5	411	FF
2006	2001	185046	3	8,396	13.7	409	30,358	86	1.0028	13.8	411	FF
2006	2001	185047	3	8,396	21.1	409	30,052	85	1.0028	21.2	411	FF
2006	2001	185048	2	8,396	10.6	409	26,815	343	1.0128	10.7	411	FF
2006	2001	185049	2	8,396	19.4	409	27,119	346	1.0128	19.7	411	FF
2006	2001	185050	3	8,396	19.6	409	27,123	346	1.0128	19.9	411	FF
2007	2001	180148	1	11,739	17.3	694	13,487	0	1.0000	17.3	704	YE
2007	2001	184302	4	11,739	64.9	694	12,877	0	1.0000	64.9	704	YE
2007	2001	185048	1	11,739	6.3	694	26,815	343	1.0128	6.4	704	FF
2007	2001	185049	1	11,739	6.3	694	27,119	346	1.0128	6.4	704	FF
2007	2001	185051	1	11,739	17.3	694	25,482	325	1.0128	17.5	704	FF
2005	2002	184420	2	11,382	jacks	0	12,267	0	1.0000	jacks	0	FF
2006	2002	184243	1	8,396	8.3	409	11,702	307	1.0262	8.5	411	FF
2006	2002	184420	3	8,396	24.8	409	12,267	0	1.0000	24.8	411	YE
2006	2002	184827	3	8,396	21.8	409	10,980	0	1.0000	21.8	411	YE
2007	2002	184243	2	11,739	32.4	694	11,702	307	1.0262	33.3	704	FF
2007	2002	184420	12	11,739	161.9	694	12,267	0	1.0000	161.9	704	YE
2007	2002	184827	13	11,739	137.7	694	10,980	0	1.0000	137.7	704	YE
2007	2002	185057	2	11,739	34.6	694	30,215	459	1.0152	35.1	704	FF
2007	2002	185341	6	11,739	50.2	694	48,318	628	1.0130	50.8	704	FF
2008	2002	184420	1	6,903	5.8	358	12,267	0	1.0000	5.8	370	YE
2008	2002	184827	2	6,903	15.3	358	10,980	0	1.0000	15.3	370	YE
2006	2003	185540	1	8,396	jacks	0	53,198	3,762	1.0707	jacks	0	FF
2007	2003	184830	3	11,739	45.4	694	12,602	0	1.0000	45.4	704	YE
2007	2003	185401	2	11,739	13.5	694	30,296	1,807	1.0596	14.3	704	FF

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
2007	2003	185402	1	11,739	6.7	694	27,744	1,814	1.0654	7.2	704	FF
2007	2003	185539	6	11,739	49.8	694	53,454	3,189	1.0597	52.7	704	FF
2007	2003	185540	3	11,739	49.7	694	53,198	3,762	1.0707	53.2	704	FF
2008	2003	184830	14	6,903	88.6	358	12,602	0	1.0000	88.6	370	YE
2008	2003	184831	3	6,903	16.8	358	12,456	0	1.0000	16.8	370	YE
2008	2003	185401	9	6,903	43.9	358	30,296	1,807	1.0596	46.5	370	FF
2008	2003	185402	1	6,903	9.5	358	27,744	1,814	1.0654	10.1	370	FF
2008	2003	185539	11	6,903	44.8	358	53,454	3,189	1.0597	47.5	370	FF
2008	2003	185540	5	6,903	40.0	358	53,198	3,762	1.0707	42.8	370	FF
2009	2003	184830	10	8,350	52.2	754	12,602	0	1.0000	52.2	788	YE
2009	2003	184831	9	8,350	50.9	754	12,456	0	1.0000	50.9	788	YE
2009	2003	185402	1	8,350	5.4	754	27,744	1,814	1.0654	5.8	788	FF
2009	2003	185539	3	8,350	16.4	754	53,454	3,189	1.0597	17.4	788	FF
2009	2003	185540	2	8,350	9.8	754	53,198	3,762	1.0707	10.5	788	FF
2007	2004	184439	4	11,739	jacks	0	14,227	0	1.0000	jacks	0	YE
2007	2004	185643	1	11,739	jacks	0	8,619	0	1.0000	jacks	0	YE
2008	2004	184439	6	6,903	48.1	358	14,227	0	1.0000	48.1	370	YE
2008	2004	185060	1	6,903	5.1	358	27,704	5,335	1.1926	6.1	370	FF
2008	2004	185643	4	6,903	30.5	358	13,995	0	1.0000	30.5	370	YE
2008	2004	185652	1	6,903	9.5	358	24,502	4,719	1.1926	11.3	370	YE
2009	2004	184439	20	8,350	103.8	754	14,227	0	1.0000	103.8	788	YE
2009	2004	185060	6	8,350	32.3	754	27,704	5,335	1.1926	38.5	788	FF
2009	2004	185409	4	8,350	21.3	754	29,672	5,715	1.1926	25.5	788	FF
2009	2004	185629	7	8,350	35.4	754	8,619	0	1.0000	35.4	788	YE
2009	2004	185643	31	8,350	162.2	754	13,995	0	1.0000	162.2	788	YE
2009	2004	185652	4	8,350	24.0	754	24,502	4,719	1.1926	28.6	788	FF
2009	2004	185653	3	8,350	17.6	754	29,762	4,022	1.1351	20.0	788	FF
2009	2004	185654	6	8,350	31.6	754	28,006	3,784	1.1351	35.9	788	FF
2009	2004	185655	5	8,350	26.1	754	25,628	3,463	1.1351	29.6	788	FF
2010	2004	184439	8	8,932	31.8	677	14,227	0	1.0000	31.8	700	YE
2010	2004	185060	2	8,932	8.2	677	27,704	5,335	1.1926	9.7	700	FF
2010	2004	185629	4	8,932	12.6	677	8,619	0	1.0000	12.6	700	YE
2010	2004	185643	4	8,932	22.5	677	13,995	0	1.0000	22.5	700	YE
2010	2004	185653	2	8,932	11.3	677	29,762	4,022	1.1351	12.8	700	FF
2010	2004	185654	1	8,932	5.6	677	28,006	3,784	1.1351	6.4	700	FF
2008	2005	185252	1	6,903	jacks	0	29,271	1,190	1.0407	jacks	0	FF
2008	2005	185255	1	6,903	jacks	0	29,199	1,096	1.0375	jacks	0	FF
2009	2005	183530	2	8,350	8.4	754	10,238	1,236	1.1207	9.4	788	FF
2009	2005	183531	2	8,350	8.7	754	8,629	324	1.0375	9.0	788	FF
2009	2005	185251	3	8,350	14.7	754	29,223	1,244	1.0426	15.3	788	FF

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
2009	2005	185252	6	8,350	27.4	754	29,217	1,244	1.0426	28.5	788	FF
2009	2005	185253	4	8,350	19.0	754	29,043	1,236	1.0426	19.8	788	FF
2009	2005	185254	1	8,350	4.0	754	27,867	1,186	1.0426	4.2	788	FF
2009	2005	185255	12	8,350	55.3	754	29,199	1,096	1.0375	57.3	788	FF
2009	2005	185256	6	8,350	27.1	754	29,022	1,090	1.0376	28.1	788	FF
2010	2005	183530	5	8,932	14.9	677	10,238	1,236	1.1207	16.7	700	FF
2010	2005	183531	2	8,932	8.0	677	8,629	324	1.0375	8.3	700	FF
2010	2005	185251	11	8,932	45.4	677	29,223	1,244	1.0426	47.3	700	FF
2010	2005	185252	8	8,932	28.4	677	29,217	1,244	1.0426	29.6	700	FF
2010	2005	185253	9	8,932	30.5	677	29,043	1,236	1.0426	31.8	700	FF
2010	2005	185254	13	8,932	43.3	677	27,867	1,186	1.0426	45.1	700	FF
2010	2005	185255	26	8,932	143.9	677	29,199	1,096	1.0375	149.3	700	FF
2010	2005	185256	4	8,932	22.7	677	29,022	1,090	1.0376	23.5	700	FF
2009	2006	02-01-59	2	8,350	jacks	0	12,002	0	1.0000	jacks	0	YE
2009	2006	185554	1	8,350	jacks	0	28,880	2,392	1.0828	jacks	0	FF
2009	2006	185555	1	8,350	jacks	0	29,569	2,449	1.0828	jacks	0	FF
2009	2006	185927	1	8,350	jacks	0	45,790	1,019	1.0223	jacks	0	FF
2009	2006	186005	1	8,350	jacks	0	2,995	52	1.0174	jacks	0	FF
2010	2006	02-01-59	15	8,932	58.8	677	12,002	0	1.0000	58.8	700	YE
2010	2006	185554	4	8,932	21.2	677	28,880	2,392	1.0828	23.0	700	FF
2010	2006	185555	1	8,932	5.8	677	29,569	2,449	1.0828	6.2	700	FF
2010	2006	185642	10	8,932	57.4	677	13,886	0	1.0000	57.4	700	YE
2010	2006	185645	4	8,932	23.1	677	18,705	1,549	1.0828	25.0	700	FF
2010	2006	185927	9	8,932	35.4	677	45,790	1,019	1.0223	36.2	700	FF
2010	2006	186133	8	8,932	46.2	677	11,209	0	1.0000	46.2	700	YE
2011	2006	20159	5	6,755	41.1	330	12,002	0	1.0000	41.1	341	YE
2011	2006	185554	3	6,755	36.9	330	28,880	2,392	1.0828	39.9	341	FF
2011	2006	185555	4	6,755	58.7	330	29,569	2,449	1.0828	63.5	341	FF
2011	2006	185642	4	6,755	53.9	330	13,886	0	1.0000	53.9	341	YE
2011	2006	185645	2	6,755	27.0	330	18,705	1,549	1.0828	29.2	341	FF
2011	2006	185927	5	6,755	19.3	330	45,790	1,019	1.0223	19.8	341	FF
2011	2006	186133	1	6,755	14.7	330	11,209	0	1.0000	14.7	341	YE
2012	2006	185555	1	6,291	3.1	269	29,569	2,449	1.0828	3.3	274	FF
2012	2006	185645	1	6,291	3.1	269	18,705	1,549	1.0828	3.3	274	FF
2010	2007	180182	2	8,932	jacks	0	54,271	445	1.0082	jacks	0	FF
2010	2007	186232	2	8,932	jacks	0	29,730	699	1.0235	jacks	0	FF
2010	2007	186233	3	8,932	jacks	0	29,664	699	1.0236	jacks	0	FF
2011	2007	180182	3	6,755	44.0	330	54,271	273	1.0050	44.2	341	FF
2011	2007	186135	1	6,755	14.7	330	54,271	445	1.0082	14.8	341	FF
2011	2007	186232	2	6,755	6.6	330	29,730	699	1.0235	6.7	341	FF

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
2011	2007	186233	1	6,755	3.3	330	29,664	699	1.0236	3.4	341	FF
2011	2007	186234	3	6,755	9.9	330	29,331	687	1.0234	10.1	341	FF
2012	2007	180182	10	6,291	32.3	269	54,271	445	1.0082	32.6	274	FF
2012	2007	183639	2	6,291	11.1	269	10,439	245	1.0235	11.3	274	FF
2012	2007	186133	12	6,291	51.1	269	11,209	0	1.0000	51.1	274	YE
2012	2007	186135	3	6,291	12.6	269	10,448	0	1.0000	12.6	274	YE
2012	2007	186232	4	6,291	23.0	269	29,730	699	1.0235	23.5	274	FF
2012	2007	186233	3	6,291	16.6	269	29,664	699	1.0236	17.0	274	FF
2012	2007	186234	3	6,291	16.6	269	29,331	687	1.0234	17.0	274	FF
2013	2007	180182	1	11,356	10.1	504	54,271	445	1.0082	10.2	518	FF
2013	2007	186133	1	11,356	22.3	504	11,209	0	1.0000	22.3	518	YE
2013	2007	186233	1	11,356	4.4	504	29,664	699	1.0236	4.6	518	FF
2011	2008	180874	1	6,755	jacks	0	26,257	766	1.0292	jacks	0	FF
2012	2008	180868	1	6,291	4.8	269	26,183	455	1.0174	4.8	274	FF
2012	2008	180874	4	6,291	23.7	269	26,257	766	1.0292	24.4	274	YE
2012	2008	186257	1	6,291	6.3	269	33,461	980	1.0293	6.5	274	FF
2012	2008	186258	1	6,291	6.3	269	25,742	625	1.0243	6.5	274	FF
2012	2008	186259	10	6,291	52.3	269	20,215	239	1.0118	52.9	274	YE
2012	2008	186262	1	6,291	6.3	269	24,415	1,894	1.0776	6.8	274	FF
2013	2008	180867	1	11,356	10.1	504	25,722	1,219	1.0474	10.6	518	FF
2013	2008	180868	2	11,356	20.3	504	26,183	455	1.0174	20.6	518	FF
2013	2008	180869	1	11,356	22.3	504	14,801	553	1.0374	23.1	518	FF
2013	2008	180874	8	11,356	72.3	504	26,257	766	1.0292	74.4	518	YE
2013	2008	186022	1	11,356	2.1	504	4,020	178	1.0443	2.2	518	FF
2013	2008	186257	2	11,356	4.2	504	33,461	980	1.0293	4.4	518	FF
2013	2008	186258	1	11,356	2.1	504	25,742	625	1.0243	2.2	518	FF
2013	2008	186259	14	11,356	140.5	504	20,215	239	1.0118	142.2	518	YE
2013	2008	186261	1	11,356	4.4	504	25,333	868	1.0343	4.6	518	FF
2013	2008	186262	4	11,356	21.2	504	24,415	1,894	1.0776	22.8	518	FF
2014	2008	180867	1	10,042	5.6	536	25,722	1,219	1.0474	5.9	549	FF
2014	2008	180874	2	10,042	18.2	536	26,257	766	1.0292	18.8	549	YE
2014	2008	186257	1	10,042	9.1	536	33,461	980	1.0293	9.4	549	FF
2014	2008	186259	1	10,042	9.1	536	20,215	239	1.0118	9.2	549	YE
2014	2008	186262	1	10,042	9.1	536	24,415	1,894	1.0776	9.8	549	FF
2012	2009	180782	1	6,291	jacks	0	5,179	267	1.0516	jacks	0	FF
2012	2009	180790	1	6,291	jacks	0	11,462	274	1.0239	jacks	0	FF
2012	2009	181285	1	6,291	jacks	0	31,053	104	1.0033	jacks	0	YE
2012	2009	181286	1	6,291	jacks	0	30,545	1,575	1.0516	jacks	0	FF
2012	2009	181287	1	6,291	jacks	0	30,354	1,565	1.0516	jacks	0	FF
2012	2009	181289	1	6,291	jacks	0	30,774	1,588	1.0516	jacks	0	FF

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
2012	2009	181290	2	6,291	jacks	0	29,352	1,859	1.0633	jacks	0	YE
2013	2009	180782	1	11,356	2.1	504	5,179	267	1.0516	2.2	518	FF
2013	2009	180790	1	11,356	22.3	504	11,462	274	1.0239	22.8	518	FF
2013	2009	180794	1	11,356	2.1	504	11,133	266	1.0239	2.2	518	FF
2013	2009	181285	6	11,356	53.0	504	26,257	766	1.0292	54.6	518	YE
2013	2009	181287	3	11,356	26.5	504	30,354	1,565	1.0516	27.9	518	FF
2013	2009	181288	3	11,356	6.4	504	30,436	1,570	1.0516	6.7	518	FF
2013	2009	181289	1	11,356	2.1	504	30,774	1,588	1.0516	2.2	518	FF
2013	2009	181290	25	11,356	53.0	504	30,774	1,588	1.0516	55.7	518	FF
2014	2009	180790	1	10,042	9.1	536	11,462	274	1.0239	9.3	549	FF
2014	2009	181285	3	10,042	16.9	536	31,053	104	1.0033	17.0	549	YE
2014	2009	181287	1	10,042	5.6	536	30,354	1,565	1.0516	5.9	549	FF
2014	2009	181288	4	10,042	29.5	536	30,436	1,570	1.0516	31.1	549	FF
2014	2009	181289	2	10,042	14.8	536	30,774	1,588	1.0516	15.5	549	FF
2014	2009	181290	7	10,042	59.1	536	27,493	1,859	1.0676	63.1	549	YE
2015	2009	181290	2	14,905	10.7	1,138	27,493	1,859	1.0676	11.4	1,197	YE
2013	2010	180785	3	11,356	jacks	0	5,148	0	1.0000	jacks	0	YE
2013	2010	180871	1	11,356	jacks	0	19,874	1,042	1.0524	jacks	0	FF
2013	2010	181597	1	11,356	jacks	0	51,799	2,722	1.0525	jacks	0	FF
2013	2010	182181	4	11,356	jacks	0	31,728	0	1.0000	jacks	0	YE
2013	2010	182182	7	11,356	jacks	0	21,000	0	1.0000	jacks	0	YE
2014	2010	180784	6	10,042	45.5	536	5,504	0	1.0000	45.5	549	YE
2014	2010	180785	3	10,042	22.7	536	5,148	0	1.0000	22.7	549	YE
2014	2010	180871	5	10,042	37.9	536	19,874	1,042	1.0524	39.9	549	FF
2014	2010	181596	1	10,042	5.6	536	51,541	2,625	1.0509	5.9	549	FF
2014	2010	181597	4	10,042	22.5	536	51,799	2,722	1.0525	23.7	549	FF
2014	2010	181983	1	10,042	5.6	536	52,441	1,993	1.0380	5.8	549	FF
2014	2010	182181	11	10,042	65.8	536	31,728	0	1.0000	65.8	549	YE
2014	2010	182182	18	10,042	136.4	536	21,000	0	1.0000	136.4	549	YE
2014	2010	182183	1	10,042	7.6	536	29,262	2,824	1.0965	8.3	549	YE
2015	2010	180784	10	14,905	57.7	1,138	5,504	0	1.0000	57.7	1,197	YE
2015	2010	180785	12	14,905	67.6	1,138	5,148	0	1.0000	67.6	1,197	YE
2015	2010	180871	3	14,905	16.6	1,138	19,874	1,042	1.0524	17.5	1,197	FF
2015	2010	180872	2	14,905	10.2	1,138	25,010	1,482	1.0593	10.8	1,197	FF
2015	2010	181595	5	14,905	27.1	1,138	51,578	3,112	1.0603	28.8	1,197	FF
2015	2010	181596	1	14,905	7.2	1,138	51,541	2,625	1.0509	7.6	1,197	FF
2015	2010	181597	2	14,905	12.4	1,138	51,799	2,722	1.0525	13.0	1,197	FF
2015	2010	182181	50	14,905	284.6	1,138	32,130	0	1.0000	284.6	1,197	YE
2015	2010	182182	24	14,905	132.7	1,138	21,000	0	1.0000	132.7	1,197	YE
2016	2010	180871	1	9,538	5.1	690	19,874	133	1.0067	5.1	748	FF

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2016	2010	181595	2	9,538	10.1	690	51,578	1,106	1.0214	10.3	748	FF
2016	2010	181596	1	9,538	5.1	690	51,541	638	1.0124	5.1	748	FF
2016	2010	181597	4	9,538	21.6	690	51,799	722	1.0139	21.9	748	FF
2016	2010	182181	3	9,538	15.2	690	32,130	0	1.0000	15.2	748	YE
2016	2010	182182	5	9,538	27.4	690	21,000	0	1.0000	27.4	748	YE
2014	2011	181973	5	10,042	jacks	0	19,911	4,417	1.2218	jacks	0	FF
2014	2011	181981	6	10,042	jacks	0	53,160	4,326	1.0814	jacks	0	FF
2014	2011	182174	1	10,042	jacks	0	9,687	1,421	1.1467	jacks	0	FF
2014	2011	182175	1	10,042	jacks	0	7,128	468	1.0657	jacks	0	FF
2014	2011	182184	2	10,042	jacks	0	24,174	2,989	1.1236	jacks	0	YE
2015	2011	181973	9	14,905	52.0	1,138	19,911	4,417	1.2218	63.6	1,197	FF
2015	2011	181981	16	14,905	86.3	1,138	53,160	4,326	1.0814	93.3	1,197	FF
2015	2011	181983	9	14,905	49.2	1,138	52,441	1,993	1.0380	51.0	1,197	FF
2015	2011	182175	2	14,905	11.0	1,138	7,128	468	1.0657	11.7	1,197	FF
2015	2011	182183	32	14,905	184.1	1,138	29,262	2,824	1.0965	201.8	1,197	YE
2015	2011	182184	21	14,905	123.1	1,138	24,174	2,989	1.1236	138.4	1,197	YE
2015	2011	182185	1	14,905	5.4	1,138	13,801	901	1.0653	5.7	1,197	FF
2016	2011	181973	23	9,538	124.8	690	19,911	1,781	1.0894	135.9	748	FF
2016	2011	181981	10	9,538	52.3	690	53,160	1,330	1.0250	53.6	748	FF
2016	2011	181983	17	9,538	89.2	690	52,441	1,414	1.0270	91.6	748	FF
2016	2011	182175	1	9,538	5.1	690	7,128	72	1.0101	5.1	748	FF
2016	2011	182183	9	9,538	47.5	690	29,262	2,824	1.0965	52.1	748	YE
2016	2011	182184	40	9,538	207.3	690	24,174	2,989	1.1236	232.9	748	YE
2016	2011	182185	4	9,538	19.9	690	13,801	187	1.0135	20.2	748	FF
2017	2011	181983	1	4,132	7.1	566	54,434	1,993	1.0366	7.4	634	FF
2017	2011	182183	2	4,132	14.2	566	32,086	2,824	1.0880	15.5	634	YE
2017	2011	182184	6	4,132	48.1	566	27,163	2,989	1.1100	53.4	634	YE
2015	2012	183175	1	14,905	jacks	0	38,550	5,801	1.1505	jacks	0	FF
2015	2012	183176	5	14,905	jacks	0	38,907	3,862	1.0993	jacks	0	FF
2015	2012	186026	1	14,905	jacks	0	10,211	1,135	1.1112	jacks	0	YE
2016	2012	180864	1	9,538	5.5	690	11,078	422	1.0381	5.7	748	FF
2016	2012	183175	2	9,538	11.0	690	38,550	1,944	1.0504	11.6	748	FF
2016	2012	183176	1	9,538	4.7	690	38,907	1,501	1.0386	4.9	748	FF
2016	2012	186026	2	9,538	9.5	690	10,211	1,135	1.1112	10.5	748	YE
2016	2012	186028	2	9,538	10.3	690	5,198	578	1.1112	11.4	748	YE
2016	2012	186247	2	9,538	9.5	690	6,657	2,853	1.4286	13.6	748	YE
2016	2012	186248	2	9,538	9.5	690	4,665	2,000	1.4287	13.6	748	YE
2017	2012	180864	1	4,132	4.9	566	12,595	1,517	1.1204	5.5	634	FF
2017	2012	183175	5	4,132	35.0	566	44,351	5,801	1.1308	39.6	634	FF
2017	2012	183176	4	4,132	27.1	566	42,769	3,862	1.0903	29.5	634	FF

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2017	2012	186026	4	4,132	25.4	566	11,346	1,135	1.1000	27.9	634	YE
2017	2012	186028	3	4,132	19.0	566	5,776	578	1.1001	20.8	634	YE
2017	2012	186247	6	4,132	48.1	566	9,510	2,853	1.3000	62.5	634	YE
2018	2012	183176	1	9,550	5.4	1,327	38,907	3,862	1.0993	5.9	1,471	FF
2018	2012	186026	1	9,550	8.0	1,327	10,211	1,135	1.1112	8.9	1,471	YE
2018	2012	186028	2	9,550	16.0	1,327	5,198	578	1.1112	17.8	1,471	YE
2018	2012	186247	2	9,550	10.8	1,327	6,657	2,853	1.4286	15.5	1,471	YE
2018	2012	186248	3	9,550	19.1	1,327	4,665	2,000	1.4287	27.3	1,471	YE
2016	2013	182195	2	9,538	jacks	0	54,241	1,170	1.0216	jacks	0	FF
2016	2013	183170	4	9,538	jacks	0	28,860	4,120	1.1428	jacks	0	YE
2016	2013	183171	3	9,538	jacks	0	30,739	363	1.0118	jacks	0	FF
2016	2013	183172	2	9,538	jacks	0	32,681	464	1.0142	jacks	0	FF
2016	2013	185614	6	9,538	jacks	0	10,245	1,062	1.1037	jacks	0	YE
2016	2013	185615	9	9,538	jacks	0	9,904	1,027	1.1037	jacks	0	YE
2016	2013	185616	4	9,538	jacks	0	10,158	1,053	1.1037	jacks	0	YE
2017	2013	182195	7	4,132	43.9	566	63,201	8,960	1.1418	50.1	634	FF
2017	2013	183170	12	4,132	71.1	566	32,980	4,120	1.1249	80.0	634	YE
2017	2013	183171	1	4,132	4.9	566	31,102	363	1.0117	5.0	634	FF
2017	2013	183173	1	4,132	6.9	566	33,148	265	1.0080	7.0	634	FF
2017	2013	185614	18	4,132	88.4	566	11,307	1,062	1.0939	96.7	634	YE
2017	2013	185615	16	4,132	78.6	566	10,931	1,027	1.0940	86.0	634	YE
2017	2013	185616	8	4,132	43.0	566	11,211	1,053	1.0939	47.1	634	YE
2018	2013	182195	12	9,550	67.8	1,327	54,241	8,960	1.1652	79.0	1,471	FF
2018	2013	183170	55	9,550	399.8	1,327	28,860	4,120	1.1428	456.9	1,471	YE
2018	2013	183171	7	9,550	49.0	1,327	30,739	363	1.0118	49.6	1,471	FF
2018	2013	183172	1	9,550	8.0	1,327	32,681	464	1.0142	8.1	1,471	FF
2018	2013	183173	2	9,550	16.0	1,327	32,883	265	1.0081	16.1	1,471	FF
2018	2013	183174	1	9,550	5.4	1,327	14,375	445	1.0310	5.6	1,471	FF
2018	2013	185614	18	9,550	97.6	1,327	10,245	1,062	1.1037	107.7	1,471	YE
2018	2013	185615	17	9,550	92.5	1,327	9,904	1,027	1.1037	102.1	1,471	YE
2018	2013	185616	39	9,550	217.0	1,327	10,158	1,053	1.1037	239.5	1,471	YE
2019	2013	183170	8	6,673	31.1	693	28,860	4,120	1.1428	35.6	732	YE
2019	2013	183171	1	6,673	2.9	693	30,739	363	1.0118	3.0	732	FF
2019	2013	183172	1	6,673	2.9	693	32,681	464	1.0142	3.0	732	FF
2019	2013	185614	2	6,673	9.4	693	10,245	1,062	1.1037	10.4	732	YE
2019	2013	185615	7	6,673	34.1	693	9,904	1,027	1.1037	37.7	732	YE
2019	2013	185616	3	6,673	14.7	693	10,158	1,053	1.1037	16.2	732	YE
2017	2014	182187	1	4,132	jacks	0	29,283	2,903	1.0991	jacks	0	YE
2017	2014	185750	2	4,132	jacks	0	9,651	182	1.0189	jacks	0	YE
2017	2014	185751	1	4,132	jacks	0	10,891	0	1.0000	jacks	0	YE

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
2017	2014	186027	3	4,132	jacks	0	10,960	0	1.0000	jacks	0	YE
2018	2014	180586	1	9,550	8.0	1,327	11,631	414	1.0356	8.3	1,471	FF
2018	2014	182187	19	9,550	139.4	1,327	29,283	2,903	1.0991	153.3	1,471	YE
2018	2014	183180	1	9,550	5.5	1,327	53,966	2,103	1.0390	5.7	1,471	FF
2018	2014	183182	2	9,550	16.5	1,327	72,078	2,566	1.0356	17.1	1,471	FF
2018	2014	183374	2	9,550	16.5	1,327	4,494	160	1.0356	17.1	1,471	FF
2018	2014	185750	3	9,550	19.0	1,327	9,469	182	1.0192	19.4	1,471	YE
2018	2014	185751	9	9,550	49.3	1,327	10,891	0	1.0000	49.3	1,471	YE
2018	2014	186027	10	9,550	60.5	1,327	10,960	0	1.0000	60.5	1,471	YE
2019	2014	180585	2	6,673	5.7	693	11,206	399	1.0356	5.9	732	FF
2019	2014	180586	3	6,673	8.6	693	11,631	414	1.0356	8.9	732	FF
2019	2014	182187	25	6,673	96.5	693	29,283	2,903	1.0991	106.0	732	YE
2019	2014	183180	3	6,673	14.7	693	53,966	2,103	1.0390	15.3	732	FF
2019	2014	183182	7	6,673	20.1	693	72,078	2,566	1.0356	20.9	732	FF
2019	2014	185750	1	6,673	4.7	693	9,469	182	1.0192	4.8	732	YE
2019	2014	185751	6	6,673	28.8	693	10,891	0	1.0000	28.8	732	YE
2019	2014	186027	11	6,673	53.0	693	10,960	0	1.0000	53.0	732	YE
2018	2015	182893	3	9,550	jacks	0	54,008	2,503	1.0463	jacks	0	FF
2018	2015	184268	1	9,550	jacks	0	9,558	450	1.0471	jacks	0	FF
2018	2015	184269	2	9,550	jacks	0	10,745	498	1.0463	jacks	0	FF
2018	2015	184270	1	9,550	jacks	0	11,537	535	1.0464	jacks	0	FF
2018	2015	184271	1	9,550	jacks	0	9,350	433	1.0463	jacks	0	FF
2018	2015	184277	6	9,550	jacks	0	32,573	1,535	1.0471	jacks	0	FF
2018	2015	184278	13	9,550	jacks	0	54,110	2,507	1.0463	jacks	0	FF
2019	2015	182875	9	6,673	37.5	693	24,815	0	1.0000	37.5	732	YE
2019	2015	182893	26	6,673	74.0	693	54,008	2,503	1.0463	77.4	732	FF
2019	2015	184267	3	6,673	15.3	693	10,518	496	1.0472	16.0	732	FF
2019	2015	184268	1	6,673	5.3	693	9,558	450	1.0471	5.5	732	FF
2019	2015	184269	4	6,673	11.0	693	10,745	498	1.0463	11.5	732	FF
2019	2015	184270	7	6,673	20.0	693	11,537	535	1.0464	20.9	732	FF
2019	2015	184271	3	6,673	12.2	693	9,350	433	1.0463	12.7	732	FF
2019	2015	184276	5	6,673	26.5	693	24,958	2,997	1.1201	29.7	732	YE
2019	2015	184277	14	6,673	70.6	693	32,573	1,535	1.0471	74.0	732	FF
2019	2015	184278	31	6,673	93.6	693	54,110	2,507	1.0463	97.9	732	FF
2020	2015	182875	6	4,777	81.1	485	24,815	0	1.0000	81.1	509	YE
2020	2015	182893	8	4,777	29.9	485	54,008	2,503	1.0463	31.3	509	FF
2020	2015	184270	2	4,777	21.8	485	11,537	535	1.0464	22.8	509	FF
2020	2015	184276	9	4,777	127.8	485	24,958	2,997	1.1201	143.2	509	YE
2020	2015	184277	8	4,777	122.0	485	32,573	1,535	1.0471	127.8	509	FF
2020	2015	184278	4	4,777	13.6	485	54,110	2,507	1.0463	14.2	509	FF

Return Year	Brood Year	Tag Code	Return Year CWT's observed	Return Year escapement	Estimated CWT's	Total return year CWT's estimated	# CWT's released	# Fish released untagged	Expansion Factor	Expanded Contribution	Total return year hatchery contribution	Release Type
2019	2016	181291	1	6,673	jacks	0	24,849	140	1.0056	jacks	0	YE
2019	2016	184287	1	6,673	jacks	0	27,351	210	1.0077	jacks	0	YE
2020	2016	181291	10	4,777	50.9	485	24,849	140	1.0056	51.2	509	YE
2020	2016	183499	1	4,777	4.4	485	19,816	114	1.0058	4.4	509	FF
2020	2016	184272	1	4,777	5.1	485	10,875	0	1.0000	5.1	509	FF
2020	2016	184287	4	4,777	19.0	485	27,351	210	1.0077	19.2	509	YE
2020	2016	184371	2	4,777	8.8	485	58,246	335	1.0058	8.9	509	FF
2019	2017	185167	1	6,673	jacks	0	56,991	576	1.0101	jacks	0	FF
2020	2017	184990	1	4,777	jacks	0	29,183	235	1.0081	jacks	0	YE
2020	2017	184997	0	4,777	jacks	0	19,512	7,752	1.3973	jacks	0	YE
2020	2017	185166	1	4,777	jacks	0	49,665	0	1.0000	jacks	0	FF
2020	2017	185167	3	4,777	jacks	0	56,991	576	1.0101	jacks	0	FF

Appendix 5. Petersen estimates of Kitsumkalum Chinook salmon escapement.

Prior to using open population models a Petersen estimator (Ricker, 1975) was used to generate escapement estimates for Kitsumkalum Chinook salmon (CTC, 2019). Petersen estimates are presented for comparison with estimates from the open models (Table A5-1).

McNicol (1999) reviewed mark-capture estimates for escapement of Kitsumkalum River Chinook salmon from 1984 to 1996. McNicol provided corrections to estimates for 1986 to 1990 where they had been previously generated for strata with less than 3 marked recoveries (Andrew and Webb, 1988; Carolsfeld et al. 1990; Nass and Bocking, 1992). Following corrections for straying between river reaches McNicol applied the Chapman modification of the Petersen estimator (Ricker, 1975) to where the population estimate was:

$$\hat{N}_{gr} = \frac{(M_{gr}+1)(C_{gr}+1)}{(R_{gr}+1)} - 1$$

with an estimated standard error of:

$$se(\hat{N}_{gr}) = \sqrt{\frac{(M_{gr}+1)^2(C_{gr}+1)(C_{gr}-R_{gr})}{(R_{gr}+1)^2(R_{gr}+2)}}$$

Where *N* was the estimate of Chinook salmon, *M* was the number of Chinook salmon marked and released, *C* was the total number of Chinook salmon carcasses encountered in the dead pitch and *R* was the number of marked large Chinook salmon carcasses recovered in the dead pitch by group or gender (subscript *g*) and river reach (subscript *r*). Separate estimates were calculated for males and females in each of the upper and lower river reaches. Stratification by river reach was not possible in 1984, 2000, 2001 and 2002 due to poor recoveries in the upper river reach. Jacks were excluded from the calculations because there were not enough marked recaptures.

Estimates for 1988 could not be determined using open models because the data were no longer available to generate individual encounter histories. Petersen estimates were used to predict the open model estimate for 1988 using regression analyses. The estimate for 1988 was 15,853 Chinook salmon with a SE of 804 fish.

Appendix Table A5-1. Petersen estimates of Kitsumkalum Chinook salmon escapements compared with revised open model estimates 1984 – 2020.
SE = Standard Error, CV = coefficient of variation

Year	Petersen Escapement Estimate	SE	CV	POPAN Escapement Estimate	SE	CV
1984	12,408	2,475	19.9%	9,569	1,644	17.2%
1985	8,304	486	5.9%	9,081	409	4.5%
1986	9,109	539	5.9%	8,080	354	4.4%
1987	23,657	2,389	10.1%	15,549	991	6.4%
1988	22,267	1,541	6.9%			
1989	17,925	1,299	7.2%	17,823	1,046	5.9%
1990	17,406	1,115	6.4%	11,119	452	4.1%
1991	9,288	669	7.2%	9,267	456	4.9%
1992	12,437	1,003	8.1%	10,880	447	4.1%
1993	14,059	775	5.5%	13,181	518	3.9%
1994	12,629	1,196	9.5%	14,004	1,245	8.9%
1995	7,221	729	10.1%	6,514	309	4.7%
1996	12,776	2,130	16.7%	8,595	704	8.2%
1997	5,342	604	11.3%	4,675	328	7.0%
1998	11,065	752	6.8%	6,009	262	4.4%
1999	9,763	872	8.9%	9,035	561	6.2%
2000	14,722	1,200	8.2%	10,179	418	4.1%
2001	24,076	2,152	8.9%	17,866	677	3.8%
2002	23,849	2,720	11.4%	11,220	685	6.1%
2003	23,608	2,601	11.0%	17,525	809	4.6%
2004	25,767	2,630	10.2%	19,664	1,607	8.2%
2005	15,046	1,387	9.2%	11,382	637	5.6%
2006	12,368	1,794	14.5%	8,396	751	8.9%
2007	15,736	2,832	18.0%	11,739	1,849	15.8%
2008	10,374	1,477	14.2%	6,903	437	6.3%
2009	10,703	1,424	13.3%	8,350	781	9.4%
2010	13,712	2,033	14.8%	8,932	585	6.5%
2011	12,105	2,441	20.2%	6,756	693	10.3%
2012	9,363	1,305	13.9%	6,291	520	8.3%
2013	10,934	1,028	9.4%	11,356	1,189	10.5%
2014	10,308	1,194	11.6%	10,042	1,238	12.3%
2015	14,500	1,239	8.5%	14,904	753	5.1%
2016	10,439	1,078	10.3%	9,537	512	5.4%
2017	4,943	817	16.5%	4,132	512	12.4%
2018	9,537	939	9.8%	9,550	571	6.0%
2019	7,500	632	8.4%	6,673	562	8.4%
2020	4,433	933	21.1%	4,777	843	17.6%

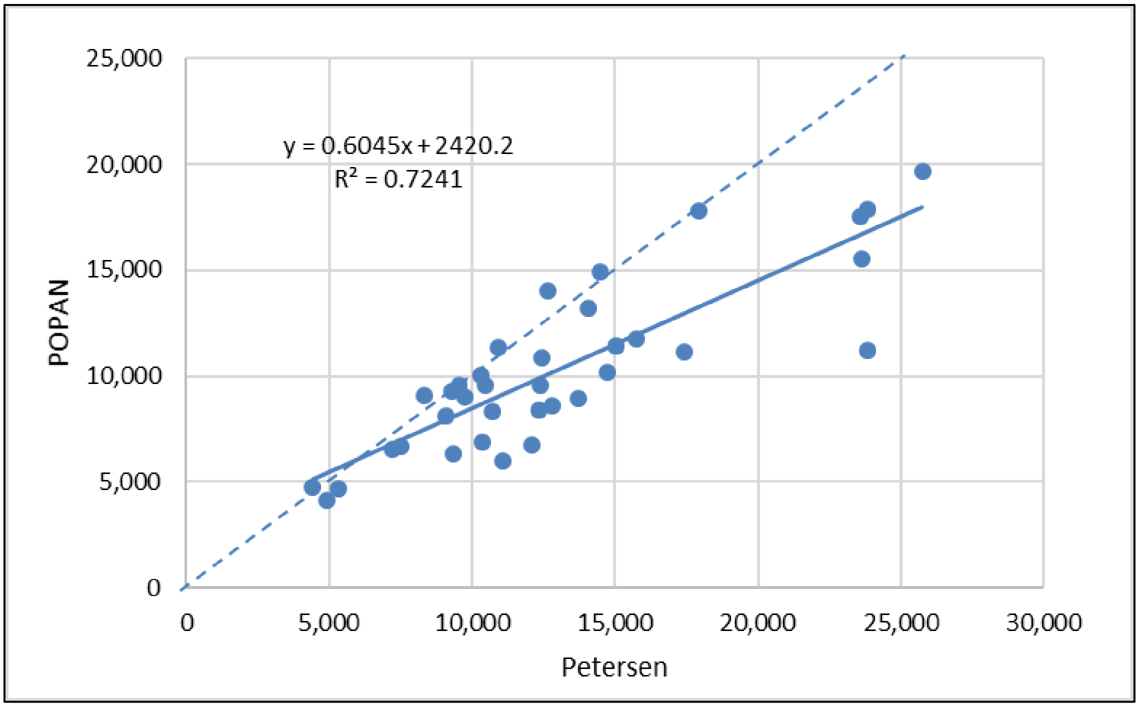

Figure A5-1. The relationship between closed model Petersen estimates and open-population model estimates (POPAN) 1984 to 2020.
The solid line is the regression line and the dashed line is the 1:1 line.

Appendix 6. Cohort specific production and parameters from the CTC exploitation rate analyses for complete broods of Kitsumkalum Chinook salmon returns 1984 to 2019.
ER = exploitation rate, AEQ = adult equivalents

Return Year	Brood Year	Age	Spawning Escapement	Terminal Total Mortality Harvest Rate	Total Mature Run	Maturation Rate	Pre-terminal Post-fishery Abundance	Non-Maturing Abundance	Pre-terminal Total Mortality ER (nominal)	Ocean Pre-fishery Abundance	Natural Mortality Rate	Cohort Abundance before Natural Mortality	Pre-terminal Fishing Mortality (nominal)	AEQ Rate	Pre-terminal Fishing Mortality (AEQ)	Total Recruits
1984	1980	4	1,559	0.2612	2,110	0.0576	36,636	34,526	0.1338	42,295	0.3	60,422	5,659	0.7811	4,420	6,531
1985	1981	4	887	0.0036	861	0.0401	21,481	20,620	0.0964	23,773	0.3	33,961	2,292	0.7553	1,731	2,564
1986	1982	4	726	0.2612	983	0.0644	15,252	14,269	0.0646	16,305	0.3	23,293	1,054	0.7857	828	1,811
1987	1983	4	537	0	537	0.0644	8,334	7,797	0.0194	8,499	0.3	12,142	165	0.7593	125	662
1988	1984	4	859	0.5791	2,005	0.0255	78,618	76,613	0.0389	81,800	0.3	116,857	3,182	0.7822	2,489	4,479
1989	1985	4	116	0.1271	74	0.1061	700	625	0.0846	764	0.3	1,092	65	0.7867	51	74
1990	1986	4	1,184	0.3351	1,774	0.0617	28,756	26,982	0.0704	30,934	0.3	44,191	2,178	0.7882	1,716	3,486
1991	1987	4	621	0.2942	802	0.0654	12,266	11,464	0.0829	13,375	0.3	19,107	1,109	0.7968	883	1,631
1992	1988	4	173	0.2612	234	0.0375	6,245	6,010	0.0655	6,682	0.3	9,546	438	0.7647	335	569
1993	1989	4	298	0.2612	403	0.0758	5,322	4,918	0.0717	5,733	0.3	8,189	411	0.7483	308	711
1994	1990	4	417	0.2312	516	0.0956	5,393	4,878	0.0439	5,641	0.3	8,059	248	0.7735	192	687
1995	1991	4	0	0.2612	0	0.0374	0	0	0.0311	0	0.3	0	0	0.7579	0	0
1996	1992	4	338	0.3887	499	0.0910	5,488	4,989	0.0707	5,906	0.3	8,437	418	0.7889	329	796
1997	1993	4	254	0.2744	328	0.0502	6,534	6,206	0.0179	6,653	0.3	9,504	119	0.7687	92	404
1998	1994	4	621	0.0005	577	0.0589	9,805	9,227	0.0476	10,295	0.3	14,707	490	0.7973	391	924
1999	1995	4	3,214	0.0595	3,400	0.0523	65,012	61,611	0.0595	69,125	0.3	98,749	4,113	0.7834	3,222	6,606
2000	1996	4	2,059	0.3525	3,147	0.0748	42,070	38,924	0.0492	44,247	0.3	63,211	2,177	0.7917	1,724	4,849
2001	1997	4	512	0.4074	802	0.0835	9,608	8,805	0.066	10,286	0.3	14,695	679	0.8014	544	1,310
2002	1998	4	1,835	0.1482	2,113	0.0541	39,058	36,945	0.071	42,043	0.3	60,062	2,985	0.7936	2,369	4,447
2003	1999	4	1,541	0.2612	2,045	0.0841	24,327	22,282	0.0524	25,672	0.3	36,674	1,345	0.7907	1,064	3,079
2004	2000	4	2,788	0.0611	2,716	0.1309	20,751	18,035	0.0604	22,085	0.3	31,551	1,334	0.8083	1,078	3,557
2005	2001	4	968	0.2504	1,249	0.0678	18,415	17,166	0.0626	19,645	0.3	28,064	1,230	0.7988	982	2,199
2006	2002	4	2,392	0.2745	3,221	0.0327	98,504	95,283	0.0329	101,855	0.3	145,508	3,351	0.7972	2,671	5,837
2007	2003	4	569	0.0653	423	0.2131	1,984	1,561	0.0775	2,151	0.3	3,073	167	0.8318	139	388
2008	2004	4	1,333	0.473	2,346	0.0863	27,188	24,841	0.0295	28,014	0.3	40,020	826	0.7973	659	2,909
2009	2005	4	1,139	0.1394	1,124	0.2002	5,616	4,492	0.1555	6,650	0.3	9,500	1,034	0.8368	865	1,818
2010	2006	4	3,652	0.1933	4,272	0.2526	16,911	12,639	0.0471	17,747	0.3	25,353	836	0.8473	708	4,774
2011	2007	4	827	0.2845	1,023	0.2898	3,529	2,506	0.1202	4,011	0.3	5,731	482	0.8505	410	1,338
2012	2008	4	2,020	0.3361	2,890	0.1425	20,279	17,389	0.078	21,994	0.3	31,421	1,716	0.8063	1,383	4,172
2013	2009	4	2,026	0.1356	2,143	0.3977	5,388	3,245	0.1459	6,308	0.3	9,011	920	0.8756	806	2,775
2014	2010	4	3,122	0.0876	3,047	0.2414	12,623	9,576	0.0432	13,193	0.3	18,847	570	0.8241	470	3,175

Return Year	Brood Year	Age	Spawning Escapement	Terminal Total Mortality Harvest Rate	Total Mature Run	Maturation Rate	Pre-terminal Post-fishery Abundance	Non-Maturing Abundance	Pre-terminal Total Mortality ER (nominal)	Ocean Pre-fishery Abundance	Natural Mortality Rate	Cohort Abundance before Natural Mortality	Pre-terminal Fishing Mortality (nominal)	AEQ Rate	Pre-terminal Fishing Mortality (AEQ)	Total Recruits
2015	2011	4	2,693	0.1039	2,379	0.2592	9,179	6,800	0.1216	10,450	0.3	14,928	1,271	0.8506	1,081	2,899
2016	2012	4	1,177	0.0002	1,103	0.1429	7,717	6,614	0.0863	8,446	0.3	12,065	729	0.8245	601	1,629
2017	2013	4	995	0.4935	1,224	0.3327	3,679	2,455	0.126	4,209	0.3	6,013	530	0.8623	457	1,306
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	1979	5	2,322	0	2,322	0.6338	3,663	1,341	0.3053	5,273	0.2	6,592	1,610	0.9000	1,449	3,771
1985	1980	5	5,457	0.2144	6,807	0.5968	11,405	4,599	0.1821	13,944	0.2	17,430	2,539	0.9597	2,437	9,134
1986	1981	5	3,521	0.152	4,001	0.3136	12,759	8,758	0.126	14,598	0.2	18,248	1,839	0.9314	1,713	5,586
1987	1982	5	3,022	0.2844	4,223	0.6338	6,663	2,440	0.181	8,136	0.2	10,169	1,473	0.9634	1,419	5,642
1988	1983	5	2,031	0.3655	3,151	0.4916	6,409	3,259	0.1187	7,273	0.2	9,091	863	0.9492	819	3,938
1989	1984	5	3,237	0.1944	3,407	0.7057	4,827	1,421	0.1825	5,905	0.2	7,381	1,078	0.9706	1,046	3,945
1990	1985	5	1,711	0.2725	2,191	0.5167	4,241	2,050	0.212	5,382	0.2	6,727	1,141	0.9517	1,086	3,160
1991	1986	5	2,347	0.3862	3,779	0.6791	5,564	1,786	0.1485	6,534	0.2	8,168	970	0.9679	939	4,690
1992	1987	5	4,394	0.1814	4,856	0.7818	6,211	1,355	0.2629	8,427	0.2	10,534	2,215	0.9782	2,167	6,604
1993	1988	5	1,761	0.1906	2,175	0.4437	4,902	2,727	0.195	6,090	0.2	7,612	1,188	0.9444	1,122	3,235
1994	1989	5	2,445	0.2844	3,417	0.0956	35,738	32,321	0.0665	38,284	0.2	47,855	2,546	0.9096	2,316	5,732
1995	1990	5	1,634	0.118	1,791	0.3694	4,848	3,057	0.1749	5,875	0.2	7,344	1,028	0.9369	963	2,699
1996	1991	5	2,173	0.4065	3,465	0.3555	9,748	6,283	0.0869	10,676	0.2	13,344	928	0.9356	868	4,217
1997	1992	5	3,011	0.1361	3,277	0.5973	5,486	2,209	0.1849	6,731	0.2	8,413	1,244	0.9597	1,194	4,291
1998	1993	5	2,200	0.1261	2,373	0.4559	5,205	2,832	0.0531	5,497	0.2	6,871	292	0.9456	276	2,523
1999	1994	5	1,807	0.0514	1,581	0.8069	1,959	378	0.2821	2,729	0.2	3,412	770	0.9807	755	2,029
2000	1995	5	4,973	0.1477	5,709	0.6430	8,879	3,170	0.2155	11,318	0.2	14,147	2,439	0.9643	2,352	7,954
2001	1996	5	9,565	0.3654	14,894	0.6859	21,715	6,821	0.205	27,314	0.2	34,143	5,599	0.9686	5,424	20,204
2002	1997	5	2,571	0.2478	3,162	0.7921	3,992	830	0.4023	6,678	0.2	8,348	2,687	0.9792	2,631	5,600
2003	1998	5	12,248	0.1066	13,348	0.7730	17,268	3,920	0.1884	21,277	0.2	26,596	4,009	0.9773	3,918	16,943
2004	1999	5	4,782	0.0358	4,522	0.8803	5,137	615	0.2818	7,152	0.2	8,940	2,015	0.988	1,991	5,818
2005	2000	5	7,510	0.0649	7,774	0.7434	10,458	2,683	0.3682	16,552	0.2	20,690	6,094	0.9743	5,938	13,472
2006	2001	5	2,305	0.1625	2,623	0.8022	3,270	647	0.2585	4,410	0.2	5,512	1,140	0.9802	1,117	3,475
2007	2002	5	8,407	0.1492	9,565	0.8790	10,881	1,317	0.3876	17,768	0.2	22,210	6,887	0.9879	6,804	15,950
2008	2003	5	1,861	0.4397	2,868	0.8287	3,461	593	0.2174	4,423	0.2	5,528	961	0.9829	945	3,559
2009	2004	5	5,988	0.0525	5,816	0.7264	8,007	2,191	0.0777	8,681	0.2	10,851	675	0.9726	656	5,993
2010	2005	5	2,934	0.1953	3,239	0.9498	3,411	171	0.2675	4,656	0.2	5,820	1,246	0.995	1,239	4,127
2011	2006	5	4,753	0.219	5,772	0.9470	6,095	323	0.2304	7,919	0.2	9,899	1,825	0.9947	1,815	7,341
2012	2007	5	2,383	0.0961	2,453	0.8688	2,824	370	0.274	3,890	0.2	4,862	1,066	0.9869	1,052	3,339
2013	2008	5	6,228	0.1405	6,890	0.6757	10,197	3,307	0.1223	11,618	0.2	14,522	1,421	0.9676	1,375	7,959
2014	2009	5	3,629	0.0966	3,860	0.9179	4,205	345	0.1536	4,968	0.2	6,210	763	0.9918	757	4,475
2015	2010	5	10,406	0.1537	12,794	0.6019	21,256	8,462	0.1236	24,254	0.2	30,318	2,998	0.9602	2,878	15,052

Return Year	Brood Year	Age	Spawning Escapement	Terminal Total Mortality Harvest Rate	Total Mature Run	Maturation Rate	Pre-terminal Post-fishery Abundance	Non-Maturing Abundance	Pre-terminal Total Mortality ER (nominal)	Ocean Pre-fishery Abundance	Natural Mortality Rate	Cohort Abundance before Natural Mortality	Pre-terminal Fishing Mortality (nominal)	AEQ Rate	Pre-terminal Fishing Mortality (AEQ)	Total Recruits
2016	2011	5	4,368	0.225	5,235	0.9788	5,348	113	0.1846	6,559	0.2	8,199	1,211	0.9979	1,208	5,844
2017	2012	5	2,231	0.2327	2,660	0.9402	2,829	169	0.1207	3,218	0.2	4,022	388	0.994	386	2,856
2018	2013	5	4,288	0.5026	6,485	0.9203	7,046	562	0.1058	7,880	0.2	9,850	834	0.992	827	6,249
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	1978	6	5,688	0.287	7,978	1	7,978	0	0.1759	9,680	0.1	10,756	1,702	1	1,702	9,680
1985	1979	6	2,737	0.1026	3,008	1	3,008	0	0.2691	4,115	0.1	4,572	1,107	1	1,107	4,077
1986	1980	6	3,833	0.2443	5,264	1	5,264	0	0.2895	7,410	0.1	8,233	2,145	1	2,145	7,367
1987	1981	6	11,991	0.1061	13,192	1	13,192	0	0.2526	17,650	0.1	19,612	4,459	1	4,459	17,452
1988	1982	6	12,964	0.287	18,183	1	18,183	0	0.1759	22,064	0.1	24,515	3,880	1	3,880	22,064
1989	1983	6	14,470	0.075	15,605	1	15,605	0	0.1477	18,309	0.1	20,343	2,704	1	2,704	18,272
1990	1984	6	8,223	0.1613	9,609	1	9,609	0	0.1798	11,715	0.1	13,017	2,106	1	2,106	11,552
1991	1985	6	6,299	0.4448	11,257	1	11,257	0	0.3469	17,236	0.1	19,151	5,979	1	5,979	17,187
1992	1986	6	6,312	0	6,293	1	6,293	0	0.0009	6,298	0.1	6,998	6	1	6	6,279
1993	1987	6	11,122	0.2548	14,823	1	14,823	0	0.1928	18,363	0.1	20,403	3,540	1	3,540	18,286
1994	1988	6	11,140	0.1908	13,692	1	13,692	0	0.1662	16,421	0.1	18,246	2,729	1	2,729	16,361
1995	1989	6	4,880	0.3909	8,374	1	8,374	0	0.1607	9,977	0.1	11,085	1,603	1	1,603	9,946
1996	1990	6	6,084	0.2531	8,061	1	8,061	0	0.1117	9,075	0.1	10,083	1,014	1	1,014	9,012
1997	1991	6	1,411	0.2693	1,682	1	1,682	0	0.2209	2,159	0.1	2,399	477	1	477	1,977
1998	1992	6	3,188	0.1477	3,640	1	3,640	0	0.2029	4,566	0.1	5,074	926	1	926	4,480
1999	1993	6	4,014	0.144	4,601	1	4,601	0	0.4343	8,134	0.1	9,038	3,533	1	3,533	8,059
2000	1994	6	3,145	0.059	3,288	1	3,288	0	0.2247	4,241	0.1	4,712	953	1	953	4,190
2001	1995	6	7,788	0.2524	10,371	1	10,371	0	0.252	13,865	0.1	15,406	3,494	1	3,494	13,831
2002	1996	6	6,814	0.3792	10,930	1	10,930	0	0.3741	17,463	0.1	19,403	6,533	1	6,533	17,434
2003	1997	6	3,735	0.1498	4,350	1	4,350	0	0.2904	6,130	0.1	6,811	1,780	1	1,780	6,094
2004	1998	6	12,094	0.0739	12,989	1	12,989	0	0.2403	17,098	0.1	18,998	4,109	1	4,109	17,031
2005	1999	6	2,904	0.2836	3,926	1	3,926	0	0.2824	5,471	0.1	6,079	1,545	1	1,545	5,380
2006	2000	6	3,699	0.4234	6,258	1	6,258	0	0.322	9,230	0.1	10,255	2,972	1	2,972	9,138
2007	2001	6	2,763	0.0645	2,835	1	2,835	0	0.0002	2,835	0.1	3,150	1	1	1	2,724
2008	2002	6	3,708	0.287	5,171	1	5,171	0	0.1762	6,277	0.1	6,974	1,106	1	1,106	6,256
2009	2003	6	1,223	0.0312	1,122	1	1,122	0	0.3064	1,618	0.1	1,798	496	1	496	1,482
2010	2004	6	2,346	0.5167	4,653	1	4,653	0	0.0555	4,927	0.1	5,474	273	1	273	4,830
2011	2005	6	1,174	0.287	1,646	1	1,646	0	0.3113	2,391	0.1	2,656	744	1	744	2,391
2012	2006	6	1,887	0	1,881	1	1,881	0	0.3446	2,870	0.1	3,189	989	1	989	2,863
2013	2007	6	3,103	0	3,067	1	3,067	0	0.0691	3,294	0.1	3,660	228	1	228	3,258
2014	2008	6	3,292	0.2109	4,105	1	4,105	0	0.2881	5,767	0.1	6,407	1,661	1	1,661	5,714
2015	2009	6	1,806	0.287	2,518	1	2,518	0	0.0002	2,518	0.1	2,798	1	1	1	2,507

Return Year	Brood Year	Age	Spawning Escapement	Terminal Total Mortality Harvest Rate	Total Mature Run	Maturation Rate	Pre-terminal Post-fishery Abundance	Non-Maturing Abundance	Pre-terminal Total Mortality ER (nominal)	Ocean Pre-fishery Abundance	Natural Mortality Rate	Cohort Abundance before Natural Mortality	Pre-terminal Fishing Mortality (nominal)	AEQ Rate	Pre-terminal Fishing Mortality (AEQ)	Total Recruits
2016	2010	6	3,994	0.2486	5,202	1	5,202	0	0.0349	5,390	0.1	5,989	188	1	188	5,303
2017	2011	6	905	0	829	1	829	0	0.1292	952	0.1	1,057	123	1	123	875
2018	2012	6	1,716	0	1,643	1	1,643	0	0	1,643	0.1	1,826	0	1	0	1,570
2019	2013	6	740	0.0068	639	1	639	0	0.4724	1,210	0.1	1,345	572	1	572	1,105

Appendix 7. Parameter estimates produced by the Ricker model with time varying productivity for complete brood years of Kitsumkalum Chinook salmon stock-recruit data, 1984 to 2013.

MLE =maximum likelihood estimation

Brood Year	α MLE	α Median	α 2.5% quantile	α 97.5% quantile	*S_{MSY} MLE*	U_{MSY} MLE	*S_{EQ} MLE*	*S_{GEN} MLE*	*85% S_{MSY} MLE*	$U_{85\%SMSY}$ MLE	25% *S_{MSY} MLE*
1984	6.87632	6.32125	2.61553	14.57068	5,628	0.704	15,417	918	4,783	0.735	1,407
1985	6.86773	6.27821	2.70151	13.85180	5,625	0.704	15,407	919	4,782	0.735	1,406
1986	6.81826	6.14620	2.56005	13.75908	5,612	0.702	15,349	924	4,770	0.734	1,403
1987	7.51341	7.03018	2.63714	17.81614	5,786	0.724	16,125	857	4,918	0.754	1,447
1988	7.15097	6.63041	2.35452	17.64045	5,699	0.713	15,730	891	4,844	0.744	1,425
1989	6.27664	5.76198	2.02176	15.26597	5,455	0.682	14,687	983	4,637	0.715	1,364
1990	4.99825	4.43189	1.68904	10.65842	4,984	0.623	12,866	1,152	4,236	0.660	1,246
1991	4.12318	3.50298	1.34617	8.27891	4,540	0.568	11,327	1,295	3,859	0.607	1,135
1992	4.19873	3.66864	1.43864	8.51854	4,584	0.573	11,472	1,282	3,896	0.612	1,146
1993	4.56262	4.03701	1.56729	9.35255	4,779	0.598	12,137	1,220	4,062	0.636	1,195
1994	5.04294	4.43960	1.75000	10.01997	5,003	0.626	12,937	1,145	4,253	0.662	1,251
1995	6.62345	6.38580	2.95309	13.28931	5,558	0.695	15,117	944	4,724	0.727	1,389
1996	7.66499	7.59712	3.56340	15.79547	5,821	0.728	16,285	844	4,948	0.758	1,455
1997	7.24307	6.80522	3.38043	13.20163	5,722	0.716	15,832	882	4,863	0.746	1,430
1998	7.70052	7.49934	3.61195	15.08335	5,829	0.729	16,322	841	4,954	0.759	1,457
1999	6.83431	6.24101	2.82295	13.09926	5,616	0.702	15,368	922	4,774	0.734	1,404
2000	6.74881	6.24257	2.59225	14.21655	5,593	0.699	15,267	931	4,754	0.731	1,398
2001	6.04370	5.34343	1.89711	13.41512	5,381	0.673	14,385	1,010	4,574	0.707	1,345
2002	5.99725	5.50821	2.02219	14.00088	5,366	0.671	14,323	1,016	4,561	0.705	1,341
2003	5.03151	4.33465	1.39023	11.57051	4,998	0.625	12,919	1,147	4,249	0.662	1,250
2004	5.10743	4.60778	1.53267	12.54187	5,031	0.629	13,039	1,135	4,276	0.666	1,258
2005	4.46751	3.93728	1.48809	9.41939	4,730	0.592	11,968	1,236	4,021	0.630	1,183
2006	4.41968	4.03829	1.70464	8.89432	4,705	0.588	11,882	1,244	3,999	0.627	1,176
2007	4.17809	3.75761	1.60583	8.14271	4,572	0.572	11,433	1,285	3,886	0.611	1,143
2008	4.42207	4.19605	1.95699	8.57276	4,706	0.589	11,887	1,243	4,000	0.627	1,177
2009	4.21678	3.94121	1.85864	7.95265	4,594	0.575	11,507	1,278	3,905	0.614	1,149
2010	4.33971	4.24390	2.03178	8.75941	4,662	0.583	11,736	1,257	3,963	0.622	1,166
2011	3.66870	3.42302	1.65375	6.78109	4,251	0.532	10,393	1,376	3,613	0.572	1,063
2012	3.20228	2.88414	1.33152	5.95497	3,895	0.487	9,306	1,460	3,311	0.528	974
2013	3.18968	2.91004	1.21340	6.57748	3,884	0.486	9,275	1,462	3,302	0.526	971