**Fishery Data Series No. 12-49**

# Estimates of the Historic Run and Escapement for the Chinook Salmon Stock Returning to the Kuskokwim River, 1976–2011

**Final Report for Study 45082 and 45554**
**Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative**

**by**

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## Symbols and Abbreviations

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**Weights and measures (metric)**

| | |
|---|---|
| centimeter | cm |
| deciliter | dL |
| gram | g |
| hectare | ha |
| kilogram | kg |
| kilometer | km |
| liter | L |
| meter | m |
| milliliter | mL |
| millimeter | mm |

**Weights and measures (English)**

| | |
|---|---|
| cubic feet per second | $ft^3/s$ |
| foot | ft |
| gallon | gal |
| inch | in |
| mile | mi |
| nautical mile | nmi |
| ounce | oz |
| pound | lb |
| quart | qt |
| yard | yd |

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| degrees kelvin | K |
| hour | h |
| minute | min |
| second | s |

**Physics and chemistry**

| | |
|---|---|
| all atomic symbols | |
| alternating current | AC |
| ampere | A |
| calorie | cal |
| direct current | DC |
| hertz | Hz |
| horsepower | hp |
| hydrogen ion activity (negative log of) | pH |
| parts per million | ppm |
| parts per thousand | ppt, ‰ |
| volts | V |
| watts | W |

**General**

| | |
|---|---|
| Alaska Administrative Code | AAC |
| all commonly accepted abbreviations | e.g., Mr., Mrs., AM, PM, etc. |
| all commonly accepted professional titles | e.g., Dr., Ph.D., R.N., etc. |
| at | @ |
| compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| copyright | © |
| corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| District of Columbia | D.C. |
| et alii (and others) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g. |
| Federal Information Code | FIC |
| id est (that is) | i.e. |
| latitude or longitude | lat. or long. |
| monetary symbols (U.S.) | $, ¢ |
| months (tables and figures): first three letters | Jan,...,Dec |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S.C. | United States Code |
| U.S. state | use two-letter abbreviations (e.g., AK, WA) |

**Mathematics, statistics**

| | |
|---|---|
| *all standard mathematical signs, symbols and abbreviations* | |
| alternate hypothesis | $H_A$ |
| base of natural logarithm | *e* |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, etc.) |
| confidence interval | CI |
| correlation coefficient (multiple) | R |
| correlation coefficient (simple) | r |
| covariance | cov |
| degree (angular ) | ° |
| degrees of freedom | df |
| expected value | *E* |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $log_{2,}$ etc. |
| minute (angular) | ' |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| variance | |
| population | Var |
| sample | var |

# *FISHERY DATA SERIES NO. 12-49*

## ESTIMATES OF THE HISTORIC RUN AND ESCAPEMENT FOR THE CHINOOK SALMON STOCK RETURNING TO THE KUSKOKWIM RIVER, 1976–2011

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# ABSTRACT

Total run of Chinook salmon (*Oncorhynchus tshawytscha)* to the Kuskokwim River from 1976 through 2011 was estimated using a model developed for data-limited situations. The model simultaneously combined information on subsistence harvest, commercial harvest and effort, sport harvest, test fish harvest and catch per unit of effort at Bethel, mark–recapture estimates of inriver abundance, and counts of salmon at 6 weirs and peak aerial counts from 14 drainages all spread throughout the Kuskokwim River drainage. The estimates of historic run size were then combined with available information on the age structure of the stock to reconstruct the total return by age and ultimately estimate a brood table.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, Kuskokwim River, run reconstruction, total run, escapement, subsistence salmon harvest, commercial salmon harvest.

# INTRODUCTION

A time series of reliable estimates of total run, spawning escapement, and productivity is important for the successful management of sustainable salmon fisheries. This is especially true when the stocks are experiencing moderate to heavy exploitation. While data on the Chinook salmon (*Oncorhynchus tshawytscha*) stock of the Kuskokwim River have been collected since before statehood, the large geographic size and diversity of the drainage, coupled with the wide geographic range of the fishery, have precluded the collection of adequate information to make estimates of total run and spawning escapement. In this report, we document the continued development and use of a run reconstruction model that was first developed by Shotwell and Adkison (2004) and refined by Bue et al. (2008) for use in estimating the historical abundance of salmon. We utilized the updated model to make estimates of total run size and spawning escapement for the Chinook salmon stock returning to the Kuskokwim River from 1976 through 2011 and then combined the estimates with available age composition information to estimate return by age and ultimately estimate a brood table.

The run reconstruction model described here differs from most others in scientific literature because the goal is to estimate total run size. Total run size and other population attributes such as total catch and escapement are typically known in other studies, and run reconstruction is used to estimate the stock composition of the catches and ultimately stock specific harvest rates (Starr and Hilborn 1988; Templin et al 1996; Branch and Hilborn 2010). Most run reconstructions are associated with large commercial fisheries and have become increasingly complex as more stock specific information is made available and computing methods improve (Flynn et al. 2006; Chasco et al. 2007; Lessard et al. 2008; Branch and Hilborn 2010). In contrast, the Kuskokwim River Chinook salmon stock is exploited primarily by local subsistence fishermen and only a small fraction of the escapement is measured. The methods presented here are appropriate for data limited situations and make use of most of the historical information collected on Chinook salmon in the Kuskokwim River drainage to estimate total abundance and total escapement by age for the stock.

Estimates of the total Chinook salmon run to the Kuskokwim River are critical for the success of our model. Recently, Schaberg et al. (2012) combined estimates of escapement from enumeration weirs located on the Kwethluk and Tulusak rivers, with expansions for unmonitored drainage areas downstream of Kalskag, and estimates of the number of Chinook salmon migrating upstream of Kalskag obtained from large-scale mark–recapture studies (Figure 1). These estimates of total run size were made for the 2003 through 2007 returns and provide the basis for calibrating our run reconstruction model.

Our approach can be viewed as the estimation of the run size most likely to produce the observed stock abundance information. While none of the datasets dealing with Chinook salmon in the Kuskokwim River alone are sufficient to provide an estimate of historical abundance in the drainage, the aggregate of information does provide an indication of trends in abundance that can be calibrated by a series of total run estimates.

# OBJECTIVES

This report documents a portion of the work performed for the completion of research Projects 45082 and 45554 *Kuskokwim Chinook Salmon Run Reconstruction* funded by the *Arctic Yukon Kuskokwim Sustainable Salmon Initiative*. The original objectives for this component of the research project were to:

1. Estimate spawning and total abundance of Chinook salmon in the Kuskokwim River from 1975 through 2007 using a statistical model for combining multiple data sources.
2. Describe the spawner-recruit relationship of Kuskokwim River Chinook salmon for the period 1975 through 2007 to assess the influence of parental escapement abundance on variations in return.

Project objective 1 was modified to encompass the 1976 through 2011 runs. It was determined early in the study that there was insufficient information to reconstruct the 1975 run while data for the 2008 through 2011 returns became available before this report was completed. The initial steps toward completion of project objective 2 involved combining the estimated spawning and total abundance estimates obtained from objective 1, with available age information to reconstruct the total run by age and estimate the brood table for the Kuskokwim River Chinook salmon stock. It became apparent at that time that a more in-depth analysis of the spawner-recruit relationship than proposed was warranted. It was decided that this report would cover objective 2 through the estimation of the brood table and that the description of the spawner-recruit relationship would be documented in a separate report.

# METHODS

## DATA SOURCES

Estimates of total inriver abundance presented in Schaberg et al. (2012; Appendix A1) are critical for scaling or anchoring the patterns of Chinook salmon abundance found in the Kuskokwim River dataset. In addition to the estimates of inriver abundance, counts of escapement collected at weirs (Appendix A2) and peak aerial survey counts (Appendix A3) were used. Escapement data are maintained by the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries, in Anchorage. Escapement counts at weirs were inclusive of all Chinook salmon counted or estimated to have passed the weir during operations. In some instances, our weir counts may be greater than those presented in other documents which typically only present counts obtained during a specified period of operation. Aerial survey data were compiled from Molyneaux and Brannian (2006) from 1976 through 2005 and the original data forms archived at the ADF&G office in Anchorage from 2006 through 2011. Aerial survey counts were inclusive of only index reaches that were considered to have been successfully surveyed (rating of good or fair) and included counts of carcasses.

Subsistence harvest data were compiled from several sources; estimates from 1976 through 1989 are found in Bavilla et al. (2010), estimates from 1989 through 2009 are found in Hamazaki (2011), and preliminary estimates for 2010 and 2011 are on file with ADF&G, Division of Commercial Fisheries, Anchorage. Commercial harvest and effort information from 1976 through 2009 were obtained from Bavilla et al. 2010 and the 2010 and 2011 data are on file with ADF&G, Division of Commercial Fisheries, Anchorage (Appendix A4). Data collected at the Bethel test fishery were provided by ADF&G Kuskokwim River research staff, Division of Commercial Fisheries. Data from the commercial fishery and Bethel test fishery were grouped into weekly intervals to facilitate the estimation of run timing. Age composition data were compiled from the Arctic Yukon Kuskokwim Salmon Database Management System maintained by the Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.

## ESTIMATION OF RUN TIMING

Run timing for Chinook salmon in the W1 commercial fishing district for the years 1984 through 2011 was estimated using information from the Bethel test fishery. The proportion of the run present by year and week ( $p_{yj}$ ) was defined by:

$$p_{yj} = \frac{CPUE_{yj}}{\sum_{j=1}^{z} CPUE_{yj}} \quad , \tag{1}$$

where $CPUE_{yj}$ is the total catch per unit effort during year (*y*), week (*j*) in the Bethel test fishery and *z* is the number of weeks that the test fishery operates. Run timing from 1976 through 1983 was estimated using the average run timing for the 1984 through 2011 runs.

## RUN RECONSTRUCTION MODEL

A reconstruction model was used to estimate total run and ultimately total escapement of Chinook salmon into the Kuskokwim River. The model simultaneously combined information on subsistence harvest, commercial harvest and effort, sport harvest, test fishery harvest and indices of abundance at Bethel, mark–recapture estimates of inriver abundance, counts of salmon at 6 weirs spread throughout the drainage, and peak aerial counts from 14 drainages also spread throughout the Kuskokwim River drainage. To simplify the description of the estimation process, the methodology was divided into 4 logical components based on the type of data used in the model: (1) weir counts, (2) aerial observations, (3) commercial harvest and effort, and (4) total inriver abundance. The model simultaneously combined input from all 4 components to estimate total run to the Kuskokwim River.

### Weir Counts

The weir component used total counts of Chinook salmon by year from 6 weirs (*i*) in the Kuskokwim drainage (Figure 1). For each weir the measurement of escapement ( $I_{iy}$ ) by year (*y*) was assumed to be related to the total annual escapement into the Kuskokwim River drainage ( $E_y$ ) by:

$$E_y = \hat{k}_i I_{iy} \quad , \tag{2}$$

and the expected weir count ( $\hat{I}_{iy}$ ) was estimated by:

$$\hat{I}_{iy} = E_y / \hat{k}_i \quad , \tag{3}$$

where $\hat{k}_i$ is a scaling factor for weir *i*.

The Poisson distribution is often used to model uncertainty in count data and was initially considered for use with the weir and aerial survey information in our model. However, the variance of the observations from weir and aerial surveys was greater than the mean of the observations, with the difference being more pronounced as the mean increased (Figure 2). This indicated that the weir and aerial survey counts did not follow a Poisson distribution, which requires that the mean and variance be equal. The negative binomial distribution is commonly used for this situation where an additional parameter, typically called the overdispersion parameter, is estimated to account for the additional variability. The form of the negative binomial density presented in Hilborn and Mangel (1997) and Millar (2011) was used:

$$f\left(I_{iy};\hat{I}_{iy},\hat{m}_i\right) = \frac{\Gamma\left(\hat{m}_i + I_{iy}\right)}{\Gamma\left(\hat{m}_i\right) I_{iy}!}\left(\frac{\hat{I}_{iy}}{\hat{m}_i + \hat{I}_{iy}}\right)^{I_{iy}}\left(\frac{\hat{m}_i}{\hat{m}_i + \hat{I}_{iy}}\right)^{\hat{m}_i} \quad , \tag{4}$$

where $\hat{I}_{iy}$ is the mean or expected value of $I_{iy}$ and $\hat{m}_i$ is the overdispersion parameter.

## Aerial Observations

Similar relationships and assumptions were made for the peak aerial counts from 14 systems (*a*) spread throughout the drainage. The peak aerial count ( $I_{ay}$ ) was assumed to be related to the total annual escapement into the Kuskokwim River drainage by:

$$E_y = \hat{k}_a I_{ay} \quad , \tag{5}$$

and the expected aerial count ($\hat{I}_{ay}$) was be estimated by:

$$\hat{I}_{ay} = E_y / \hat{k}_a \quad , \tag{6}$$

where $\hat{k}_a$ is a scaling factor for aerial counts from system *a*. As with the weir counts, the uncertainty between observed ( $I_{ay}$ ) and estimated ( $\hat{I}_{ay}$ ) aerial counts was assumed to follow a negative binomial distribution which required estimating both a scaling factor ( $\hat{k}_a$ ) and an overdispersion parameter ( $\hat{m}_a$ ).

## Commercial Harvest and Effort

The commercial harvest component relates weekly (*j*) commercial harvest and effort data from commercial fishing district W1 ($C_{yi}$; Figure 1) to total estimated abundance by week ($\hat{N}_{yj}$). Commercial fishing effort was defined as the number of permits fished during a fishery opening times the length of the opening in hours. Subsistence harvest that occurred in the Bay, downstream of fishing district W1 was subtracted from the estimated total abundance ($\hat{N}_y$) to produce an estimate of Chinook salmon available to the commercial fishery ($\hat{W}_y$) which can be further partitioned to estimates of weekly abundance using the estimated run timing at the Bethel test fishery. The number of Chinook salmon present in commercial fishing district W1 by year and week ($\hat{W}_{yj}$) was estimated by:

$$\hat{W}_{yj} = \hat{W}_y p_{yj} \quad . \tag{7}$$

Catch by year and week ($\hat{C}_{yj}$) was estimated by:

$$\hat{C}_{yj} = \hat{W}_{yj}\left(1 - e^{-\hat{q}B_{yj}}\right)e^{\varepsilon_{yj}} \quad , \quad \varepsilon_{yj} = N(0, \sigma_\varepsilon^2) \quad , \tag{8}$$

which is the Baranov catch equation where $\hat{q}$ is the estimated catchability coefficient and $B_{yj}$ is the observed effort for year *y* and week *j*. The uncertainty between observed harvest ($C_{yj}$) and estimated harvest ($\hat{C}_{yj}$) was assumed to be distributed lognormally with a mean of zero and a standard deviation of $\sigma_\varepsilon$.

The commercial harvest component was stratified into three groups to account for changes in the fishery which have been shown to have dramatic effects on harvest and effort models (Maunder and Punt 2002). Catchability coefficients were estimated for fisheries with no restriction on gillnet stretched mesh size ($\hat{q}_{un}$), for fisheries with gill net stretched mesh size restricted to 6 inches or less for 1976 through 1984 ($\hat{q}_r$) and for fisheries with gillnet stretched mesh size restricted to 6 inches or less after 1984 ($\hat{q}_m$). While the distinction between fisheries using gillnets of any stretched mesh size (unrestricted) and fisheries where gillnets of 6 inches or less stretched mesh were allowed (restricted) were straightforward, the decision of whether to further stratify and for what time period within restricted fisheries was not. A major change in gillnet twine construction occurred in the early 1980s (Bue 1986a) and greatly increased the efficiency of gillnets in the Bristol Bay sockeye salmon fishery at that time (Bue 1986a, Bue 1986b). We assumed that fishermen in the Kuskokwim River salmon fisheries would have switched to gillnets with the new twine construction by 1985, and used that year to group the restricted gear for analysis.

## Total Inriver Abundance

An intensive stock assessment program designed to estimate the total inriver run was essential for the successful completion of this modeling effort. An accurate estimate of the number of Chinook salmon migrating upstream of Kalskag, combined with accurate estimates of escapement for tributaries downstream of Kalskag, and estimates of the subsistence, commercial, sport, and test fishery harvests, allowed for a comparison of the observed total run ( $N_y$ ) to the estimated total run ( $\hat{N}_y$ ),

$$N_y = E_{(Downstream)y} + E_{(Upriver)y} + S_y + C_y + R_y + G_y \quad , \tag{9}$$

where annual subsistence, commercial, sport, and test-fish harvests are $S_y$, $C_y$, $R_y$ and $G_y$, respectively, and

$$\hat{N}_y = N_y + \delta_y \quad , \quad \delta_y \sim N(0, \sigma_\delta^2) \quad . \tag{10}$$

The work described by Schaberg et al. (2012) provided estimates of both $N_y$ and its standard deviation ( $\sigma_{N_y}$ ) for the years 2003 through 2007 which were incorporated into the model as a penalized negative log likelihood similar to that described in Branch and Hilborn (2010) and Flynn et al. (2006),

$$-\ln L = \sum_y \frac{\left(N_y - \hat{N}_y\right)^2}{2\sigma_{N_y}^2} \quad . \tag{11}$$

Because the $\sigma_{N_y}$ values were considered fixed and not estimated by the reconstruction model, the constant term (ln $\sigma_{N_y}$ ) typically included in the negative log likelihood form of the normal model was omitted.

The estimated annual escapement into the Kuskokwim River drainage ( $\hat{E}_y$ ) was calculated as:

$$\hat{E}_y = \left(\hat{N}_y - S_y - C_y - R_y - G_y\right) \quad , \tag{12}$$

## Likelihood Model

The weir, aerial, catch, and total inriver components were combined into a single likelihood model that simultaneously estimated the total run to the Kuskokwim drainage for each year,

$$
L\left(\theta \middle| data\right) = \begin{aligned}
&\prod_y \prod_i \frac{\Gamma\left(\hat{m}_i + I_{iy}\right)}{\Gamma\left(\hat{m}_i\right) I_{iy}!} \left( \frac{\hat{I}_{iy}}{\hat{m}_i + \hat{I}_{iy}} \right)^{I_{iy}} \left( \frac{\hat{m}_i}{\hat{m}_i + \hat{I}_{iy}} \right)^{\hat{m}_i} \\
&\prod_y \prod_a \frac{\Gamma\left(\hat{m}_a + I_{ay}\right)}{\Gamma\left(\hat{m}_a\right) I_{ay}!} \left( \frac{\hat{I}_{ay}}{\hat{m}_a + \hat{I}_{ay}} \right)^{I_{ay}} \left( \frac{\hat{m}_a}{\hat{m}_a + \hat{I}_{ay}} \right)^{\hat{m}_a} \\
&\prod_y \prod_j \frac{1}{\sigma_\varepsilon \sqrt{2\pi}} \exp^{\frac{-\left(\ln C_{yj} - \ln \hat{C}_{yj}\right)^2}{2\sigma_\varepsilon^2}} \\
&\prod_y \exp^{\frac{-\left(N_y - \hat{N}_y\right)^2}{2\sigma_{N_y}^2}}
\end{aligned} \tag{13}
$$

The negative log likelihood form of the model was minimized (Hilborn and Mangel 1997) to arrive at the best estimates of the model parameters ($\hat{k}_i$, $\hat{k}_a$, $\hat{q}_{un}$, $\hat{q}_r$, $\hat{q}_m$, $\hat{m}_i$, $\hat{m}_a$ and $\hat{N}_y$) with the optimizer constrained to (1) values of estimated total run ($\hat{N}_y$) greater than the number of fish already accounted for in the catch and escapement and (2) values for the escapement scaling factors ($\hat{k}_i$ and $\hat{k}_a$) of 1.0 or greater. Both of these constraints reflect the assumption that there were more fish in the river system than were counted by catch and escapement programs. The optimizer was also constrained when estimating the catchability coefficients ($\hat{q}_{un}, \hat{q}_r, \hat{q}_m$) to values less than $1 \times 10^{-4}$ and greater than or equal to $5 \times 10^{-7}$ to protect against obtaining nonsensical negative log likelihood values. An *ad hoc* sensitivity analysis which examined model convergence for a wide range of possible starting values was performed. In addition, the negative log likelihood profile for each model parameter was examined for localized minima which could affect model convergence and the resulting estimates.

The confidence regions about the estimates of total run were calculated using the negative log-likelihood profiles for $\hat{N}_y$ for each year. For this method, the negative log-likelihood profile for an estimate of total abundance for a selected year was estimated by calculating the negative log-likelihood for individual levels of possible run size within a wide range of possible run abundances while searching over all possible values of the other parameters in the model. The confidence bounds for $\hat{N}_y$ were then estimated using the negative log-likelihood ($\mathbf{L}(N)$) for a total run of abundance *N* by,

$$
2\left[\mathbf{L}(N) - \mathbf{L}(N)_{\min}\right] \ , \tag{14}
$$

which is chi-square distributed with 1 df (Venzon and Moolgavkar 1988; Hilborn and Mangel 1997).

## BROOD TABLE ESTIMATION

Estimates of the number of Chinook salmon in the harvest and escapement obtained from the run reconstruction model were combined with available age information to reconstruct the total run by year and age, and the resulting information was then used to estimate a brood table. Whenever possible, estimates of age composition were combined with the corresponding segment of the total run estimate. For example, the estimated age composition of the 2009 commercial harvest was applied to the estimated number of fish caught in the commercial fishery in 2009 to estimate the number of fish by age in that segment of the run. For many years, however, age composition information was missing for one or more of the segments, which required some form of data pooling to estimate the number of salmon by age. Commercial and subsistence fisheries both use gillnets to harvest Chinook salmon. This gear has been shown to be selective for size and age, which makes it highly unlikely that the harvest and escapement would have the same age composition. Because of the selective nature of the fisheries, it was decided that only age information from the harvest segment would be used to estimate the age composition of the harvest, while only age information from the escapement would be used to estimate the age structure of the escapement.

The harvest segment was composed of harvest from the commercial, subsistence, sport, and test fishery, with the commercial and subsistence fisheries comprising by far most of the harvest. In addition, age composition information for the subsistence harvests was available only from 2001 through 2011. Since subsistence harvest was greater than commercial harvest for all years except 1978 (Appendix A2), it was important to include an estimate of age composition for that segment. The subsistence fishery has historically used large mesh gillnets and the age composition of the harvest from 2001 through 2011 has been relatively consistent, which suggested that the average age composition from 2001 through 2011 could be used for the previous years (1976–2000). In contrast, the commercial fishery for Chinook salmon occurs at the same time as the fishery for chum salmon and the stretched mesh size of the gillnets allowed in the commercial fishery was often restricted to 6 inches or less (smaller gear), which suggested that age information from the commercial and subsistence harvest were not interchangeable. No estimate of the number of fish by age in the harvest was made when the commercial harvest was greater than 1,000 fish and corresponding age information was not available. When the commercial harvest was less than 1,000 fish and corresponding age composition information was not available, the number of fish by age was estimated by summing the commercial and subsistence harvests and then applying the subsistence age information. Because the magnitude of sport and test fishery harvests were always quite small relative to the overall harvest, harvests from these fisheries were pooled with commercial and subsistence information whenever age information for the sport and test fisheries were unavailable.

The number of fish by age in the escapement segment was estimated using age information obtained from all of the operational escapement projects. Age composition information came solely from the Kogrukluk River weir from 1976 through 1990 after which additional escapement projects became operational and more age information became available. A weighted estimate of the proportion ($\hat{P}_{ya}$) of each age group (*a*) was obtained for each year (*y*) by weighting the age composition estimates ($\hat{h}_{yai}$) from each weir (*i*) by the number of fish enumerated at the project for which age information was collected at ($g_{yi}$),

$$\hat{P}_{ya} = \frac{\hat{h}_{yai} g_{yi}}{\sum_{y} g_{yi}} \quad . \tag{15}$$

The number of fish of age *a* from year *y* ($\hat{n}_{ya}$) was estimated by multiplying the estimated escapement from the reconstruction model ($\hat{E}_y$) by the estimated proportion of age *a* fish,

$$\hat{n}_{ya} = \hat{E}_y \hat{P}_{ya} \quad . \tag{16}$$

No estimate of the age composition of the escapement was made, if age information from the escapement was unavailable.

The harvests and escapements by age and year were summed to estimate the total run by year for all years where both harvest and escapement by age were estimated. No estimate of total run by age was made if either the harvest or escapement component was not estimated.

A brood table was estimated using the estimates of total run by age. An evaluation of the sibling relationships for the major age classes (age 1.2, 1.3, 1.4, and 1.5; Peterman 1982) was performed for years with complete age data to determine whether the appropriate sibling relationship could be used to estimate the number of fish by age for years with incomplete age data. If the sibling relationships were unreliable for that purpose, then the average return by age was used.

# RESULTS

## ESTIMATION OF RUN TIMING

Run timing of Chinook salmon in commercial fishing district W1 was generally unimodal, peaking during week 4 of the season (June 17 through June 23); although a wide range of entry patterns and run timings have been observed (Figure 3).

## RUN RECONSTRUCTION MODELING

Seventy-nine parameters were estimated for the run reconstruction model: 36 total runs ($\hat{N}_y$; 1976 through 2011), 6 scaling factors ($\hat{k}_i$) and 6 overdispersion parameters ($\hat{m}_i$) for the escapement monitored by weirs, 14 scaling factors ($\hat{k}_a$) and 14 overdispersion parameters ($\hat{m}_a$) for the systems monitored by aerial survey, and 3 catchability coefficients ($\hat{q}_{un}$, $\hat{q}_r$ and $\hat{q}_m$; Table 1). While the number of parameters is high, 432 observations were used to fit the model (Appendices A2, A3, and A4). Constraints placed on the estimation of catchability did not adversely influence parameter estimation since the value of catchability that minimized the negative log likelihood was between $8.0 \times 10^{-5}$ and $1.0 \times 10^{-5}$ for the 3 catchability models. The *ad hoc* examination of model stability showed that the model converged to approximately the same values for nearly all scenarios. The exception to this occurred when a starting catchability value was less than the constrained range.

All model parameters associated with the escapement components displayed pronounced "U-shaped" profiles across a wide range of possible values (Figures 4 and 5). This pattern in the negative log likelihoods indicated that there was a unique solution for the model within the range of parameter values examined. The point where the profile was minimized was the parameter value which provided the most likely solution for the run reconstruction model. In addition, the negative log likelihood scales for Figures 4–6 have been adjusted such that the minimum value was zero and each unit increase in the negative log likelihood was one unit increase in the scale. This adjustment not only simplified the scale but also provided an easy way to approximate the 95% confidence range about the parameter estimates. Two times the difference between the negative log likelihood for a parameter value and the minimum negative log likelihood was chi-square distributed with 1 degree of freedom (Equation 14). The chi-square value for 95.45% and 1 degree of freedom is 4.0; thus an approximate 95% confidence range for a parameter was found at the points where the likelihood profile crossed the value of 2.0 on the adjusted axis. An examination of the negative log likelihood profiles for the catchability parameters also indicated good model convergence (Figure 6) as well as evidence that the model stratification was appropriate and showed little overlap of the parameter profiles at adjusted values less than 2.0.

The reconstructed counts for the weirs located above Kalskag compared well with the observed counts while there was an indication that the reconstruction model estimated higher escapements for the lower weir counts and lower escapements for the high weir counts observed at the Kwethluk and Tuluksak River weirs; more so for the Kwethluk than the Tuluksak (Figure 7). The mouths of both of these systems are in the lower Kuskokwim River where the majority of subsistence and commercial harvests occur, and it is possible that fishery management decisions influenced the exploitation rates on these populations differently from other weir populations. There was some suggestion that large aerial counts did not always result in large reconstructed counts (Figure 8; Kwethluk, Kisaralik, Aniak, and Oskawalik for example). The inconsistencies with the aerial information is not surprising since salmon entry and mortality in these systems can be very dynamic and variable from year to year, and abundance data are obtained from a single aerial survey made during the same time period each year often using different observers. Some researchers recommend against the use of peak aerial surveys for estimating abundance (Parsons and Skalski 2010) while others have demonstrated that escapement estimates based on multiple observations distributed throughout the run are imprecise (Bue et al. 1998; Hilborn et al. 1999; Holt and Cox 2008). We felt that the inclusion of the aerial survey information in the reconstruction was justified since it provided abundance information from throughout the Kuskokwim drainage and any uncertainty in the model fit was reflected in the likelihoods. Estimates of harvest obtained from the catchability model were generally in agreement with the observed harvests (Figure 9).

Total run estimates provided by the model were a good fit to the total runs estimated by Schaberg et al. (2012; Figure 10). The greatest difference between a reconstructed estimate and a total run estimated by Schaberg et al. (2012) occurred for 2006. However, the 95% confidence bounds for the two estimates overlapped, providing little evidence that the two estimates were significantly different from each other (Figure 11).

The largest estimates of total run occurred in 1981, 1994, 1995, 2004, and 2005 with the lowest occurring in 1986, 2000, 2010, and 2011 (range 118,507 to 389,791; Table 2, Figure 12). Coefficients of variation for the annual escapement estimates ranged from 8% to 16%. The time series of Chinook salmon escapement estimates ranged from lows in 1986, 2000, and 2010, to highs in 1981, 2004, and 2005 (range 49,073 to 287,178; Table 2, Figure 12). Coefficients of variation for the annual escapement estimates ranged from 12% to 33%.

## BROOD TABLE CONSTRUCTION

Sufficient age information was available to reconstruct the age composition of the total run for 30 of the 36 years estimated by the run reconstruction model (Appendix A6). Fortunately, the years for which information was lacking occurred early in the time series and in close proximity to each other temporally, which minimized the effect of missing age data upon the estimation of the brood table. Estimates for 1976 and 1979 were not made due to the lack of age information from the commercial harvest, while estimates for 1977, 1980, 1983 and 1987 were omitted due to the lack of age information from the escapements (Table 3; Appendix A6). Estimates of the age composition of the harvest were made for 2000 through 2003 and 2007 even though no age information was collected from the commercial harvest (Table 3; Appendix A6). Commercial harvest for those years was low relative to the subsistence harvest (less than 500 fish or 0.5% of the subsistence harvest for all years; Appendix A6). Estimates of age composition were available from the subsistence harvest for 2001 through 2003 and 2007, and were used to estimate the number of fish by age in both the commercial and subsistence harvest for their respective years while average age composition from the subsistence fishery for 2001 through 2011 was used to estimate the 2000 harvest.

The estimates of total run by age and year were rearranged by brood year so the number of fish produced for a particular escapement could be estimated (Table 4). Nine brood years, 1976 through 1984 (Table 4), were affected by the lack of age information for the 1976, 1977, 1979, 1980, 1983, and 1987 returns. Examination of the sibling relationships for the major age classes indicated that the number of age 1.3 ($r^2$=0.47, $p$<0.001) and age 1.4 ($r^2$=0.59, $p$<0.001) fish could be estimated using sibling models. However, the relationship for age 1.2 fish was not statistically significant ($r^2$=0.0, $p$>0.34; Figure 13), and the relationship for age 1.5 fish ($r^2$=0.22, $p$<0.02) was driven by one data point (Figure 13), and was thought to be unreliable. Thus, sibling relationships were used to estimate missing returns for age 1.3 and 1.4 fish, while the average return by age class was used to estimate missing returns for the other age classes.

The estimated number of fish in the escapement for the period 1976 through 2011 ranged from a low of 49,073 in 2010 to a high of 287,178 in 2004 (Table 4). The number of fish returning for every spawning fish (return per spawner) ranged from lows of 0.57, 0.58, and 0.50 (1994, 2004 and 2005 brood years, respectively) to a high of 6.90 (2000 brood year). The return per spawner tended to cycle from periods of low production to periods of higher production (Figure 14A; Table 4). There also was a suggestion that return per spawner trended with level of escapement, with higher production occurring for lower levels of escapement and lower production being observed for higher levels of escapements (Figure 14B).

# DISCUSSION

We believe our methodology did an acceptable job of describing the true pattern of abundance and provided reasonable estimates of the time series of total run size and escapement. The overall confidence in our time series of abundance estimates depends on the number and accuracy of the independent estimates of total run, as well as the range of abundance levels encompassed by the independent estimates. Generally, our confidence in the run reconstruction estimates increases as the range and number of independent estimates of total run increases. Schaberg et al. (2012) provided 5 independent estimates of total run, spanning almost a two-fold range of run sizes (241,617 to 422,657).

Reliance upon a relatively small number of independent estimates of run size from a narrow window of time may result in a degradation of model accuracy over time. Hilborn et al. (2003) and Schindler et al. (2010) demonstrated for Bristol Bay sockeye salmon that distinct geographic and life history components of a stock contribute differently to the stock's abundance through time, with some populations being minor producers under one climatic regime but dominating during the next. If this pattern is also true for the Chinook salmon stock returning to the Kuskokwim River drainage, our reconstruction model will perform well for the years closer to the time period for which the independent estimates of run size were made, with accuracy decreasing for earlier and later years. Because of this it will be important to periodically update the model with new independent estimates of total run size.

Estimates of uncertainty about the age composition estimates and estimates of return by brood year were not made. Sample size information was available for all cases where age composition estimates were made, but there was the potential for unknown sampling bias. The subsistence fishery was not sampled sufficiently until 2001 and the average estimated age composition of the 2001 through 2011 subsistence harvests was used to estimate the 1976 through 2000 harvest. While the commercial harvests and weir projects were sampled for most years using adequate sample sizes and stratified designs to account for differences in population structure through time, less than 14% of the total escapement was counted past the weirs prior to 1996, with the percentage increasing as more weir projects became operational (Table 5). More than 75% of the escapement was never in the population of fish available for age sampling, and if age structure varies between tributaries, the true age structure of the escapement may be different than that estimated by the weir populations.

We do not feel these weakness decreases the value of our estimates of the historical time series, age composition by return year, and estimates of brood year returns. This study provides new information for the formulation of fisheries management strategies and hopefully helps with the development of future population assessment projects.

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# TABLES AND FIGURES

Table 1.–Estimates of the parameter values for the reconstruction of the historical total runs of Chinook salmon to the Kuskokwim River.

| | | Parameter Estimate | 95% Bound Lower | 95% Bound Upper | CV | Overdispersion Parameter |
|---|---|---|---|---|---|---|
| Weir Projects | $\hat{k}_i$ | | | | | |
| Kwethluk Weir | | 16.8 | 12.5 | 22.0 | 14% | 10.5 |
| Tuluksak Weir | | 153.0 | 110.0 | 205.0 | 16% | 4.8 |
| George Weir | | 37.4 | 28.0 | 48.0 | 14% | 9.3 |
| Kogrukluk Weir | | 13.3 | 10.5 | 17.0 | 12% | 10.7 |
| Tatlawiksuk Weir | | 89.4 | 70.0 | 112.5 | 12% | 28.4 |
| Takotna Weir | | 335.2 | 240.0 | 450.0 | 16% | 6.0 |
| Aerial Survey Streams | $\hat{k}_a$ | | | | | |
| Kwethluk River | | 94.5 | 65.0 | 135.0 | 19% | 3.8 |
| Kisaralik River | | 144.1 | 90.0 | 215.0 | 22% | 1.5 |
| Tuluksak River | | 410.4 | 280.0 | 600.0 | 20% | 3.6 |
| Salmon (Aniak River) | | 185.2 | 135.0 | 245.0 | 15% | 4.3 |
| Kipchuk River | | 159.7 | 115.0 | 210.0 | 15% | 4.6 |
| Aniak River | | 57.1 | 42.0 | 74.0 | 14% | 7.9 |
| Holokuk River | | 883.2 | 600.0 | 1,250.0 | 19% | 1.9 |
| Oskawalik River | | 520.2 | 330.0 | 770.0 | 22% | 2.0 |
| Holitna River | | 95.6 | 70.0 | 125.0 | 15% | 9.0 |
| Cheeneetnuk River | | 198.3 | 140.0 | 280.0 | 18% | 3.4 |
| Gagaryah River | | 331.3 | 240.0 | 440.0 | 15% | 4.2 |
| Pitka Fork | | 703.5 | 500.0 | 960.0 | 17% | 6.3 |
| Bear River | | 728.4 | 550.0 | 925.0 | 13% | 14.9 |
| Salmon(Pitka Fork) | | 152.6 | 115.0 | 195.0 | 13% | 7.3 |
| Catchability | | | | | | |
| Unrestricted gear | $\hat{q}_{un}$ | 0.0000791 | 0.000060 | 0.000100 | 13% | |
| Restricted 1976-1984 | $\hat{q}_r$ | 0.0000141 | 0.000010 | 0.000020 | 18% | |
| Restricted 1985-2011 | $\hat{q}_m$ | 0.0000545 | 0.000044 | 0.000068 | 11% | |

*Note*: The upper and lower bound represent the 95% confidence interval as estimated from the negative log likelihood profiles for each parameter; CV is estimated as the standard deviation divided by the estimate where standard deviation is estimated by dividing the width of the 95% confidence interval by 2 x 1.96.

Table 2.–Estimated total run and escapement for Kuskokwim River Chinook salmon, 1976 through 2011.

| Year | Estimated Total Run | 95% Confidence Bounds Lower | 95% Confidence Bounds Upper | CV | Estimated Escapement | 95% Confidence Bounds Lower | 95% Confidence Bounds Upper | CV |
|---|---|---|---|---|---|---|---|---|
| 1976 | 233,967 | 185,000 | 300,000 | 13% | 143,420 | 94,453 | 209,453 | 20% |
| 1977 | 295,559 | 230,000 | 385,000 | 13% | 201,852 | 136,293 | 291,293 | 20% |
| 1978 | 264,325 | 210,000 | 330,000 | 12% | 180,853 | 126,528 | 246,528 | 17% |
| 1979 | 253,970 | 190,000 | 350,000 | 16% | 157,668 | 93,698 | 253,698 | 26% |
| 1980 | 300,573 | 230,000 | 410,000 | 15% | 203,605 | 133,032 | 313,032 | 23% |
| 1981 | 389,791 | 300,000 | 515,000 | 14% | 279,392 | 189,601 | 404,601 | 20% |
| 1982 | 187,354 | 160,000 | 225,000 | 9% | 80,353 | 52,999 | 117,999 | 21% |
| 1983 | 166,333 | 135,000 | 210,000 | 12% | 84,188 | 52,855 | 127,855 | 23% |
| 1984 | 188,238 | 150,000 | 250,000 | 14% | 99,062 | 60,824 | 160,824 | 26% |
| 1985 | 176,292 | 140,000 | 235,000 | 14% | 94,365 | 58,073 | 153,073 | 26% |
| 1986 | 129,168 | 105,000 | 160,000 | 11% | 58,556 | 34,388 | 89,388 | 24% |
| 1987 | 193,465 | 155,000 | 270,000 | 15% | 89,222 | 50,757 | 165,757 | 33% |
| 1988 | 207,818 | 180,000 | 250,000 | 9% | 80,055 | 52,237 | 122,237 | 22% |
| 1989 | 241,857 | 205,000 | 295,000 | 9% | 115,704 | 78,847 | 168,847 | 20% |
| 1990 | 264,802 | 230,000 | 320,000 | 9% | 100,614 | 65,812 | 155,812 | 23% |
| 1991 | 218,705 | 185,000 | 270,000 | 10% | 105,589 | 71,884 | 156,884 | 21% |
| 1992 | 284,846 | 240,000 | 350,000 | 10% | 153,573 | 108,727 | 218,727 | 18% |
| 1993 | 269,305 | 220,000 | 340,000 | 11% | 169,816 | 120,511 | 240,511 | 18% |
| 1994 | 365,246 | 285,000 | 485,000 | 14% | 242,616 | 162,370 | 362,370 | 21% |
| 1995 | 360,513 | 295,000 | 450,000 | 11% | 225,595 | 160,082 | 315,082 | 18% |
| 1996 | 302,603 | 235,000 | 405,000 | 14% | 197,092 | 129,489 | 299,489 | 22% |
| 1997 | 303,189 | 240,000 | 395,000 | 13% | 211,247 | 148,058 | 303,058 | 19% |
| 1998 | 213,873 | 170,000 | 275,000 | 13% | 113,627 | 69,754 | 174,754 | 24% |
| 1999 | 189,939 | 150,000 | 240,000 | 12% | 112,082 | 72,143 | 162,143 | 20% |
| 2000 | 136,618 | 115,000 | 165,000 | 9% | 65,180 | 43,562 | 93,562 | 20% |
| 2001 | 223,707 | 180,000 | 280,000 | 11% | 145,232 | 101,525 | 201,525 | 18% |
| 2002 | 246,296 | 200,000 | 300,000 | 10% | 164,635 | 118,339 | 218,339 | 15% |
| 2003 | 248,789 | 205,000 | 295,000 | 9% | 180,687 | 136,898 | 226,898 | 13% |
| 2004 | 388,136 | 320,000 | 465,000 | 10% | 287,178 | 219,042 | 364,042 | 13% |
| 2005 | 366,601 | 305,000 | 435,000 | 9% | 275,598 | 213,997 | 343,997 | 12% |
| 2006 | 307,662 | 255,000 | 375,000 | 10% | 214,004 | 161,342 | 281,342 | 14% |
| 2007 | 273,060 | 230,000 | 320,000 | 8% | 174,943 | 131,883 | 221,883 | 13% |
| 2008 | 237,074 | 200,000 | 285,000 | 9% | 128,978 | 91,904 | 176,904 | 17% |
| 2009 | 204,747 | 170,000 | 250,000 | 10% | 118,478 | 83,731 | 163,731 | 17% |
| 2010 | 118,507 | 105,000 | 140,000 | 8% | 49,073 | 35,566 | 70,566 | 18% |
| 2011 | 133,059 | 110,000 | 160,000 | 10% | 72,097 | 49,037 | 99,037 | 18% |

*Note*: The upper and lower bound represent the 95% confidence interval as estimated from the negative log likelihood profiles for each parameter; CV is estimated as the standard deviation divided by the estimate where standard deviation is estimated by dividing the width of the 95% confidence interval by 2 x 1.96.

Table 3.–Sources of the age information used to estimate the total run by age of Chinook salmon returning to the Kuskokwim River, Alaska, 1976 through 2011.

| | Harvest | | | | Escapement | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Commercial | Subsistence | Sport | Test fish | Kwethluk | Tuluksak | George | Kogrukluk | Tatlawiksuk | Takotna |
| 1976 | | x [a] | | | | | | x | | |
| 1977 | x | x [a] | | | | | | | | |
| 1978 | x | x [a] | | | | | | x | | |
| 1979 | | x [a] | | | | | | x | | |
| 1980 | x | x [a] | | | | | | | | |
| 1981 | x | x [a] | | | | | | x | | |
| 1982 | x | x [a] | | | | | | x | | |
| 1983 | x | x [a] | | | | | | | | |
| 1984 | x | x [a] | | | | | | x | | |
| 1985 | x | x [a] | | | | | | x | | |
| 1986 | x | x [a] | | | | | | x | | |
| 1987 | x | x [a] | | | | | | | | |
| 1988 | x | x [a] | | | | | | x | | |
| 1989 | x | x [a] | | | | | | x | | |
| 1990 | x | x [a] | | | | | | x | | |
| 1991 | x | x [a] | | | | x | | x | | |
| 1992 | x | x [a] | | | x | x | | x [b] | | |
| 1993 | x | x [a] | | | | x | | x [b] | | |
| 1994 | x | x [a] | | | | x | | x [b] | | |
| 1995 | x | x [a] | | | | | | x | | |
| 1996 | x | x [a] | | | | | x | x | | |
| 1997 | x | x [a] | | | | | x | x | | |
| 1998 | x | x [a] | | | | | | x | | |
| 1999 | x | x [a] | | | | | x [b] | x | | |
| 2000 | | x [a] | | | x | | | x | | x |
| 2001 | | x | | x | | | x | x | | |
| 2002 | | x | | x | x | x | x | x | x | x |
| 2003 | | x | | x | x | x | | x | | x [c] |
| 2004 | x | x | | x | x | x | x | x | x | x [d] |
| 2005 | x | x | | x | | x | x | x | x | |
| 2006 | x | x | | | x | x | x | x | x | x |
| 2007 | | x | | | x | x | x [b] | x | x | x |
| 2008 | x | x | | | x | x | x | x | x | x |
| 2009 | x | x | | | x | x | x | x | x | x |
| 2010 | x | x | | | x | x | x | x | x | |
| 2011 | x | x | | | x | | x | x | x | x |

[a] Estimated using the average age composition from the 2001 to 2011 subsistence harvests.

[b] Estimated using information from 2 of the 3 sampling strata for the year.

[c] Age composition estimated using 61 ASL samples collected from a weir passage of 378 fish.

[d] Age composition estimated using 69 ASL samples collected from a weir passage of 462 fish.

Table 4.–Estimated brood table for Chinook salmon returning to the Kuskokwim River, Alaska, 1976 through 2011.

| Brood Year | Escapement | Return by Age Class | | | | | | | | | | | | Return | Return per Spawner |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.2 | 1.1 | 1.2 | 2.1 | 1.3 | 2.2 | 1.4 | 2.3 | 1.5 | 2.4 | 1.6 | 2.5 | | |
| 1976 | 143,420 | 5 [a] | 685 [a] | 45,301 [a] | 7 [a] | 129,032 | 26 | 113,427 | 78 | 7,813 [a] | 270 [a] | 80 | 0 | 296,724 | 2.07 |
| 1977 | 201,852 | 5 [a] | 685 [a] | 29,297 | 0 | 53,519 | 24 | 67,261 [b] | 350 [a] | 8,145 | 503 | 101 | 0 | 159,889 | 0.79 |
| 1978 | 180,853 | 0 | 913 | 11,960 | 0 | 59,692 [b] | 313 [a] | 65,360 | 491 | 6,014 | 43 | 5 | 0 | 144,790 | 0.80 |
| 1979 | 157,668 | 0 | 139 | 45,301 [a] | 7 [a] | 82,411 | 152 | 75,392 | 58 | 7,029 | 50 | 13 [a] | 12 [a] | 210,564 | 1.34 |
| 1980 | 203,605 | 5 [a] | 685 [a] | 30,686 | 32 | 62,372 | 170 | 48,479 | 68 | 7,813 [a] | 270 [a] | 7 | 0 | 150,587 | 0.74 |
| 1981 | 279,392 | 0 | 367 | 31,815 | 0 | 61,253 | 21 | 72,840 [b] | 350 [a] | 11,546 | 70 | 7 | 0 | 178,270 | 0.64 |
| 1982 | 80,353 | 0 | 318 | 11,508 | 0 | 59,307 [b] | 313 [a] | 69,437 | 95 | 7,410 | 1,045 | 10 | 0 | 149,444 | 1.86 |
| 1983 | 84,188 | 0 | 747 | 45,301 [a] | 7 [a] | 97,996 | 30 | 119,935 | 723 | 6,245 | 108 | 37 | 281 | 271,408 | 3.22 |
| 1984 | 99,062 | 5 [a] | 685 [a] | 28,540 | 0 | 73,040 | 1,568 | 73,672 | 146 | 5,617 | 841 | 8 | 0 | 184,122 | 1.86 |
| 1985 | 94,365 | 0 | 86 | 38,015 | 0 | 126,302 | 46 | 110,193 | 1,253 | 5,788 | 449 | 8 | 90 | 282,231 | 2.99 |
| 1986 | 58,556 | 0 | 99 | 55,236 | 0 | 72,342 | 1,939 | 100,040 | 253 | 10,399 | 745 | 10 | 0 | 241,062 | 4.12 |
| 1987 | 89,222 | 0 | 3016 | 26,034 | 0 | 94,115 | 942 | 99,770 | 768 | 5,912 | 1,432 | 9 | 0 | 231,998 | 2.60 |
| 1988 | 80,055 | 65 | 90 | 76,148 | 0 | 80,801 | 186 | 119,483 | 1,744 | 4,517 | 251 | 10 | 0 | 283,295 | 3.54 |
| 1989 | 115,704 | 0 | 7088 | 76,113 | 0 | 194,963 | 1,603 | 189,281 | 293 | 33,004 | 103 | 7 | 0 | 502,456 | 4.34 |
| 1990 | 100,614 | 0 | 409 | 39,167 | 170 | 103,957 | 43 | 110,564 | 615 | 3,623 | 79 | 8 | 0 | 258,635 | 2.57 |
| 1991 | 105,589 | 73 | 670 | 61,980 | 0 | 128,496 | 324 | 144,684 | 108 | 6,060 | 81 | 7 | 0 | 342,483 | 3.24 |
| 1992 | 153,573 | 0 | 163 | 29,341 | 0 | 70,580 | 34 | 85,749 | 110 | 3,787 | 72 | 6 | 0 | 189,842 | 1.24 |
| 1993 | 169,816 | 0 | 127 | 83,961 | 0 | 105,460 | 34 | 117,186 | 97 | 5,193 | 70 | 0 | 0 | 312,128 | 1.84 |
| 1994 | 242,616 | 0 | 97 | 16,062 | 0 | 53,331 | 236 | 55,960 | 95 | 11,520 | 2 | 0 | 0 | 137,304 | 0.57 |
| 1995 | 225,595 | 0 | 293 | 14,894 | 0 | 55,957 | 30 | 120,178 | 0 | 8,318 | 0 | 0 | 0 | 199,669 | 0.89 |
| 1996 | 197,092 | 0 | 317 | 19,163 | 0 | 67,457 | 0 | 97,481 | 0 | 9,395 | 0 | 0 | 0 | 193,813 | 0.98 |
| 1997 | 211,247 | 0 | 131 | 24,550 | 0 | 88,004 | 63 | 80,879 | 0 | 4,899 | 0 | 0 | 0 | 198,527 | 0.94 |
| 1998 | 113,627 | 0 | 0 | 52,214 | 0 | 107,444 | 0 | 112,376 | 0 | 4,917 | 172 | 0 | 0 | 277,124 | 2.44 |
| 1999 | 112,082 | 0 | 215 | 50,637 | 0 | 118,418 | 439 | 122,425 | 618 | 14,411 | 107 | 0 | 0 | 307,272 | 2.74 |
| 2000 | 65,180 | 0 | 434 | 150,604 | 0 | 170,004 | 10 | 121,781 | 161 | 6,204 | 814 | 0 | 0 | 450,011 | 6.90 |
| 2001 | 145,232 | 0 | 1398 | 67,655 | 0 | 92,751 | 54 | 97,738 | 294 | 5,190 | 198 | 0 | 0 | 265,278 | 1.83 |
| 2002 | 164,635 | 0 | 801 | 77,048 | 0 | 90,865 | 0 | 67,652 [a] | 1,354 | 2,330 | 329 | 0 | 0 | 240,378 | 1.46 |
| 2003 | 180,687 | 0 | 996 | 76,950 | 0 | 115,515 | 70 | 86,835 | 300 | 3,268 | 43 | 61 | 0 | 284,036 | 1.57 |
| 2004 | 287,178 | 0 | 196 | 46,546 | 0 | 76,442 | 842 | 40,712 | 0 | 1,768 | 43 | 13 [a] | 12 [a] | 166,576 | 0.58 |
| 2005 | 275,598 | 0 | 542 | 37,652 | 0 | 49,730 | 67 | 42,194 | 340 | 7,813 [a] | 270 [a] | 13 [a] | 12 [a] | 138,634 | 0.50 |
| 2006 | 214,004 | 0 | 169 | 24,509 | 0 | 51,306 | 116 | | | | | | | | |
| 2007 | 174,943 | 0 | 178 | 36,998 | 0 | | | | | | | | | | |
| 2008 | 128,978 | 0 | 157 | | | | | | | | | | | | |
| 2009 | 118,478 | | | | | | | | | | | | | | |
| 2010 | 49,073 | | | | | | | | | | | | | | |
| 2011 | 72,097 | | | | | | | | | | | | | | |

[a] Interpolated as the average return for that age. Information prior to the 1976 brood year not included in the average.

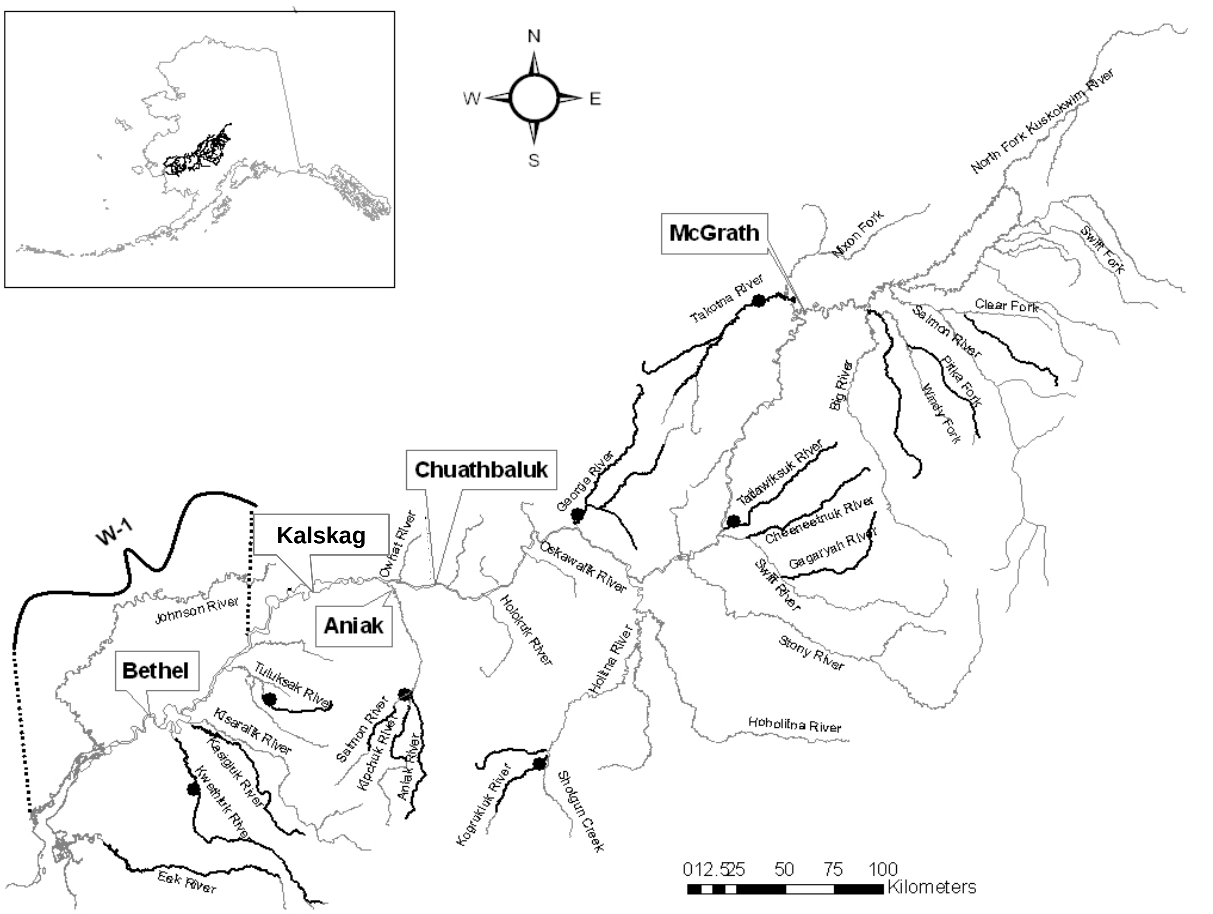
[b] Interpolated using sibling relationships.

Table 5.–Total estimated Chinook salmon escapement obtained from the run reconstruction, monitored escapement counted past weirs, and the percent of the total estimated escapement that was monitored, Kuskokwim River, Alaska.

| | Escapement | | Percent | | Escapement | | Percent |
|---|---|---|---|---|---|---|---|
| Year | Estimated [a] | Monitored [b] | Monitored | Year | Estimated [a] | Monitored [b] | Monitored |
| 1976 | 143,420 | 5,600 | 3.9% | 1994 | 242,616 | 18,144 | 7.5% |
| 1977 | 201,852 | | | 1995 | 225,595 | 20,651 | 9.2% |
| 1978 | 180,853 | 13,667 | 7.6% | 1996 | 197,092 | 29,752 | 15.1% |
| 1979 | 157,668 | 11,338 | 7.2% | 1997 | 211,247 | 32,717 | 15.5% |
| 1980 | 203,605 | | | 1998 | 113,627 | 12,107 | 10.7% |
| 1981 | 279,392 | 16,809 | 6.0% | 1999 | 112,082 | 10,608 | 9.5% |
| 1982 | 80,353 | 10,993 | 13.7% | 2000 | 65,180 | 10,972 | 16.8% |
| 1983 | 84,188 | 3,025 | 3.6% | 2001 | 145,232 | 16,336 | 11.2% |
| 1984 | 99,062 | 4,928 | 5.0% | 2002 | 164,635 | 24,949 | 15.2% |
| 1985 | 94,365 | 4,625 | 4.9% | 2003 | 180,687 | 34,063 | 18.9% |
| 1986 | 58,556 | 5,038 | 8.6% | 2004 | 287,178 | 58,232 | 20.3% |
| 1987 | 89,222 | | | 2005 | 275,598 | 31,924 | 11.6% |
| 1988 | 80,055 | 8,520 | 10.6% | 2006 | 214,004 | 44,672 | 20.9% |
| 1989 | 115,704 | 11,940 | 10.3% | 2007 | 174,943 | 33,693 | 19.3% |
| 1990 | 100,614 | 10,214 | 10.2% | 2008 | 128,978 | 19,888 | 15.4% |
| 1991 | 105,589 | 8,547 | 8.1% | 2009 | 118,478 | 20,854 | 17.6% |
| 1992 | 153,573 | 17,513 | 11.4% | 2010 | 49,073 | 9,805 | 20.0% |
| 1993 | 169,816 | 14,551 | 8.6% | 2011 | 72,097 | 13973 | 19.4% |

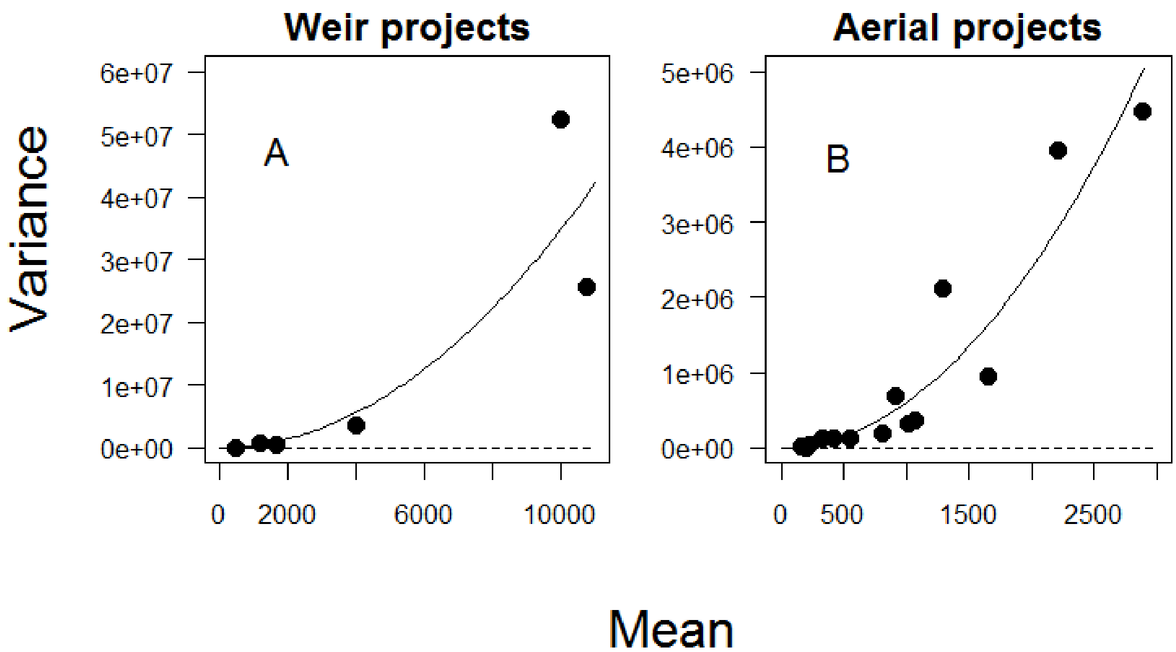
[a] Estimated escapement obtained from the run reconstruction.

[b] Total number of fish counted past the weirs operating for that year.



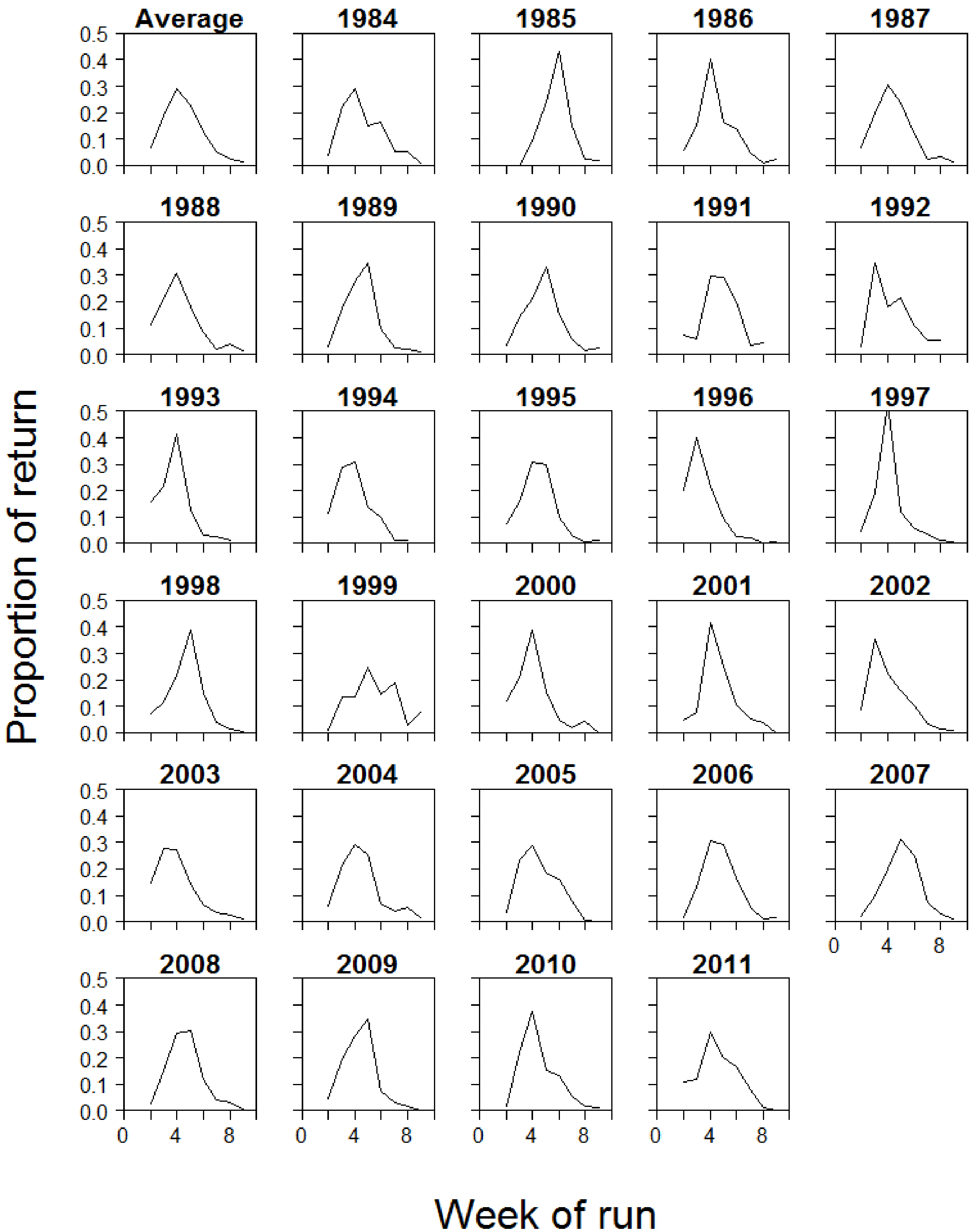

*Note*: Black dots show the location of the enumeration weirs, bold river segments represent systems monitored by aerial surveys, the bracket indicates the location of the W-1 fishing district, and some major communities are shown in text boxes.

Figure 1.–Map of the study area from which data were obtained for the Kuskokwim River Chinook salmon run reconstruction project.



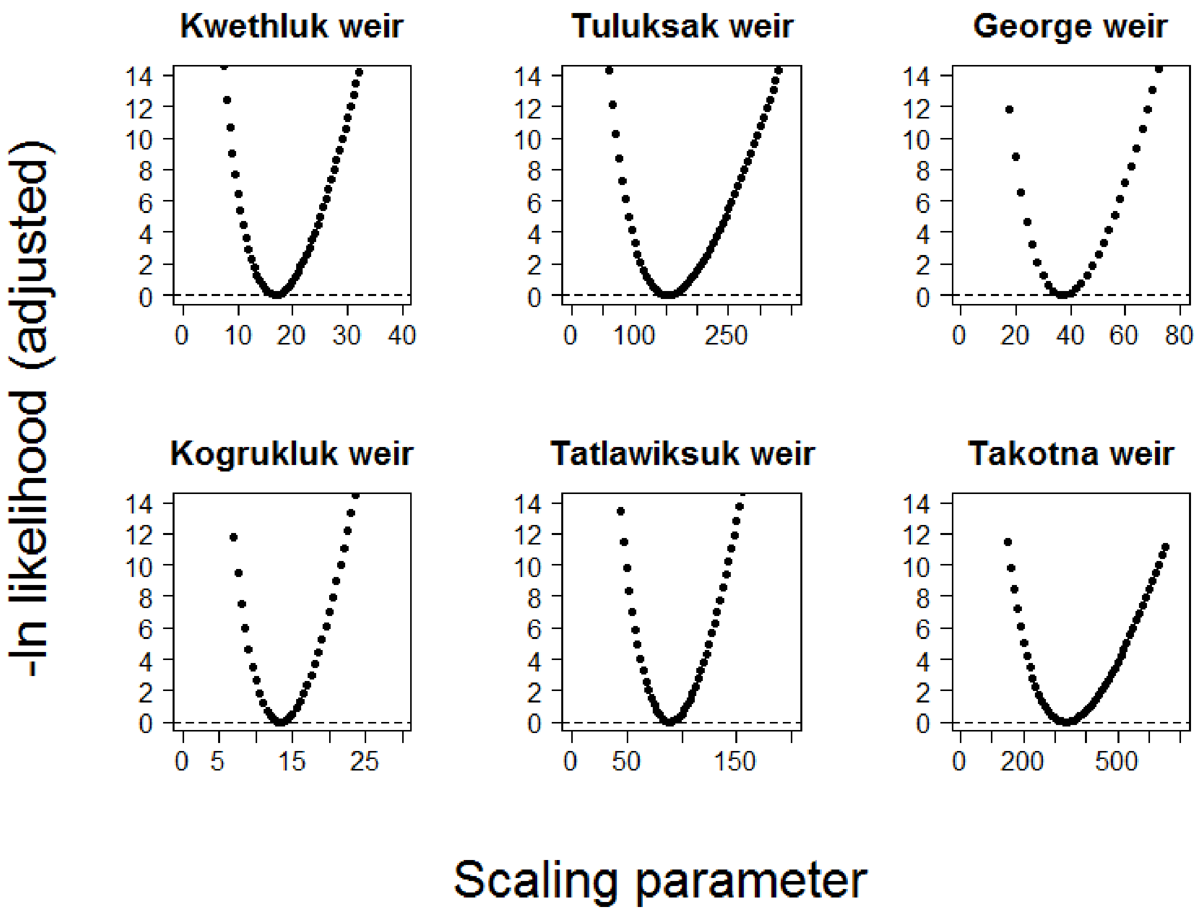

*Note*: Dashed lines show where the means (μ) and variances (var{Y}) are equal for these projects. Solid lines are the least squares fit of var{Y} = μ+0.349μ2 for weir projects (A) and var{Y} = μ+0.599μ2 for aerial projects (B).

Figure 2.–Comparison of mean and variance estimates for weir (A) and aerial (B) projects.



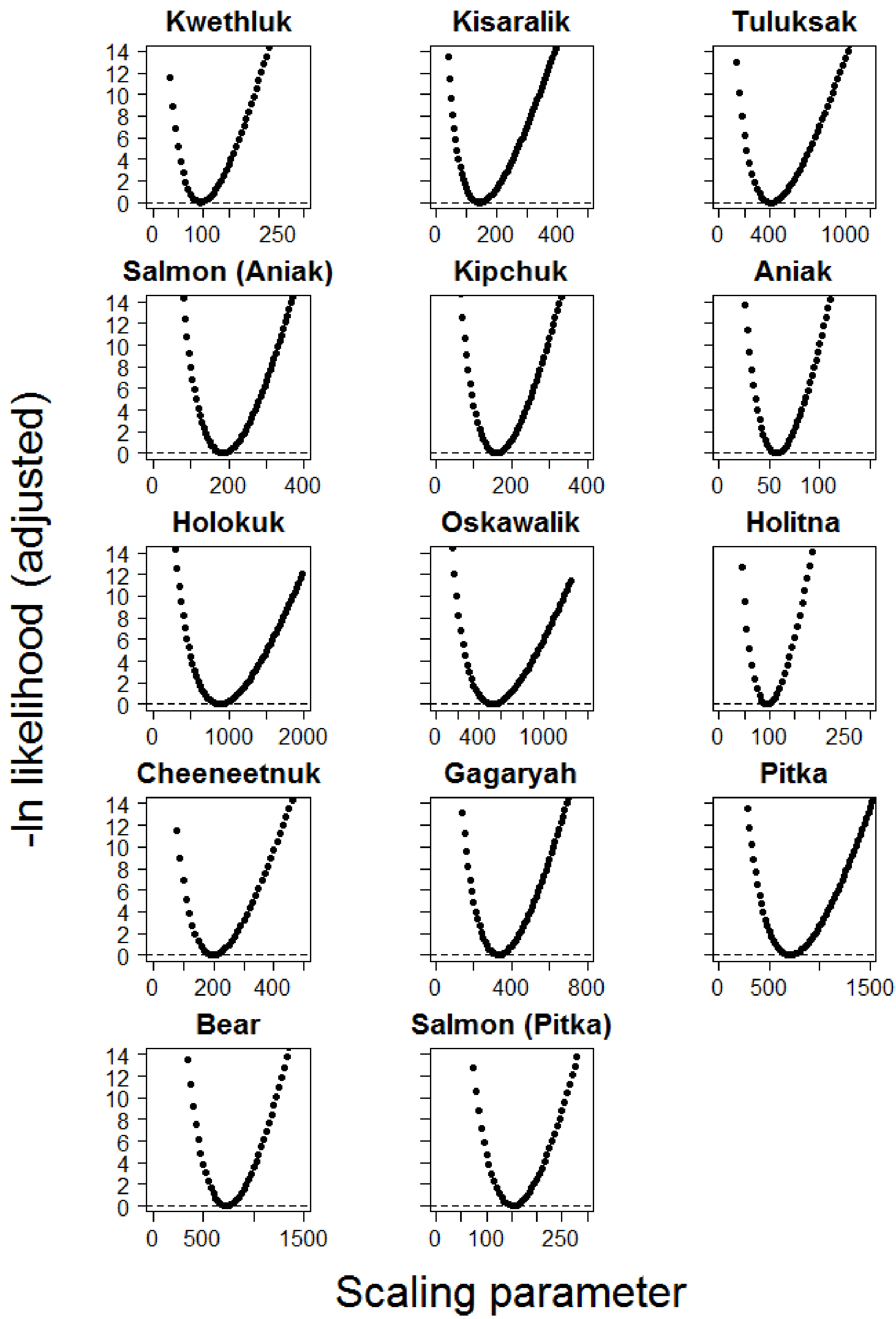

*Note*: Week of Run is described in Appendix A5 with Week 4 beginning on June 17 each year.

Figure 3.–Average and year specific run timing of Chinook salmon in the W1 commercial fishing district of the Kuskokwim River, Alaska, as estimated by the Bethel test fishery from 1984 through 2011.



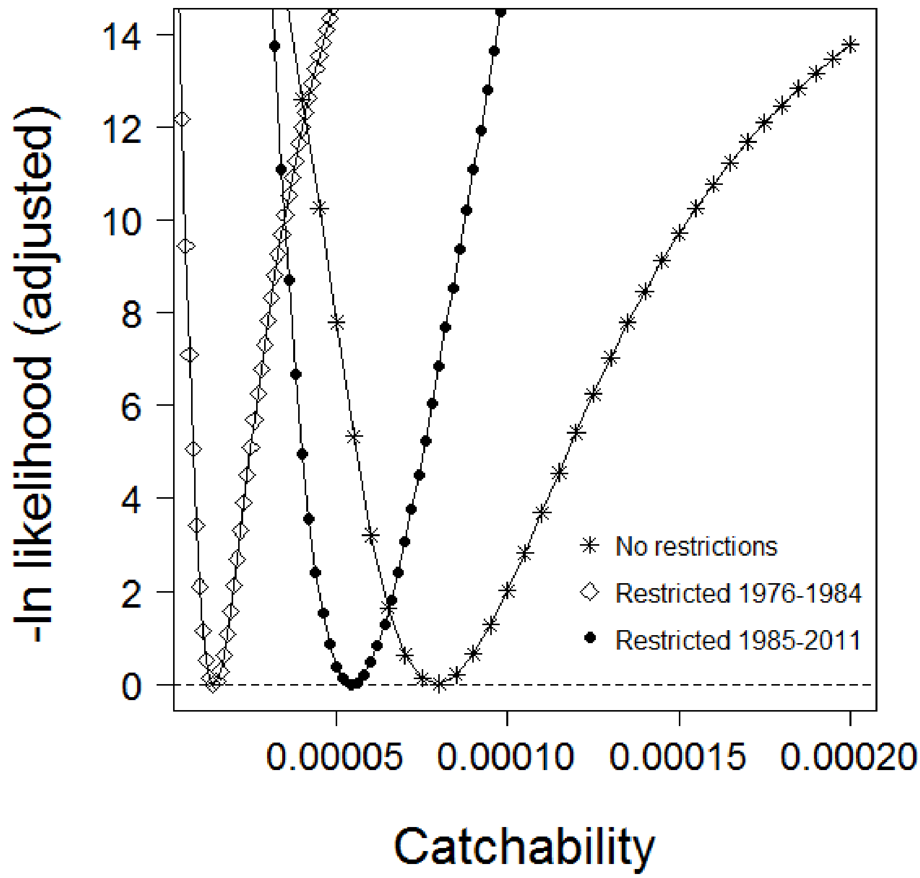

*Note*: The negative log likelihood scale was adjusted such that the minimum value was zero.

Figure 4.–Negative log likelihood profiles for the escapement scaling factor ($\hat{k}_i$) used to expand total weir counts of Chinook salmon in the Kuskokwim River drainage.



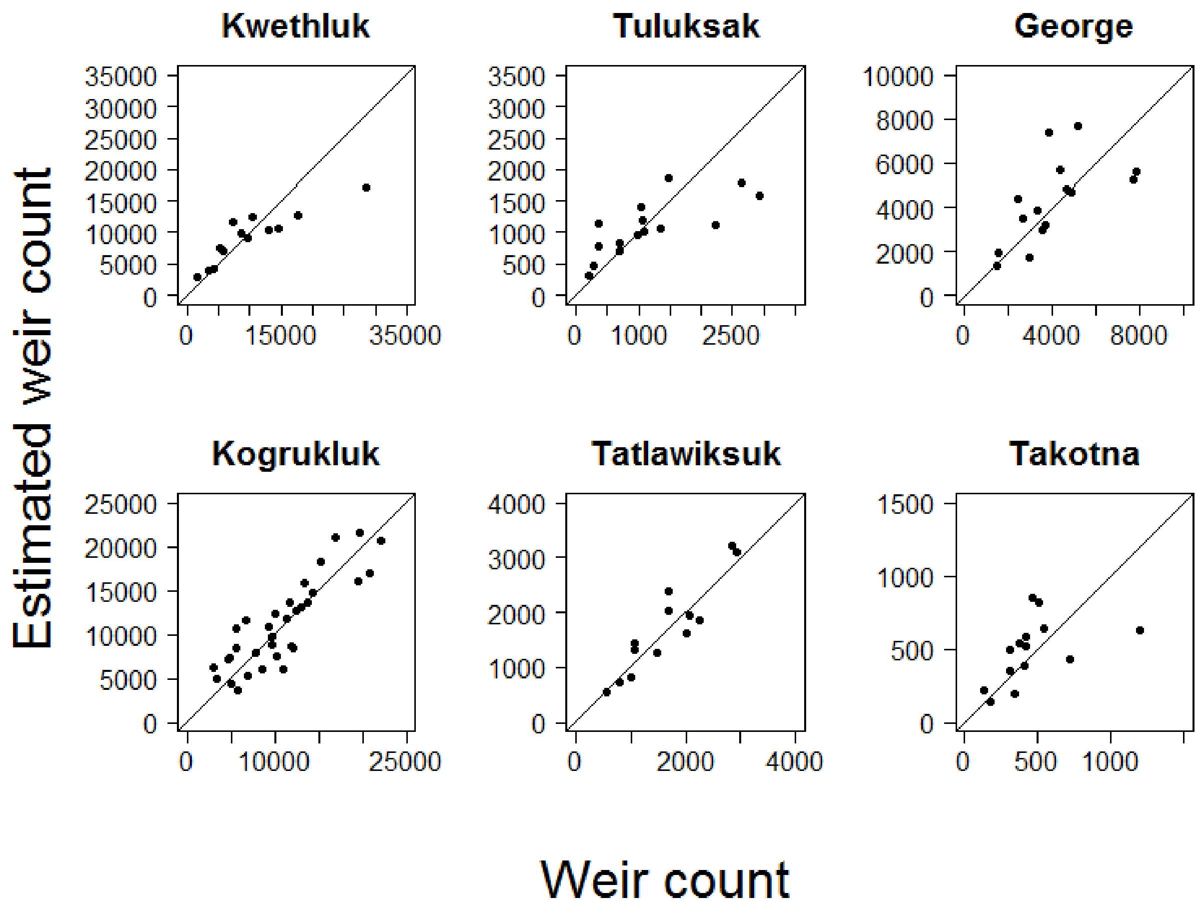

*Note*: The negative log likelihood scale was adjusted such that the minimum value was zero.

Figure 5.–Negative log likelihood profiles of the escapement scaling factors ($\hat{k}_a$) used to expand aerial counts of Chinook salmon in the Kuskokwim River.



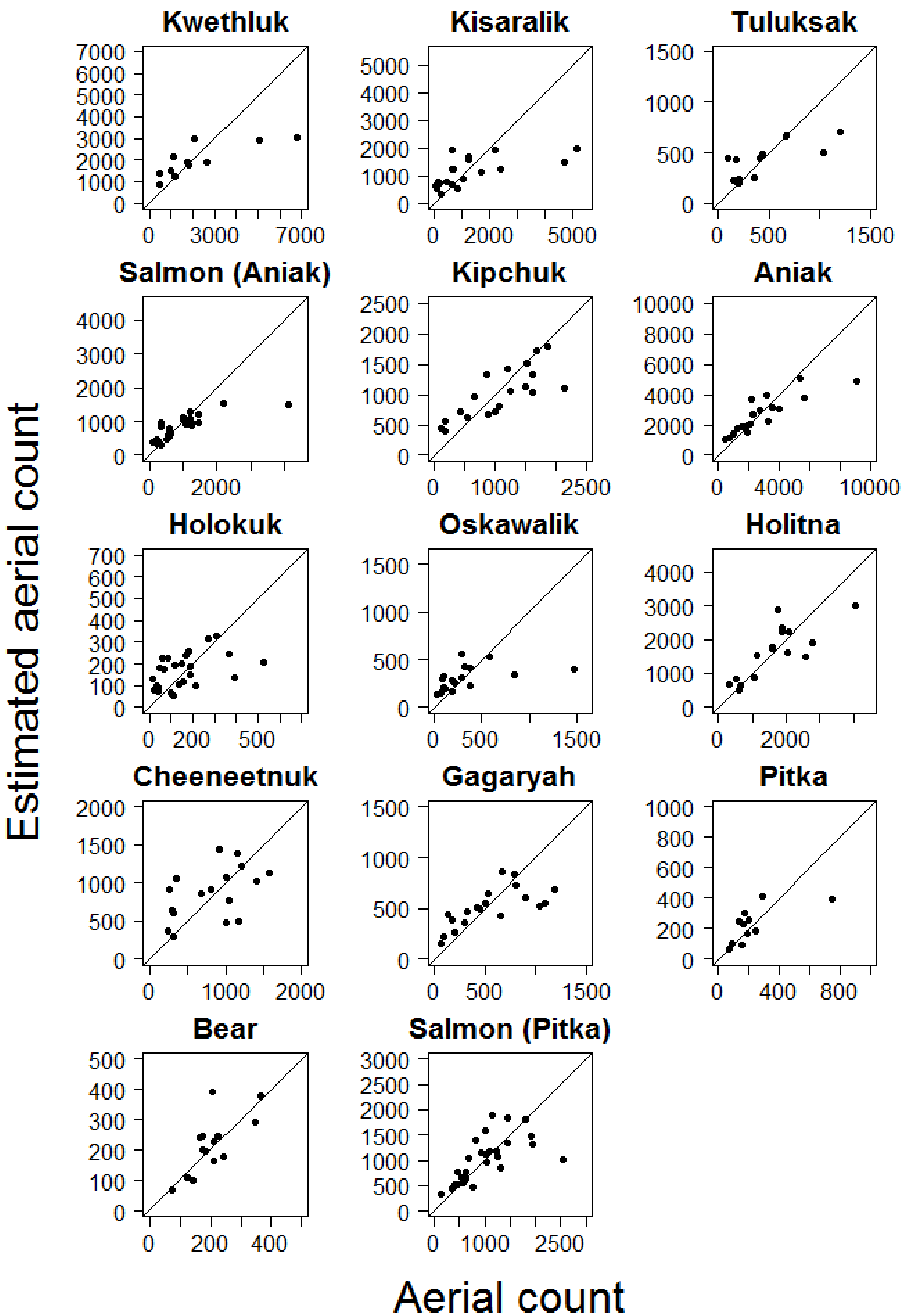

*Note*: The negative log likelihood scale was adjusted such that the minimum value was zero.

Figure 6.–Negative log likelihood profiles of the catchability parameters estimated for each of the three strata of the commercial harvest component of the model to reconstruct the Chinook salmon run to the Kuskokwim River.



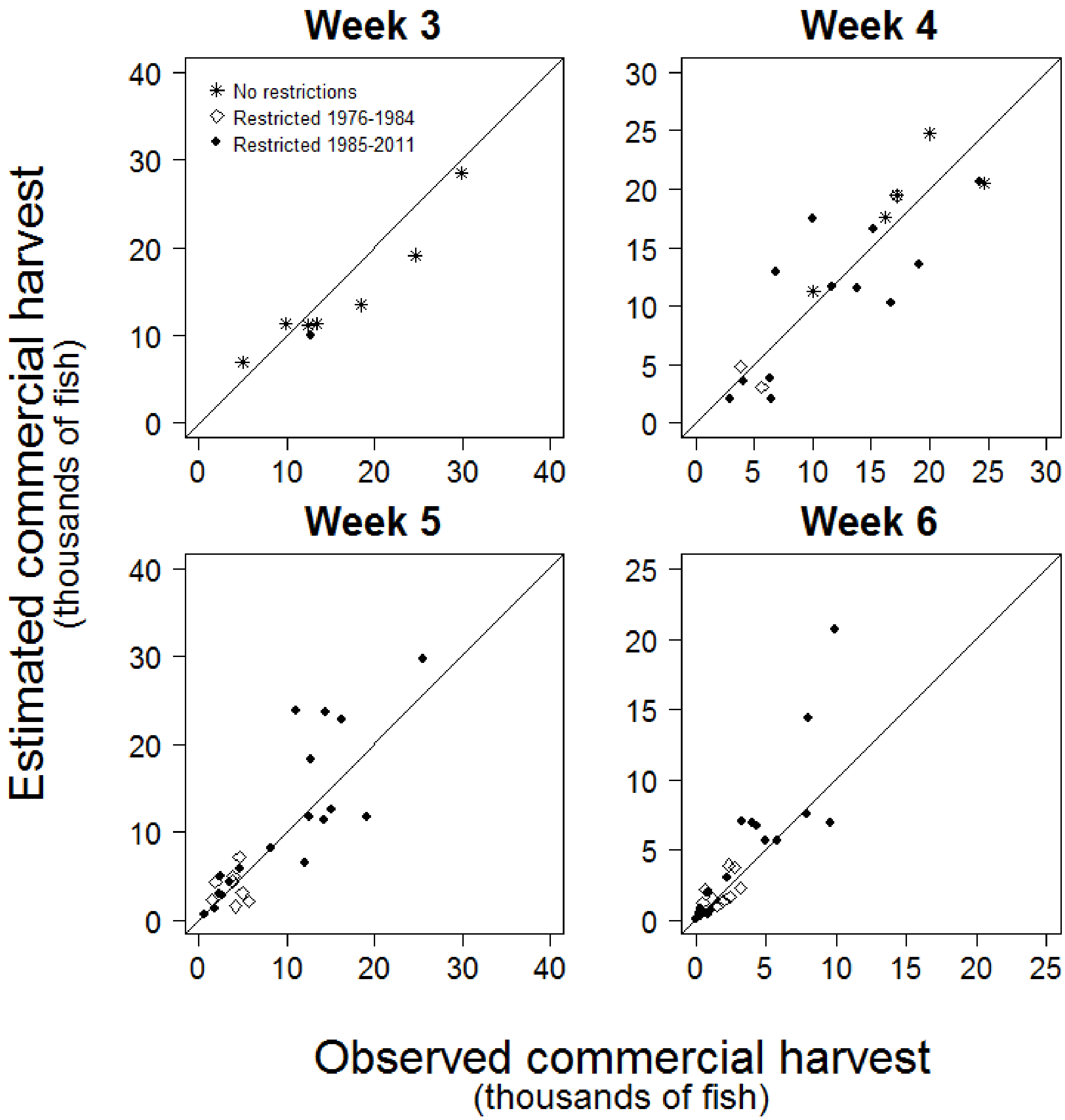

*Note*: The solid lines are where estimated counts are the same as actual counts.

Figure 7.–Comparison of the estimated weir count obtained from the run reconstruction model to actual weir counts obtained from the individual weir projects for Chinook salmon returning to the Kuskokwim River.



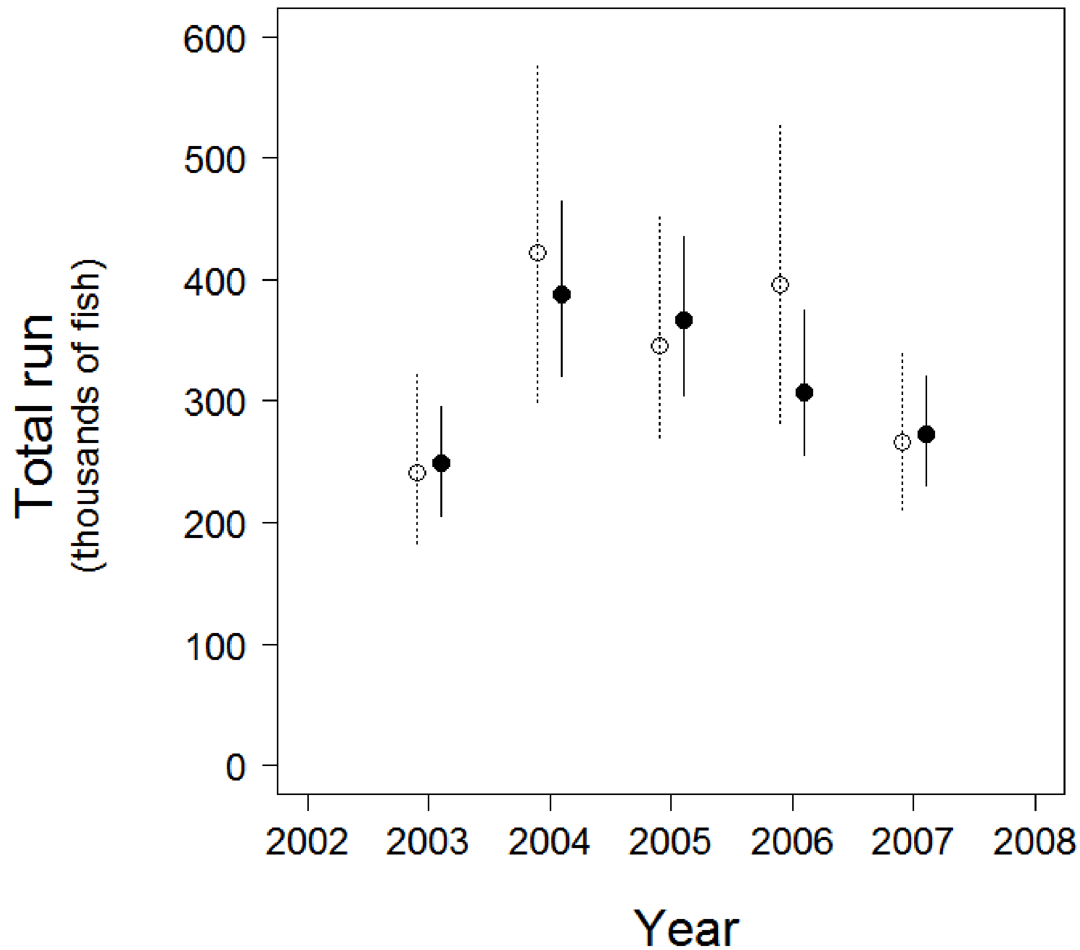

*Note*: The solid lines are where estimated counts are the same as actual counts.

Figure 8.–Comparison of the estimated aerial count obtained from the run reconstruction model to actual aerial survey observations from individual streams for Chinook salmon returning to the Kuskokwim River.



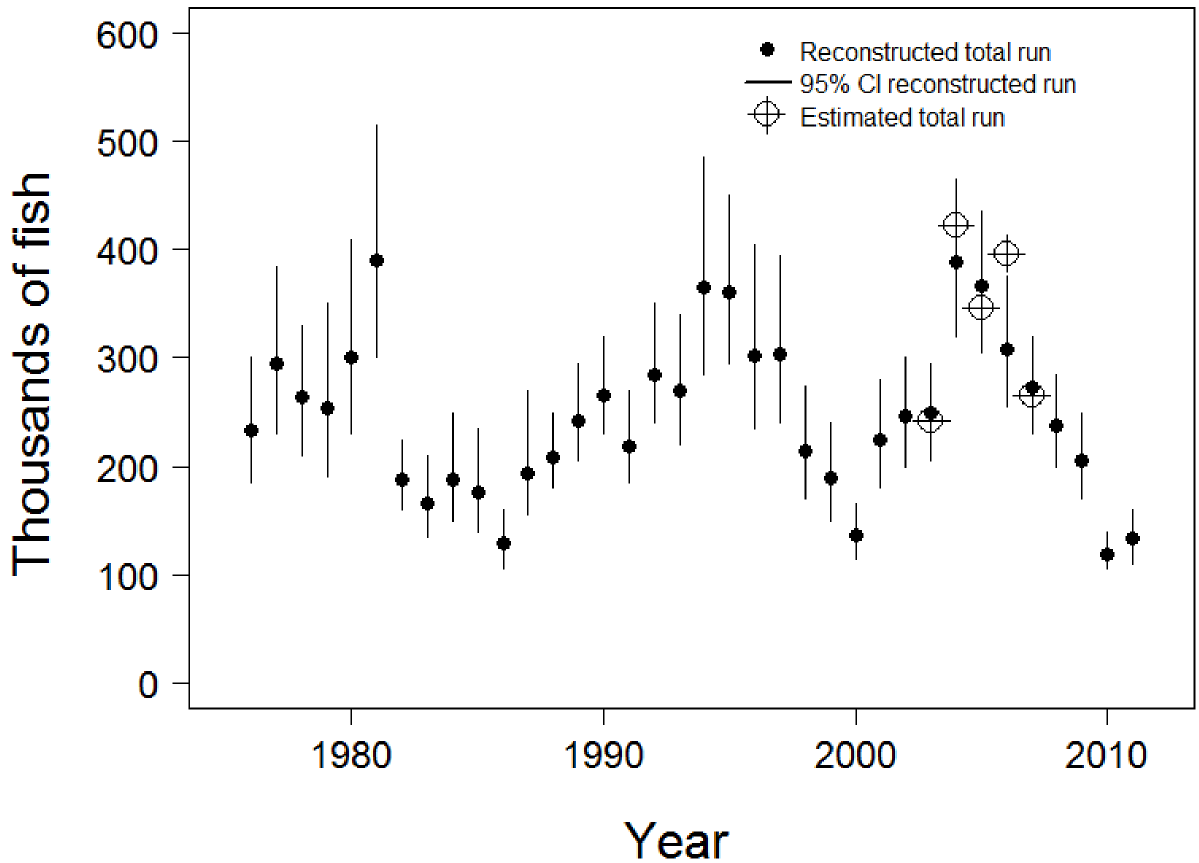

*Note*: The solid lines are where estimated counts are the same as actual counts. Weeks are described in Appendix A5 with Week 4 beginning on June 17 each year.

Figure 9.–Comparison of the estimates of commercial harvest obtained from the run reconstruction model to the observed commercial harvest of Chinook salmon harvested in District W1 of the Kuskokwim River.




*Note*: The open points and dashed lines are the Schaberg et al. (2012) estimates and corresponding 95% confidence intervals, while the solid points and lines are the run reconstruction estimates and corresponding 95% confidence intervals.

Figure 10.–Comparison of the estimates of total run obtained from the run reconstruction model to the corresponding estimates made by Schaberg et al. (2012) for Chinook salmon returning to the Kuskokwim River.




*Note*: Confidence bounds are presented for the reconstructed total run.

Figure 11.–Estimates of the total run of Chinook salmon returning to the Kuskokwim River, Alaska, obtained from the run reconstruction model and the estimates of total run from Schaberg et al. (2012).

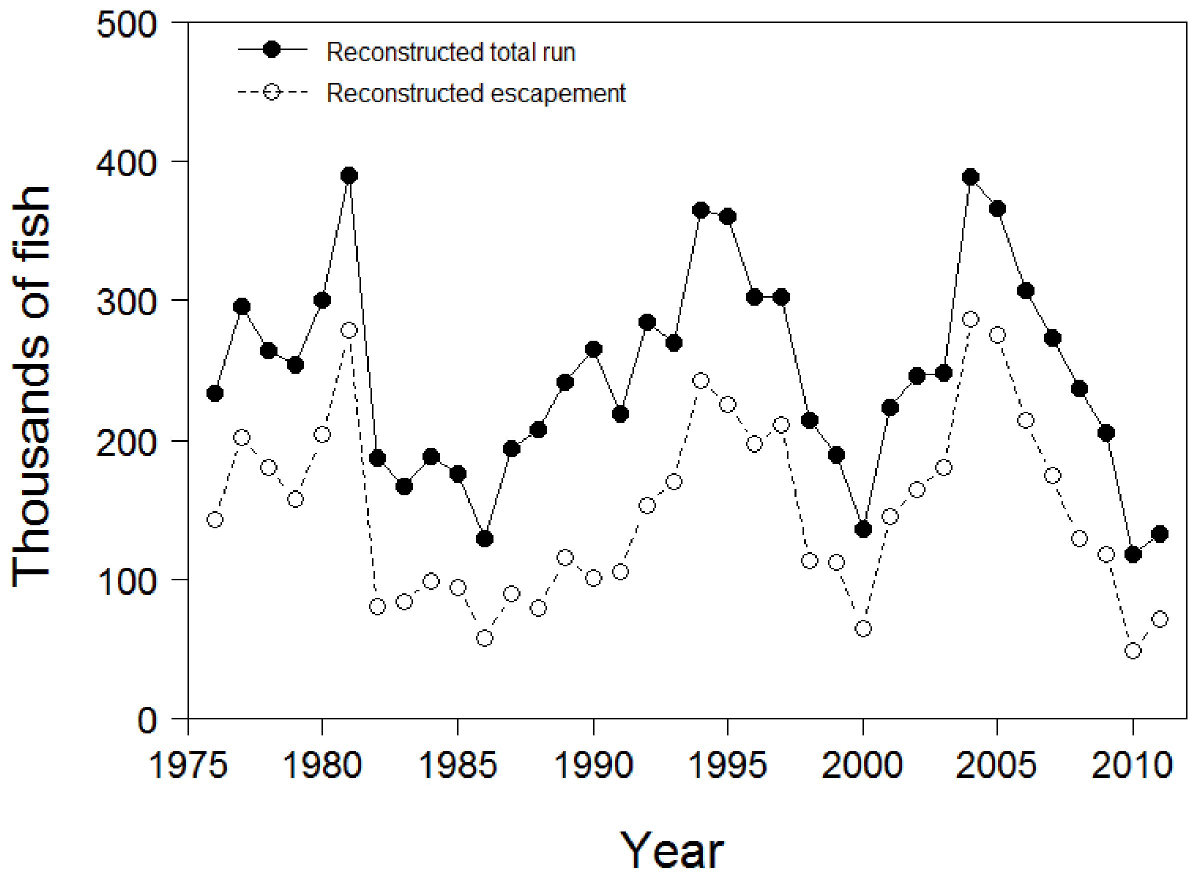



Figure 12.–Estimates of the total run and escapement of Chinook salmon returning to the Kuskokwim River, Alaska, from 1976 through 2011, obtained from the run reconstruction model.

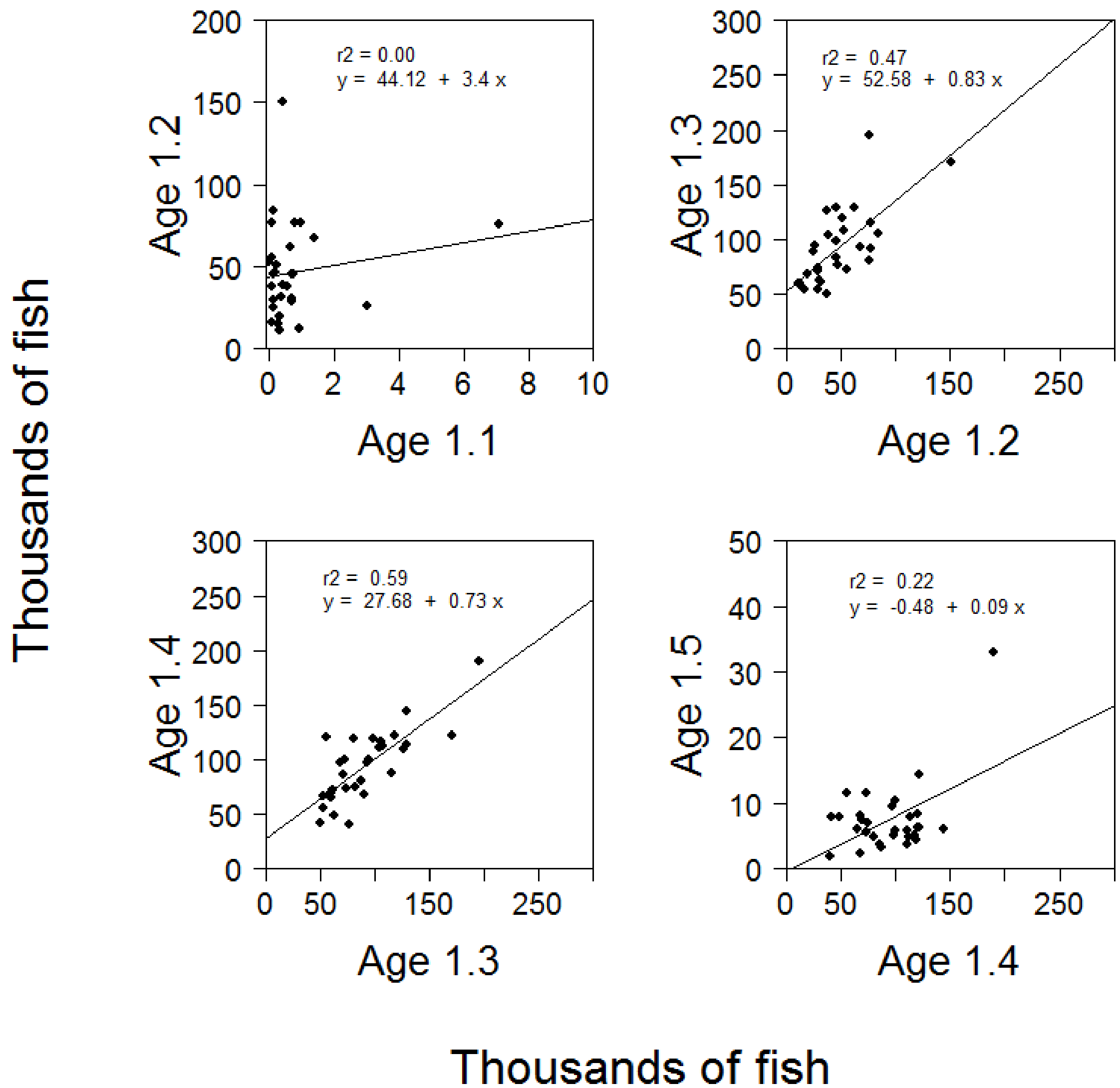
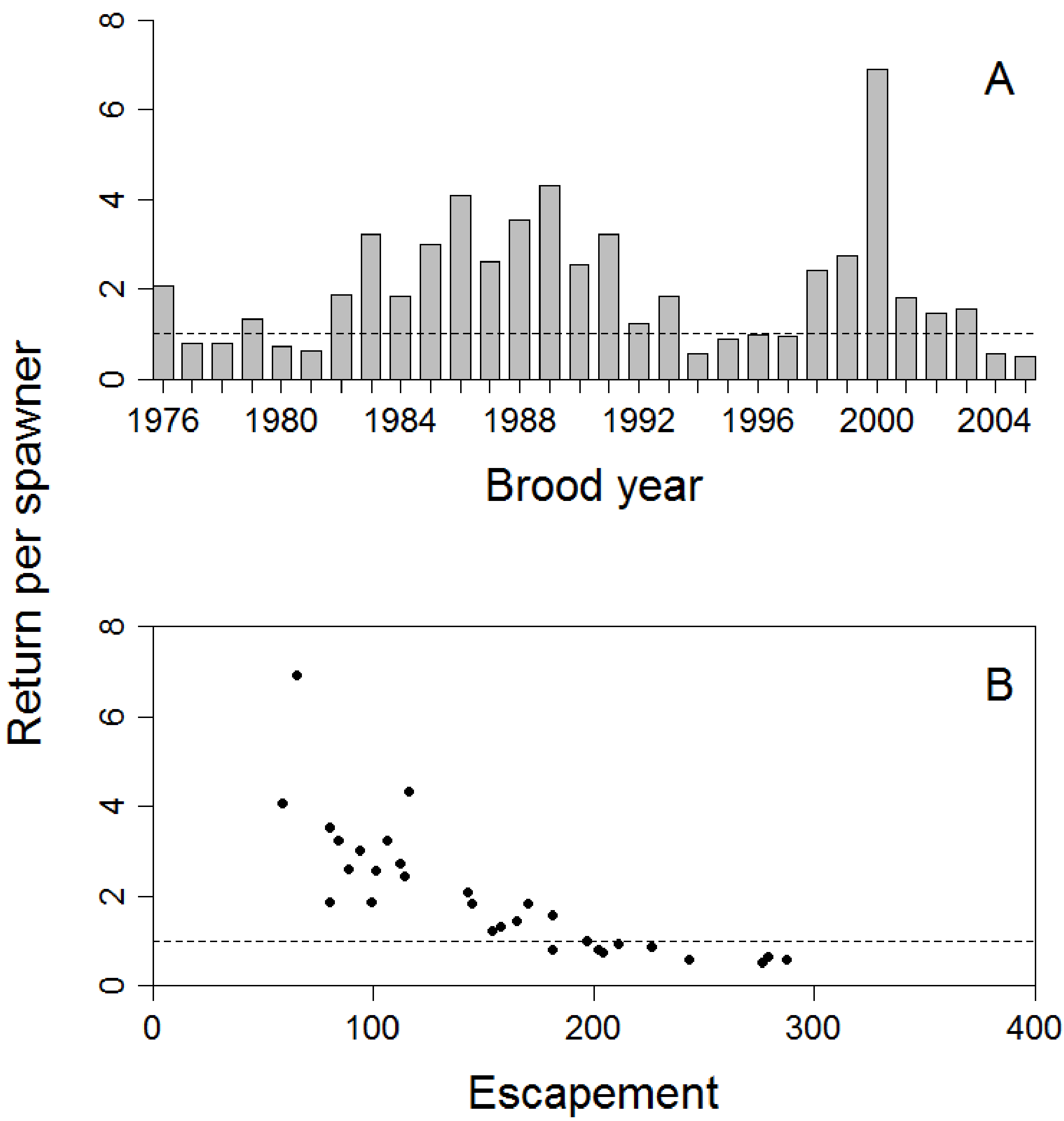



Figure 13.–Sibling relationships for Chinook salmon returning to the Kuskokwim River, Alaska.




*Note*: The horizontal dashed line is at a return per spawner value of 1.0, the level of return at which the number of fish that escape to spawn produce an equal number of returning fish.

Figure 14.–Return per spawner by year (A) and level of escapement (B) for the Chinook salmon population returning to the Kuskokwim River, Alaska.

# APPENDIX A: SUPPORTING INFORMATION

Appendix A1.–Total inriver abundance of Chinook salmon in the Kuskokwim River, 2003 through 2007.

| Component | Year | | | | | |
|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
| Abundance Upstream of Birch Tree Crossing | - | 125,235 | 224,519 | 174,317 | 245,043 | 130,279 |
| Escapement Downstream of Birch Tree Crossing | 33,171 | 53,864 | 105,118 | 87,051 | 65,034 | 46,925 |
| Lower Kuskokwim River Harvest | | | | | | |
| Subsistence [a] | 72,932 | 61,550 | 89,172 | 78,533 | 82,598 | 87,053 |
| Commercial [b] | 72 | 158 | 2,300 | 4,784 | 2,777 | 179 |
| Bethel Test Fishery [b] | 288 | 409 | 691 | 557 | 352 | 305 |
| Sport [c] | 319 | 401 | 857 | 572 | 444 | 1,478 |
| Total Harvest | 73,611 | 62,518 | 93,020 | 84,446 | 86,171 | 89,015 |
| Total Inriver Abundance | - | 241,617 | 422,657 | 345,814 | 396,248 | 266,219 |
| Lower 95% CI | | 182,710 | 298,728 | 270,560 | 281,847 | 211,280 |
| Upper 95% CI | | 326,202 | 577,993 | 453,516 | 528,218 | 340,445 |

*Source*: Schaberg et al. 2012.

*Note*: Abundance was estimated by combining harvest estimates and estimates derived from mark–recapture and habitat model techniques.

[a] Subsistence harvest includes all villages from Kalskag downstream to the mouth of the Kuskokwim River, plus the north Kuskokwim Bay village of Kongiganak. Source for subsistence data is Hamazaki (2011).

[b] Source for commercial and Bethel test fishery data is Bavilla et al. (2010).

[c] Sport harvest data from a personal communication with John Chythlook, Sport Fish Biologist, ADF&G; Fairbanks.

Appendix A2.–Harvests and escapements of Chinook salmon returning to the Kuskokwim River, Alaska, 1976 to 2011.

| | Harvest | | | | Weir | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Subsistence | Commercial | Sport | Test fishery | Kwethluk | Tuluksak | George | Kogrukluk | Tatlawiksuk | Takotna |
| 1976 | 58,606 | 30,735 | | 1,206 | | | | 5,600 | | |
| 1977 | 56,580 | 35,830 | 33 | 1,264 | | | | | | |
| 1978 | 36,270 | 45,641 | 116 | 1,445 | | | | 13,667 | | |
| 1979 | 56,283 | 38,966 | 74 | 979 | | | | 11,338 | | |
| 1980 | 59,892 | 35,881 | 162 | 1,033 | | | | | | |
| 1981 | 61,329 | 47,663 | 189 | 1,218 | | | | 16,809 | | |
| 1982 | 58,018 | 48,234 | 207 | 542 | | | | 10,993 | | |
| 1983 | 47,412 | 33,174 | 420 | 1,139 | | | | 3,025 | | |
| 1984 | 56,930 | 31,742 | 273 | 231 | | | | 4,928 | | |
| 1985 | 43,874 | 37,889 | 85 | 79 | | | | 4,625 | | |
| 1986 | 51,019 | 19,414 | 49 | 130 | | | | 5,038 | | |
| 1987 | 67,325 | 36,179 | 355 | 384 | | | | | | |
| 1988 | 70,943 | 55,716 | 528 | 576 | | | | 8,520 | | |
| 1989 | 81,175 | 43,217 | 1,218 | 543 | | | | 11,940 | | |
| 1990 | 109,778 | 53,504 | 394 | 512 | | | | 10,214 | | |
| 1991 | 74,820 | 37,778 | 401 | 117 | | 697 | | 7,850 | | |
| 1992 | 82,654 | 46,872 | 367 | 1,380 | 9,675 | 1,083 | | 6,755 | | |
| 1993 | 87,684 | 8,735 | 587 | 2,483 | | 2,218 | | 12,333 | | |
| 1994 | 103,343 | 16,211 | 1,139 | 1,937 | | 2,917 | | 15,227 | | |
| 1995 | 102,110 | 30,846 | 541 | 1,421 | | | | 20,651 | | |
| 1996 | 96,413 | 7,419 | 1,432 | 247 | 7,415 | | 7,716 | 14,199 | | 422 |
| 1997 | 79,381 | 10,441 | 1,788 | 332 | 10,395 | | 7,834 | 13,285 | | 1,203 |
| 1998 | 81,213 | 17,359 | 1,464 | 210 | | | | 12,107 | | |
| 1999 | 72,775 | 4,705 | 279 | 98 | | | 3,548 | 5,570 | 1,490 | |
| 2000 | 70,825 | 444 | 105 | 64 | 3,547 | | 2,960 | 3,310 | 810 | 345 |
| 2001 | 78,009 | 90 | 290 | 86 | | 998 | 3,309 | 9,298 | 2,010 | 721 |
| 2002 | 80,982 | 72 | 319 | 288 | 8,502 | 1,346 | 2,444 | 10,104 | 2,237 | 316 |
| 2003 | 67,134 | 158 | 401 | 409 | 14,474 | 1,064 | 4,693 | 11,771 | 1,683 | 378 |
| 2004 | 97,110 | 2,300 | 857 | 691 | 28,604 | 1,475 | 5,207 | 19,651 | 2,833 | 462 |
| 2005 | 85,090 | 4,784 | 572 | 557 | | 2,653 | 3,845 | 22,000 | 2,920 | 506 |
| 2006 | 90,085 | 2,777 | 444 | 352 | 17,618 | 1,043 | 4,357 | 19,414 | 1,700 | 540 |
| 2007 | 96,155 | 179 | 1,478 | 305 | 12,927 | 374 | 4,883 | 13,029 | 2,061 | 419 |
| 2008 | 98,103 | 8,865 | 708 | 420 | 5,275 | 701 | 2,698 | 9,730 | 1,071 | 413 |
| 2009 | 78,231 | 6,664 | 904 | 470 | 5,744 | 362 | 3,663 | 9,702 | 1,071 | 312 |
| 2010 | 66,056 | 2732 | 354 | 292 | 1,669 | 201 | 1,500 | 5,690 | 567 | 178 |
| 2011 | 59,245 | 748 | 633 | 337 | 4,079 | 284 | 1,571 | 6,891 | 1,012 | 136 |

Appendix A3.–Peak aerial survey counts of Chinook Salmon returning to drainages of the Kuskokwim River, Alaska, 1976 to 2011.

| Year | Kwethluk | Kisaralik | Tuluksak | Salmon (Aniak) | Kipchuk | Aniak | Holokuk | Oskawalik | Holitna | Cheeneetnuk | Gagaryah | Pitka | Bear | Salmon (Pitka) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 997 | | | | | | | | 2,571 | | 663 | | 182 | |
| 1977 | 1,116 | | 439 | | | | 60 | | | 1,407 | 897 | | | 1,940 |
| 1978 | 1,722 | 2,417 | 403 | 322 | | | | | 2,766 | 268 | 504 | | 227 | 1,100 |
| 1979 | | | | | | | 45 | | | | | | | 682 |
| 1980 | | | 1,035 | 1,186 | | | | | | | | | | 1,450 |
| 1981 | 2,034 | 672 | | | | 9,074 | | | | | | | | 1,439 |
| 1982 | 471 | 81 | | | | | 42 | | 521 | | | | 123 | 413 |
| 1983 | | | 202 | 231 | | 1,909 | 33 | | 1,069 | | | | | 572 |
| 1984 | | | | | | | | | | 1,177 | | | | 545 |
| 1985 | | 63 | 142 | | | | 135 | | | 1,002 | | | | 620 |
| 1986 | | | | 336 | | 424 | 100 | | 650 | 317 | | | | |
| 1987 | | | | 516 | 193 | | 210 | 193 | | | 205 | | | |
| 1988 | | 869 | 188 | 244 | | 954 | | 80 | | | | | | 473 |
| 1989 | 1,157 | 152 | | 631 | 994 | 2,109 | | | | | | | | 452 |
| 1990 | | 631 | 200 | 596 | 537 | 1,255 | 157 | 113 | | | | | | |
| 1991 | | 217 | 358 | 583 | 885 | 1,564 | | | | | | | | |
| 1992 | | | | 335 | 670 | 2,284 | 64 | 91 | 2,022 | 1,050 | 328 | | | 2,536 |
| 1993 | | | | 1,082 | 1,248 | 2,687 | 114 | 103 | 1,573 | 678 | 419 | | | 1,010 |
| 1994 | | 1,243 | | 1,218 | 1,520 | | | | | 1,206 | 807 | | | 1,010 |
| 1995 | | 1,243 | | 1,446 | 1,215 | 3,171 | 181 | 326 | 1,887 | 1,565 | 1,193 | | | 1,911 |
| 1996 | | | | 985 | | | 85 | | | | | | | |
| 1997 | | | | 980 | 855 | 2,187 | 165 | 1,470 | 2,093 | 345 | | | | |
| 1998 | | 457 | | 557 | 443 | 1,930 | | | | | | | | |
| 1999 | | | | | | | 18 | 98 | | | | | | |
| 2000 | | | | 238 | 182 | 714 | 42 | | 301 | | | 151 | | 362 |
| 2001 | | | | 598 | | | | 186 | 1,130 | | 143 | | 175 | 1,033 |
| 2002 | 1,795 | 1,727 | | 1,236 | 1,615 | | 186 | 295 | 1,578 | | 452 | 165 | 211 | 1,255 |
| 2003 | 2,628 | 654 | 94 | 1,242 | 1,493 | 3,514 | 528 | 844 | | 810 | 1,095 | 197 | 176 | 1,241 |
| 2004 | 6,801 | 5,157 | 1,196 | 2,177 | 1,868 | 5,362 | 306 | 293 | 4,051 | 918 | 670 | 290 | 206 | 1,138 |
| 2005 | 5,059 | 2,206 | 672 | 4,097 | 1,679 | | 268 | 582 | 1,760 | 1,155 | 788 | 744 | 367 | 1,801 |
| 2006 | | 4,734 | | | 1,618 | 5,639 | 365 | 386 | 1,866 | 1,015 | 531 | 170 | 347 | 833 |
| 2007 | | 692 | 173 | 1,458 | 2,147 | 3,984 | 146 | | | | 1,035 | 131 | 165 | 921 |
| 2008 | 487 | 1,074 | | 589 | 1,061 | 3,222 | 190 | 213 | | 290 | 177 | 242 | 245 | 1,305 |
| 2009 | | | | | | | 390 | 379 | | 323 | 303 | 187 | 209 | 632 |
| 2010 | | 235 | | | | | 108 | | 587 | | 62 | 67 | 75 | 135 |
| 2011 | | | | 79 | 116 | | 20 | 26 | | 249 | 96 | 85 | 145 | 767 |

Appendix A4.–Harvest and effort data for Chinook salmon in commercial fishing district W1 by week and year, Kuskokwim River, Alaska, 1976 to 2011.

| | Week 3 6/10 - 6/16 | | Week 4 6/17 - 6/23 | | Week 5 6/24 - 6/30 | | Week 6 7/1 - 7/7 | | Week 7 7/8 - 7/14 | | Week 8 7/15 - 7/21 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Catch | Effort | Catch | Effort | Catch | Effort | Catch | Effort | Catch | Effort | Catch | Effort |
| 1976 | 0 | 0 | 20,010 | 5,724 [a] | 4,143 | 2,088 [b] | 1,550 | 2,490 [b] | 1,238 | 4,548 [b] | 236 | 1,590 [b] |
| 1977 | 12,458 | 2,802 [a] | 16,227 | 2,904 [a] | 1,841 | 4,722 [b] | 673 | 4,194 [b] | 153 | 2,310 [b] | 0 | 0 |
| 1978 | 18,483 | 3,972 [a] | 10,066 | 2,004 [a] | 3,723 | 5,346 [b] | 2,354 | 8,676 [b] | 987 | 7,668 [b] | 0 | 0 |
| 1979 | 24,633 | 6,432 [a] | 5,651 | 3,012 [b] | 3,860 | 6,438 [b] | 1,233 | 3,252 [b] | 470 | 3,120 [b] | 0 | 0 |
| 1980 | 9,891 | 2,814 [a] | 21,698 | 5,364 [d] | 1,460 | 2,448 [b] | 498 | 2,298 [b] | 445 | 2,586 [b] | 0 | 0 |
| 1981 | 29,882 | 6,180 [a] | 3,830 | 3,066 [b] | 4,563 | 5,952 [b] | 2,795 | 5,520 [b] | 941 | 2,640 [b] | 0 | 0 |
| 1982 | 4,912 | 2,784 [a] | 24,628 | 5,970 [a] | 12,555 | 5,176 [d] | 1,970 | 3,968 [b] | 1,055 | 4,734 [b] | 0 | 0 |
| 1983 | 13,406 | 5,634 [a] | 8,063 | 5,544 [b] | 4,925 | 5,958 [b] | 2,415 | 5,634 [b] | 633 | 2,796 [b] | 0 | 0 |
| 1984 | 0 | 0 | 17,181 | 5,562 [a] | 5,643 | 5,616 [b] | 3,206 | 5,454 [b] | 2,069 | 5,592 [b] | 744 | 2,238 [b] |
| 1985 | 0 | 0 | 6,519 | 2,538 [c] | 19,204 | 5,880 [c] | 9,942 | 5,844 [c] | 0 | 0 | 0 | 0 |
| 1986 | 0 | 0 | 0 | 0 | 11,986 | 6,540 [c] | 5,029 | 6,852 [c] | 1,156 | 3,192 [c] | 0 | 0 |
| 1987 | 0 | 0 | 19,126 | 4,734 [c] | | | 9,606 | 6,948 [c] | 1,910 | 3,582 [c] | 2,758 | 6,720 [c] |
| 1988 | 12,640 | 4,816 [c] | 11,708 | 3,672 [c] | 15,060 | 7,518 [c] | 5,871 | 6,954 [c] | 5,270 | 10,794 [c] | 1,728 | 6,636 [c] |
| 1989 | 0 | 0 | 15,215 | 5,208 [c] | 11,094 | 6,144 [c] | 7,911 | 7,092 [c] | 6,043 | 10,962 [c] | 868 | 2,622 [c] |
| 1990 | 0 | 0 | 16,690 | 3,780 [c] | 25,459 | 7,536 [c] | 4,071 | 3,546 [c] | 4,931 | 8,534 [c] | 0 | 0 |
| 1991 | 0 | 0 | 13,813 | 3,606 [c] | 12,612 | 3,696 [c] | 8,068 | 7,308 [c] | 904 | 3,426 [c] | 452 | 3,408 [c] |
| 1992 | 0 | 0 | 24,334 | 9,488 [c] | 16,307 | 8,628 [c] | 3,250 | 4,696 [c] | 0 | 0 | 0 | 0 |
| 1993 | 0 | 0 | 0 | 0 | 8,184 | 4,976 [c] | 0 | 0 | 0 | 0 | 0 | 0 |
| 1994 | 0 | 0 | 0 | 0 | 14,221 | 4,608 [c] | 0 | 0 | 578 | 1,984 [c] | 441 | 3,000 [c] |
| 1995 | 0 | 0 | 6,895 | 2,276 [c] | 14,424 | 4,532 [c] | 4,368 | 3,824 [c] | 1,452 | 3,716 [c] | 568 | 3,488 [c] |
| 1996 | 0 | 0 | 4,091 | 1,056 [c] | 666 | 360 [c] | 861 | 836 [c] | 408 | 896 [c] | 251 | 1,195 [c] |
| 1997 | 0 | 0 | 10,023 | 2,118 [c] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1998 | 0 | 0 | 0 | 0 | 12,771 | 4,584 [c] | 2,277 | 1,780 [c] | 1,127 | 1,668 [c] | 0 | 0 |
| 1999 | 0 | 0 | 0 | 0 | 4,668 | 2,454 [c] | 0 | 0 | 0 | 0 | 0 | 0 |
| 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 357 | 896 [c] | 0 | 0 | 0 | 0 |
| 2001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 0 | 0 | 0 | 0 | 520 | 104 [c] | 1,107 | 446 [c] | 0 | 0 | 0 | 0 |
| 2005 | 0 | 0 | 0 | 0 | 3,531 | 1,189 [c] | 874 | 604 [c] | 0 | 0 | 0 | 0 |
| 2006 | 0 | 0 | 0 | 0 | 2,493 | 1,038 [c] | 0 | 0 | 0 | 0 | 0 | 0 |
| 2007 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 0 | 0 | 6,415 | 1,026 [c] | 2,362 | 783 [c] | 19 | 4 [c] | 1 | 6 [c] | 0 | 6 [c] |
| 2009 | 0 | 0 | 3,003 | 668 [c] | 2,539 | 752 [c] | 762 | 519 [c] | 113 | 436 [c] | 83 | 672 [c] |
| 2010 | 0 | 0 | 0 | 0 | 1,724 | 1,324 [c] | 290 | 522 [c] | 271 | 686 [c] | 186 | 958 [c] |
| 2011 | 0 | 0 | 0 | 0 | 0 | 0 | 361 | 634 [c] | 227 | 996 [c] | 129 | 1,226 [c] |

*Note*: Effort is estimated as the number of permits fished times the number of hours the fishery was open; week is described in Appendix A5.

[a] Unrestricted fishery, large mesh gear allowed.

[b] Restricted fishery, gill net mesh size restricted to 6 inches or less.

[c] Restricted fishery, gill net mesh size restricted to 6 inches or less; 1985–2011.

[d] Both unrestricted and restricted openings during this week. The information was not used in the run reconstruction model.

Appendix A5.–Dates used for grouping commercial and test fishery data into weekly intervals for the estimation of run timing.

| Week Number | Date Range |
|---|---|
| 1 | May 27 – June 2 |
| 2 | June 3 – June 9 |
| 3 | June 10 – June 16 |
| 4 | June 17 – June 23 |
| 5 | June 24 – June 30 |
| 6 | July 1 – July 7 |
| 7 | July 8 – July 14 |
| 8 | July 15 – July 21 |
| 9 | July 22 – July 28 |
| 10 | July 29 – August 4 |
| 11 | August 5 – August 11 |
| 12 | August 12 – August 18 |
| 13 | August 19 – August 25 |
| 14 | August 26 – September 1 |

Appendix A6.–Reconstructed run by year, harvest, escapement, and age for Chinook salmon returning to the Kuskokwim River, Alaska, 1976 to 2011.

| Run Year | | Age Class 0.2 | 1.1 | 1.2 | 2.1 | 1.3 | 2.2 | 1.4 | 2.3 | 1.5 | 2.4 | 1.6 | 2.5 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | Commercial | Age data not available | | | | | | | | | | | | 30,735 |
| | Subsistence | 0 | 70 | 4,627 | 0 | 23,419 | 24 | 28,144 | 78 | 2,170 | 57 | 5 | 0 | 58,606 |
| | Sport | Age data not available | | | | | | | | | | | | |
| | Test fishery | Age data not available | | | | | | | | | | | | 1,206 |
| | Total Harvest | No estimate made due to limited age information | | | | | | | | | | | | 90,547 |
| | Total Escapement | 0 | 0 | 10,900 | 0 | 58,372 | 0 | 72,857 | 0 | 574 | 0 | 0 | 0 | 143,420 |
| | Total | No estimate made due to limited harvest age information | | | | | | | | | | | | 233,967 |
| 1977 | Commercial | 0 | 0 | 251 | 0 | 11,179 | 0 | 23,397 | 0 | 1,003 | 0 | 0 | 0 | 35,830 |
| | Subsistence | 0 | 68 | 4,467 | 0 | 22,610 | 24 | 27,171 | 75 | 2,095 | 55 | 5 | 0 | 56,580 |
| | Sport | Age data not available | | | | | | | | | | | | 33 |
| | Test fishery | Age data not available | | | | | | | | | | | | 1,264 |
| | Total Harvest | 0 | 69 | 4,784 | 0 | 34,263 | 24 | 51,278 | 76 | 3,142 | 56 | 5 | 0 | 93,707 |
| | Total Escapement | Age data not available | | | | | | | | | | | | 201,852 |
| | Total | No estimate made due to limited escapement age information | | | | | | | | | | | | 295,559 |
| 1978 | Commercial | 0 | 0 | 91 | 0 | 5,842 | 0 | 37,517 | 0 | 2,191 | 0 | 0 | 0 | 45,641 |
| | Subsistence | 0 | 43 | 2,863 | 0 | 14,494 | 15 | 17,418 | 48 | 1,343 | 35 | 3 | 0 | 36,270 |
| | Sport | Age data not available | | | | | | | | | | | | 116 |
| | Test fishery | Age data not available | | | | | | | | | | | | 1,445 |
| | Total Harvest | 0 | 44 | 3,011 | 0 | 20,723 | 15 | 55,982 | 49 | 3,601 | 36 | 3 | 0 | 83,472 |
| | Total Escapement | 0 | 362 | 30,745 | 0 | 18,990 | 0 | 100,916 | 2,532 | 5,426 | 21,883 | 0 | 0 | 180,853 |
| | Total | 0 | 406 | 33,756 | 0 | 39,713 | 15 | 156,898 | 2,581 | 9,027 | 21,919 | 3 | 0 | 264,325 |
| 1979 | Commercial | Age data not available | | | | | | | | | | | | 38,966 |
| | Subsistence | 0 | 68 | 4,443 | 0 | 22,491 | 23 | 27,028 | 75 | 2,084 | 35 | 5 | 0 | 56,283 |
| | Sport | Age data not available | | | | | | | | | | | | 74 |
| | Test fishery | Age data not available | | | | | | | | | | | | 979 |
| | Total Harvest | No estimate made due to limited age information | | | | | | | | | | | | 96,302 |
| | Total Escapement | 0 | 0 | 104,376 | 0 | 22,704 | 0 | 25,700 | 0 | 4,888 | 21,883 | 0 | 0 | 157,668 |
| | Total | No estimate made due to limited harvest age information | | | | | | | | | | | | 253,970 |
| 1980 | Commercial | 0 | 0 | 3,911 | 0 | 23,359 | 0 | 7,427 | 0 | 1,148 | 0 | 0 | 0 | 35,881 |
| | Subsistence | 0 | 72 | 4,728 | 0 | 23,933 | 25 | 28,762 | 79 | 2,218 | 59 | 5 | 0 | 59,892 |
| | Sport | Age data not available | | | | | | | | | | | | 162 |
| | Test fishery | Age data not available | | | | | | | | | | | | 1,033 |
| | Total Harvest | 0 | 73 | 8,747 | 0 | 47,882 | 25 | 36,640 | 80 | 3,408 | 59 | 6 | 0 | 96,968 |
| | Total Escapement | Age data not available | | | | | | | | | | | | 203,605 |
| | Total | No estimate made due to limited escapement age information | | | | | | | | | | | | 300,573 |

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| Run Year | | Age Class 0.2 | 1.1 | 1.2 | 2.1 | 1.3 | 2.2 | 1.4 | 2.3 | 1.5 | 2.4 | 1.6 | 2.5 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | Commercial | 0 | 0 | 3,670 | 0 | 19,304 | 0 | 23,117 | 0 | 1,573 | 0 | 0 | 0 | 47,663 |
| | Subsistence | 0 | 74 | 4,842 | 0 | 24,507 | 26 | 29,452 | 81 | 2,271 | 60 | 6 | 0 | 61,329 |
| | Sport | Age data not available | | | | | | | | | | | | 189 |
| | Test fishery | Age data not available | | | | | | | | | | | | 1,218 |
| | Total Harvest | 0 | 75 | 8,622 | 0 | 44,376 | 26 | 53,247 | 82 | 3,894 | 61 | 6 | 0 | 110,388 |
| | Total Escapement | 0 | 838 | 20,675 | 0 | 84,656 | 0 | 162,327 | 0 | 10,896 | 0 | 0 | 0 | 279,392 |
| | Total | 0 | 913 | 29,297 | 0 | 129,032 | 26 | 215,574 | 82 | 14,790 | 61 | 6 | 0 | 389,780 |
| 1982 | Commercial | 0 | 68 | 2,189 | 0 | 11,209 | 0 | 33,146 | 0 | 1,558 | 63 | 0 | 0 | 48,234 |
| | Subsistence | 0 | 70 | 4,580 | 0 | 23,184 | 24 | 27,862 | 77 | 2,149 | 57 | 5 | 0 | 58,018 |
| | Sport | Age data not available | | | | | | | | | | | | 207 |
| | Test fishery | Age data not available | | | | | | | | | | | | 542 |
| | Total Harvest | 0 | 139 | 6,817 | 0 | 34,636 | 24 | 61,438 | 78 | 3,733 | 121 | 5 | 0 | 106,990 |
| | Total Escapement | 0 | 0 | 5,143 | 0 | 18,883 | 0 | 51,989 | 0 | 4,339 | 0 | 0 | 0 | 80,353 |
| | Total | 0 | 139 | 11,960 | 0 | 53,519 | 24 | 113,427 | 78 | 8,072 | 121 | 5 | 0 | 187,344 |
| 1983 | Commercial | 0 | 498 | 7,000 | 0 | 6,469 | 0 | 17,317 | 0 | 1,692 | 199 | 0 | 0 | 33,174 |
| | Subsistence | 0 | 57 | 3,743 | 0 | 18,946 | 20 | 22,768 | 63 | 1,756 | 46 | 4 | 0 | 47,412 |
| | Sport | Age data not available | | | | | | | | | | | | 420 |
| | Test fishery | Age data not available | | | | | | | | | | | | 1,139 |
| | Total Harvest | 0 | 565 | 10,950 | 0 | 25,907 | 20 | 40,861 | 64 | 3,514 | 250 | 4 | 0 | 82,145 |
| | Total Escapement | Age data not available | | | | | | | | | | | | 84,188 |
| | Total | No estimate made due to limited escapement age information | | | | | | | | | | | | 166,333 |
| 1984 | Commercial | 0 | 222 | 3,904 | 32 | 12,379 | 127 | 11,649 | 413 | 2,571 | 444 | 0 | 0 | 31,742 |
| | Subsistence | 0 | 68 | 4,494 | 0 | 22,750 | 24 | 27,339 | 76 | 2,108 | 56 | 5 | 0 | 56,930 |
| | Sport | Age data not available | | | | | | | | | | | | 273 |
| | Test fishery | Age data not available | | | | | | | | | | | | 231 |
| | Total Harvest | 0 | 292 | 8,446 | 32 | 35,329 | 152 | 39,210 | 491 | 4,706 | 503 | 5 | 0 | 89,166 |
| | Total Escapement | 0 | 75 | 22,240 | 0 | 47,083 | 0 | 26,150 | 0 | 3,439 | 0 | 75 | 0 | 99,062 |
| | Total | 0 | 367 | 30,686 | 32 | 82,411 | 152 | 65,360 | 491 | 8,145 | 503 | 80 | 0 | 188,228 |
| 1985 | Commercial | 0 | 265 | 13,072 | 0 | 11,139 | 152 | 11,897 | 0 | 1,364 | 0 | 0 | 0 | 37,889 |
| | Subsistence | 0 | 53 | 3,464 | 0 | 17,532 | 18 | 21,069 | 58 | 1,625 | 43 | 4 | 0 | 43,874 |
| | Sport | Age data not available | | | | | | | | | | | | 85 |
| | Test fishery | Age data not available | | | | | | | | | | | | 79 |
| | Total Harvest | 0 | 318 | 16,569 | 0 | 28,729 | 170 | 33,033 | 58 | 2,995 | 43 | 4 | 0 | 81,919 |
| | Total Escapement | 0 | 0 | 15,247 | 0 | 33,643 | 0 | 42,359 | 0 | 3,019 | 0 | 97 | 0 | 94,365 |
| | Total | 0 | 318 | 31,815 | 0 | 62,372 | 170 | 75,392 | 58 | 6,014 | 43 | 101 | 0 | 176,284 |

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| Run | | Age Class | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | | 0.2 | 1.1 | 1.2 | 2.1 | 1.3 | 2.2 | 1.4 | 2.3 | 1.5 | 2.4 | 1.6 | 2.5 | Total |
| 1986 | Commercial | 0 | 427 | 2,427 | 0 | 10,969 | 0 | 4,698 | 0 | 893 | 0 | 0 | 0 | 19,414 |
| | Subsistence | 0 | 61 | 4,028 | 0 | 20,387 | 21 | 24,501 | 68 | 1,889 | 50 | 5 | 0 | 51,019 |
| | Sport | | | | | Age data not available | | | | | | | | 49 |
| | Test fishery | | | | | Age data not available | | | | | | | | 130 |
| | Total Harvest | 0 | 490 | 6,471 | 0 | 31,436 | 21 | 29,273 | 68 | 2,789 | 50 | 5 | 0 | 70,603 |
| | Total Escapement | 0 | 257 | 5,037 | 0 | 29,817 | 0 | 19,206 | 0 | 4,239 | 0 | 0 | 0 | 58,556 |
| | Total | 0 | 747 | 11,508 | 0 | 61,253 | 21 | 48,479 | 68 | 7,029 | 50 | 5 | 0 | 129,158 |
| 1987 | Commercial | 0 | 0 | 17,076 | 0 | 5,680 | 0 | 12,916 | 0 | 543 | 0 | 0 | 0 | 36,179 |
| | Subsistence | 0 | 81 | 5,315 | 0 | 26,903 | 28 | 32,331 | 89 | 2,493 | 66 | 6 | 0 | 67,325 |
| | Sport | | | | | Age data not available | | | | | | | | 355 |
| | Test fishery | | | | | Age data not available | | | | | | | | 384 |
| | Total Harvest | 0 | 81 | 22,551 | 0 | 32,816 | 28 | 45,570 | 90 | 3,058 | 66 | 6 | 0 | 104,243 |
| | Total Escapement | | | | | Age data not available | | | | | | | | 89,222 |
| | Total | | | | | No estimate made due to limited escapement age information | | | | | | | | 193,465 |
| 1988 | Commercial | 0 | 0 | 17,216 | 0 | 24,515 | 0 | 10,642 | 0 | 3,343 | 0 | 0 | 0 | 55,716 |
| | Subsistence | 0 | 85 | 5,601 | 0 | 28,349 | 30 | 34,068 | 94 | 2,627 | 69 | 6 | 0 | 70,943 |
| | Sport | | | | | Age data not available | | | | | | | | 528 |
| | Test fishery | | | | | Age data not available | | | | | | | | 576 |
| | Total Harvest | 0 | 86 | 23,016 | 0 | 53,325 | 30 | 45,100 | 95 | 6,022 | 70 | 7 | 0 | 127,750 |
| | Total Escapement | 0 | 0 | 5,524 | 0 | 44,671 | 0 | 24,337 | 0 | 5,524 | 0 | 0 | 0 | 80,055 |
| | Total | 0 | 86 | 28,540 | 0 | 97,996 | 30 | 69,437 | 95 | 11,546 | 70 | 7 | 0 | 207,805 |
| 1989 | Commercial | 0 | 0 | 14,305 | 0 | 10,718 | 1,513 | 12,879 | 605 | 2,247 | 951 | 0 | 0 | 43,217 |
| | Subsistence | 0 | 97 | 6,408 | 0 | 32,438 | 34 | 38,982 | 108 | 3,006 | 79 | 7 | 0 | 81,175 |
| | Sport | | | | | Age data not available | | | | | | | | 1,218 |
| | Test fishery | | | | | Age data not available | | | | | | | | 543 |
| | Total Harvest | 0 | 99 | 21,006 | 0 | 43,767 | 1,568 | 52,595 | 723 | 5,328 | 1,045 | 7 | 0 | 126,138 |
| | Total Escapement | 0 | 0 | 17,009 | 0 | 29,273 | 0 | 67,340 | 0 | 2,083 | 0 | 0 | 0 | 115,704 |
| | Total | 0 | 99 | 38,015 | 0 | 73,040 | 1,568 | 119,935 | 723 | 7,410 | 1,045 | 7 | 0 | 241,842 |
| 1990 | Commercial | 0 | 0 | 22,151 | 0 | 20,197 | 0 | 9,303 | 0 | 1,854 | 0 | 0 | 0 | 53,504 |
| | Subsistence | 0 | 132 | 8,666 | 0 | 43,868 | 46 | 52,718 | 146 | 4,065 | 107 | 10 | 0 | 109,778 |
| | Sport | | | | | Age data not available | | | | | | | | 394 |
| | Test fishery | | | | | Age data not available | | | | | | | | 512 |
| | Total Harvest | 0 | 132 | 30,988 | 0 | 64,420 | 46 | 62,365 | 146 | 5,952 | 108 | 10 | 0 | 164,168 |
| | Total Escapement | 0 | 2,884 | 24,248 | 0 | 61,882 | 0 | 11,307 | 0 | 293 | 0 | 0 | 0 | 100,614 |
| | Total | 0 | 3,016 | 55,236 | 0 | 126,302 | 46 | 73,672 | 146 | 6,245 | 108 | 10 | 0 | 264,782 |

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| Run Year | | Age Class 0.2 | 1.1 | 1.2 | 2.1 | 1.3 | 2.2 | 1.4 | 2.3 | 1.5 | 2.4 | 1.6 | 2.5 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | Commercial | 65 | 0 | 12,479 | 0 | 11,508 | 704 | 10,743 | 554 | 1,050 | 503 | 0 | 171 | 37,778 |
| | Subsistence | 0 | 90 | 5,907 | 0 | 29,898 | 31 | 35,930 | 99 | 2,771 | 73 | 7 | 0 | 74,820 |
| | Sport | | | | | | | Age data not available | | | | | | 401 |
| | Test fishery | | | | | | | Age data not available | | | | | | 117 |
| | Total Harvest | 65 | 90 | 18,471 | 0 | 41,597 | 739 | 46,888 | 657 | 3,839 | 579 | 7 | 171 | 113,102 |
| | Total Escapement | 0 | 0 | 7,563 | 0 | 30,745 | 1,200 | 63,305 | 596 | 1,778 | 262 | 30 | 109 | 105,589 |
| | Total | 65 | 90 | 26,034 | 0 | 72,342 | 1,939 | 110,193 | 1,253 | 5,617 | 841 | 37 | 281 | 218,691 |
| 1992 | Commercial | 0 | 549 | 21,427 | 0 | 12,987 | 111 | 11,266 | 0 | 466 | 66 | 0 | 0 | 46,872 |
| | Subsistence | 0 | 99 | 6,525 | 0 | 33,029 | 35 | 39,692 | 110 | 3,061 | 81 | 8 | 0 | 82,654 |
| | Sport | | | | | | | Age data not available | | | | | | 367 |
| | Test fishery | | | | | | | Age data not available | | | | | | 1,380 |
| | Total Harvest | 0 | 657 | 28,329 | 0 | 46,637 | 147 | 51,646 | 111 | 3,575 | 149 | 8 | 0 | 131,258 |
| | Total Escapement | 0 | 6,431 | 47,819 | 0 | 47,478 | 795 | 48,394 | 142 | 2,214 | 300 | 0 | 0 | 153,573 |
| | Total | 0 | 7,088 | 76,148 | 0 | 94,115 | 942 | 100,040 | 253 | 5,788 | 449 | 8 | 0 | 284,830 |
| 1993 | Commercial | 0 | 0 | 5,381 | 0 | 1,878 | 0 | 839 | 419 | 44 | 87 | 0 | 87 | 8,735 |
| | Subsistence | 0 | 105 | 6,922 | 0 | 35,039 | 37 | 42,108 | 116 | 3,247 | 86 | 8 | 0 | 87,684 |
| | Sport | | | | | | | Age data not available | | | | | | 587 |
| | Test fishery | | | | | | | Age data not available | | | | | | 2,483 |
| | Total Harvest | 0 | 109 | 12,695 | 0 | 38,092 | 38 | 44,314 | 553 | 3,396 | 179 | 8 | 90 | 99,473 |
| | Total Escapement | 0 | 300 | 63,418 | 0 | 42,709 | 149 | 55,456 | 215 | 7,003 | 567 | 0 | 0 | 169,816 |
| | Total | 0 | 409 | 76,113 | 0 | 80,801 | 186 | 99,770 | 768 | 10,399 | 745 | 8 | 90 | 269,289 |
| 1994 | Commercial | 0 | 81 | 2,805 | 0 | 8,154 | 308 | 4,215 | 162 | 324 | 162 | 0 | 0 | 16,211 |
| | Subsistence | 0 | 124 | 8,158 | 0 | 41,296 | 43 | 49,628 | 137 | 3,827 | 101 | 9 | 0 | 103,343 |
| | Sport | | | | | | | Age data not available | | | | | | 1,139 |
| | Test fishery | | | | | | | Age data not available | | | | | | 1,937 |
| | Total Harvest | 0 | 210 | 11,245 | 0 | 50,723 | 360 | 55,228 | 307 | 4,258 | 270 | 10 | 0 | 122,611 |
| | Total Escapement | 73 | 459 | 27,922 | 170 | 144,240 | 1,243 | 64,255 | 1,437 | 1,654 | 1,162 | 0 | 0 | 242,616 |
| | Total | 73 | 670 | 39,167 | 170 | 194,963 | 1,603 | 119,483 | 1,744 | 5,912 | 1,432 | 10 | 0 | 365,227 |
| 1995 | Commercial | 0 | 38 | 10,540 | 0 | 4,914 | 0 | 15,101 | 0 | 252 | 0 | 0 | 0 | 30,846 |
| | Subsistence | 0 | 122 | 8,061 | 0 | 40,804 | 43 | 49,036 | 135 | 3,781 | 100 | 9 | 0 | 102,110 |
| | Sport | | | | | | | Age data not available | | | | | | 541 |
| | Test fishery | | | | | | | Age data not available | | | | | | 1,421 |
| | Total Harvest | 0 | 163 | 18,876 | 0 | 46,393 | 43 | 65,083 | 137 | 4,093 | 101 | 9 | 0 | 134,899 |
| | Total Escapement | 0 | 0 | 43,104 | 0 | 57,564 | 0 | 124,198 | 156 | 424 | 150 | 0 | 0 | 225,595 |
| | Total | 0 | 163 | 61,980 | 0 | 103,957 | 43 | 189,281 | 293 | 4,517 | 251 | 9 | 0 | 360,495 |

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| Run Year | | Age Class 0.2 | 1.1 | 1.2 | 2.1 | 1.3 | 2.2 | 1.4 | 2.3 | 1.5 | 2.4 | 1.6 | 2.5 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1996 | Commercial | 0 | 19 | 2,058 | 0 | 3,157 | 0 | 1,473 | 11 | 694 | 0 | 8 | 0 | 7,419 |
| | Subsistence | 0 | 116 | 7,611 | 0 | 38,527 | 40 | 46,300 | 128 | 3,570 | 94 | 9 | 0 | 96,413 |
| | Sport | Age data not available | | | | | | | | | | | | 1,432 |
| | Test fishery | Age data not available | | | | | | | | | | | | 247 |
| | Total Harvest | 0 | 127 | 8,330 | 0 | 42,163 | 44 | 50,669 | 140 | 3,907 | 103 | 10 | 0 | 105,492 |
| | Total Escapement | 0 | 0 | 21,011 | 0 | 86,333 | 280 | 59,895 | 475 | 29,097 | 0 | 0 | 0 | 197,092 |
| | Total | 0 | 127 | 29,341 | 0 | 128,496 | 324 | 110,564 | 615 | 33,004 | 103 | 10 | 0 | 302,584 |
| 1997 | Commercial | 0 | 0 | 5,482 | 0 | 1,744 | 0 | 3,153 | 0 | 63 | 0 | 0 | 0 | 10,441 |
| | Subsistence | 0 | 95 | 6,267 | 0 | 31,721 | 33 | 38,121 | 105 | 2,940 | 78 | 7 | 0 | 79,381 |
| | Sport | Age data not available | | | | | | | | | | | | 1,788 |
| | Test fishery | Age data not available | | | | | | | | | | | | 332 |
| | Total Harvest | 0 | 97 | 12,026 | 0 | 34,255 | 34 | 42,248 | 108 | 3,073 | 79 | 7 | 0 | 91,927 |
| | Total Escapement | 0 | 0 | 71,935 | 0 | 36,326 | 0 | 102,436 | 0 | 550 | 0 | 0 | 0 | 211,247 |
| | Total | 0 | 97 | 83,961 | 0 | 70,580 | 34 | 144,684 | 108 | 3,623 | 79 | 7 | 0 | 303,174 |
| 1998 | Commercial | 0 | 191 | 4,131 | 0 | 10,242 | 0 | 2,413 | 0 | 382 | 0 | 0 | 0 | 17,359 |
| | Subsistence | 0 | 97 | 6,411 | 0 | 32,453 | 34 | 39,000 | 108 | 3,007 | 79 | 7 | 0 | 81,213 |
| | Sport | Age data not available | | | | | | | | | | | | 1,464 |
| | Test fishery | Age data not available | | | | | | | | | | | | 210 |
| | Total Harvest | 0 | 293 | 10,722 | 0 | 43,420 | 34 | 42,117 | 110 | 3,447 | 81 | 8 | 0 | 100,231 |
| | Total Escapement | 0 | 0 | 5,340 | 0 | 62,040 | 0 | 43,633 | 0 | 2,613 | 0 | 0 | 0 | 113,627 |
| | Total | 0 | 293 | 16,062 | 0 | 105,460 | 34 | 85,749 | 110 | 6,060 | 81 | 8 | 0 | 213,858 |
| 1999 | Commercial | 0 | 24 | 1,388 | 0 | 1,092 | 0 | 2,150 | 0 | 52 | 0 | 0 | 0 | 4,705 |
| | Subsistence | 0 | 87 | 5,745 | 0 | 29,081 | 30 | 34,948 | 97 | 2,695 | 71 | 7 | 0 | 72,775 |
| | Sport | Age data not available | | | | | | | | | | | | 279 |
| | Test fishery | Age data not available | | | | | | | | | | | | 98 |
| | Total Harvest | 0 | 111 | 7,168 | 0 | 30,320 | 31 | 37,279 | 97 | 2,760 | 72 | 7 | 0 | 77,844 |
| | Total Escapement | 0 | 205 | 7,726 | 0 | 23,012 | 205 | 79,907 | 0 | 1,027 | 0 | 0 | 0 | 112,082 |
| | Total | 0 | 317 | 14,894 | 0 | 53,331 | 236 | 117,186 | 97 | 3,787 | 72 | 7 | 0 | 189,926 |
| 2000 | Commercial | Age data not available | | | | | | | | | | | | 444 |
| | Subsistence | 0 | 85 | 5,591 | 0 | 28,302 | 30 | 34,012 | 94 | 2,623 | 69 | 6 | 0 | 70,825 |
| | Sport | Age data not available | | | | | | | | | | | | 105 |
| | Test fishery | Age data not available | | | | | | | | | | | | 64 |
| | Total Harvest | 0 | 86 | 5,640 | 0 | 28,547 | 30 | 34,306 | 95 | 2,645 | 70 | 6 | 0 | 71,425 |
| | Total Escapement | 0 | 45 | 13,523 | 0 | 27,410 | 0 | 21,654 | 0 | 2,548 | 0 | 0 | 0 | 65,180 |
| | Total | 0 | 131 | 19,163 | 0 | 55,957 | 30 | 55,960 | 95 | 5,193 | 70 | 6 | 0 | 136,605 |

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| Run Year | | Age Class 0.2 | 1.1 | 1.2 | 2.1 | 1.3 | 2.2 | 1.4 | 2.3 | 1.5 | 2.4 | 1.6 | 2.5 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | Commercial | | | | | Age data not available | | | | | | | | 90 |
| | Subsistence | 0 | 0 | 3,354 | 0 | 13,574 | 0 | 54,294 | 0 | 6,787 | 0 | 0 | 0 | 78,009 |
| | Sport | | | | | Age data not available | | | | | | | | 290 |
| | Test fishery | 0 | 0 | 26 | 0 | 23 | 0 | 29 | 0 | 6 | 2 | 0 | 0 | 86 |
| | Total Harvest | 0 | 0 | 3,397 | 0 | 13,663 | 0 | 54,587 | 0 | 6,826 | 2 | 0 | 0 | 78,475 |
| | Total Escapement | 0 | 0 | 21,153 | 0 | 53,794 | 0 | 65,590 | 0 | 4,694 | 0 | 0 | 0 | 145,232 |
| | Total | 0 | 0 | 24,550 | 0 | 67,457 | 0 | 120,178 | 0 | 11,520 | 2 | 0 | 0 | 223,707 |
| 2002 | Commercial | | | | | Age data not available | | | | | | | | 72 |
| | Subsistence | 0 | 0 | 6,317 | 0 | 26,643 | 0 | 43,730 | 0 | 4,211 | 0 | 0 | 0 | 80,982 |
| | Sport | | | | | Age data not available | | | | | | | | 319 |
| | Test fishery | 0 | 0 | 92 | 0 | 95 | 4 | 95 | 0 | 1 | 0 | 0 | 0 | 288 |
| | Total Harvest | 0 | 0 | 6,446 | 0 | 26,894 | 4 | 44,080 | 0 | 4,237 | 0 | 0 | 0 | 81,661 |
| | Total Escapement | 0 | 215 | 45,768 | 0 | 61,110 | 59 | 53,401 | 0 | 4,081 | 0 | 0 | 0 | 164,635 |
| | Total | 0 | 215 | 52,214 | 0 | 88,004 | 63 | 97,481 | 0 | 8,318 | 0 | 0 | 0 | 246,296 |
| 2003 | Commercial | | | | | Age data not available | | | | | | | | 158 |
| | Subsistence | 0 | 134 | 4,565 | 0 | 29,673 | 0 | 28,263 | 0 | 4,498 | 0 | 0 | 0 | 67,134 |
| | Sport | | | | | Age data not available | | | | | | | | 401 |
| | Test fishery | 0 | 1 | 148 | 0 | 162 | 0 | 82 | 0 | 16 | 0 | 0 | 0 | 409 |
| | Total Harvest | 0 | 137 | 4,752 | 0 | 30,082 | 0 | 28,580 | 0 | 4,551 | 0 | 0 | 0 | 68,102 |
| | Total Escapement | 0 | 297 | 45,885 | 0 | 77,362 | 0 | 52,300 | 0 | 4,843 | 0 | 0 | 0 | 180,687 |
| | Total | 0 | 434 | 50,637 | 0 | 107,444 | 0 | 80,879 | 0 | 9,395 | 0 | 0 | 0 | 248,789 |
| 2004 | Commercial | 0 | 28 | 1,339 | 0 | 584 | 0 | 336 | 0 | 14 | 0 | 0 | 0 | 2,300 |
| | Subsistence | 0 | 194 | 13,498 | 0 | 35,397 | 291 | 45,108 | 0 | 2,622 | 0 | 0 | 0 | 97,110 |
| | Sport | | | | | Age data not available | | | | | | | | 857 |
| | Test fishery | 0 | 0 | 223 | 0 | 294 | 4 | 155 | 0 | 15 | 0 | 0 | 0 | 691 |
| | Total Harvest | 0 | 224 | 15,189 | 0 | 36,585 | 298 | 45,988 | 0 | 2,673 | 0 | 0 | 0 | 100,958 |
| | Total Escapement | 0 | 1,174 | 135,415 | 0 | 81,833 | 141 | 66,388 | 0 | 2,226 | 0 | 0 | 0 | 287,177 |
| | Total | 0 | 1,398 | 150,604 | 0 | 118,418 | 439 | 112,376 | 0 | 4,899 | 0 | 0 | 0 | 388,135 |
| 2005 | Commercial | 0 | 0 | 1,761 | 0 | 2,296 | 10 | 708 | 0 | 10 | 0 | 0 | 0 | 4,784 |
| | Subsistence | 0 | 35 | 4,558 | 0 | 42,333 | 0 | 36,361 | 212 | 1,519 | 71 | 0 | 0 | 85,090 |
| | Sport | | | | | Age data not available | | | | | | | | 572 |
| | Test fishery | 0 | 0 | 141 | 0 | 244 | 0 | 166 | 0 | 7 | 0 | 0 | 0 | 557 |
| | Total Harvest | 0 | 36 | 6,500 | 0 | 45,157 | 10 | 37,470 | 213 | 1,545 | 71 | 0 | 0 | 91,003 |
| | Total Escapement | 0 | 765 | 61,154 | 0 | 124,847 | 0 | 84,954 | 405 | 3,371 | 101 | 0 | 0 | 275,598 |
| | Total | 0 | 801 | 67,655 | 0 | 170,004 | 10 | 122,425 | 618 | 4,917 | 172 | 0 | 0 | 366,601 |

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| Run Year | | Age Class 0.2 | 1.1 | 1.2 | 2.1 | 1.3 | 2.2 | 1.4 | 2.3 | 1.5 | 2.4 | 1.6 | 2.5 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2006 | Commercial | 0 | 31 | 1,691 | 0 | 755 | 0 | 286 | 0 | 14 | 0 | 0 | 0 | 2,777 |
| | Subsistence | 0 | 160 | 5,657 | 0 | 32,181 | 53 | 48,084 | 160 | 3,682 | 107 | 0 | 0 | 90,085 |
| | Sport | | | | | Age data not available | | | | | | | | 444 |
| | Test fishery | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 352 |
| | Total Harvest | 0 | 192 | 7,383 | 0 | 33,093 | 54 | 48,601 | 161 | 3,714 | 107 | 0 | 0 | 93,304 |
| | Total Escapement | 0 | 804 | 69,665 | 0 | 59,658 | 0 | 73,180 | 0 | 10,698 | 0 | 0 | 0 | 214,004 |
| | Total | 0 | 996 | 77,048 | 0 | 92,751 | 54 | 121,781 | 161 | 14,411 | 107 | 0 | 0 | 307,308 |
| 2007 | Commercial | | | | | Age data not available | | | | | | | | 179 |
| | Subsistence | 0 | 0 | 7,036 | 0 | 35,507 | 0 | 50,235 | 281 | 2,486 | 610 | 0 | 0 | 96,155 |
| | Sport | | | | | Age data not available | | | | | | | | 1,478 |
| | Test fishery | | | | | Age data not available | | | | | | | | 305 |
| | Total Harvest | 0 | 0 | 7,179 | 0 | 36,231 | 0 | 51,260 | 287 | 2,537 | 622 | 0 | 0 | 98,117 |
| | Total Escapement | 0 | 196 | 69,771 | 0 | 54,634 | 0 | 46,478 | 7 | 3,667 | 191 | 0 | 0 | 174,943 |
| | Total | 0 | 196 | 76,950 | 0 | 90,865 | 0 | 97,738 | 294 | 6,204 | 814 | 0 | 0 | 273,060 |
| 2008 | Commercial | 0 | 0 | 3,573 | 0 | 4,131 | 27 | 887 | 115 | 133 | 0 | 0 | 0 | 8,865 |
| | Subsistence | 0 | 196 | 8,044 | 0 | 52,779 | 0 | 33,649 | 589 | 2,551 | 196 | 0 | 0 | 98,103 |
| | Sport | | | | | Age data not available | | | | | | | | 708 |
| | Test fishery | | | | | Age data not available | | | | | | | | 420 |
| | Total Harvest | 0 | 198 | 11,740 | 0 | 57,511 | 27 | 34,900 | 711 | 2,712 | 198 | 0 | 0 | 107,997 |
| | Total Escapement | 0 | 343 | 34,806 | 0 | 58,004 | 43 | 32,752 | 642 | 2,478 | 0 | 0 | 0 | 128,978 |
| | Total | 0 | 542 | 46,546 | 0 | 115,515 | 70 | 67,652 | 1,354 | 5,190 | 198 | 0 | 0 | 236,975 |
| 2009 | Commercial | 0 | 0 | 2,792 | 0 | 1,999 | 33 | 1,753 | 0 | 67 | 13 | 0 | 0 | 6,664 |
| | Subsistence | 0 | 78 | 7,823 | 0 | 27,146 | 78 | 41,932 | 78 | 1,017 | 78 | 0 | 0 | 78,231 |
| | Sport | | | | | Age data not available | | | | | | | | 904 |
| | Test fishery | | | | | Age data not available | | | | | | | | 470 |
| | Total Harvest | 0 | 79 | 10,787 | 0 | 29,617 | 113 | 44,391 | 79 | 1,101 | 93 | 0 | 0 | 86,269 |
| | Total Escapement | 0 | 90 | 26,865 | 0 | 46,825 | 729 | 42,443 | 220 | 1,228 | 236 | 0 | 0 | 118,478 |
| | Total | 0 | 169 | 37,652 | 0 | 76,442 | 842 | 86,835 | 300 | 2,330 | 329 | 0 | 0 | 204,747 |
| 2010 | Commercial | 0 | 0 | 973 | 0 | 1,058 | 0 | 680 | 0 | 9 | 12 | 0 | 0 | 2,732 |
| | Subsistence | 0 | 66 | 5,152 | 0 | 32,566 | 66 | 26,224 | 0 | 1,982 | 0 | 0 | 0 | 66,056 |
| | Sport | | | | | Age data not available | | | | | | | | 354 |
| | Test fishery | | | | | Age data not available | | | | | | | | 292 |
| | Total Harvest | 0 | 67 | 6,183 | 0 | 33,939 | 67 | 27,157 | 0 | 2,009 | 12 | 0 | 0 | 0 |
| | Total Escapement | 0 | 111 | 18,326 | 0 | 15,791 | 0 | 13,555 | 0 | 1,259 | 31 | 0 | 0 | 49,073 |
| | Total | 0 | 178 | 24,509 | 0 | 49,730 | 67 | 40,712 | 0 | 3,268 | 43 | 0 | 0 | 118,507 |
| 2011 | Commercial | | | | | Age data not available | | | | | | | | 748 |
| | Subsistence | 0 | 59 | 7,880 | 0 | 28,438 | 0 | 21,565 | 118 | 1,126 | 0 | 59 | 0 | 59,245 |
| | Sport | | | | | Age data not available | | | | | | | | 633 |
| | Test fishery | | | | | Age data not available | | | | | | | | 337 |
| | Total Harvest | 0 | 61 | 8,108 | 0 | 29,262 | 0 | 22,190 | 122 | 1,158 | 0 | 61 | 0 | 60,963 |
| | Total Escapement | 0 | 96 | 28,890 | 0 | 22,044 | 116 | 20,004 | 219 | 610 | 43 | 0 | 0 | 72,097 |
| | Total | 0 | 157 | 36,998 | 0 | 51,306 | 116 | 42,194 | 340 | 1,768 | 43 | 61 | 0 | 133,059 |