Regional Operational Plan SF.1J.2013.09

# A Mark-Recapture Experiment to Estimate the Escapement of Chinook Salmon in the Unuk River, 2013.

by

**Todd Johnson**

June 2013

Alaska Department of Fish and Game | Divisions of Sport Fish and Commercial Fisheries

# 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 |

*REGIONAL OPERATIONAL PLAN SF.1J.2013.09*

# A MARK-RECAPTURE EXPERIMENT TO ESTIMATE THE ESCAPEMENT OF CHINOOK SALMON IN THE UNUK RIVER, 2013.

by

Todd Johnson

Alaska Department of Fish and Game, Division of Sport Fish, Ketchikan

Alaska Department of Fish and Game
Division of Sport Fish

June 2013

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# PURPOSE

The primary goals of this and a companion study (see separate operational plan: Chinook Salmon Coded Wire Tagging on the Unuk River, 2013–2014) are to estimate inriver run size, total run size, marine harvest rate and distribution, marine exploitation rate, smolt and parr abundance, marine survival (smolt-to-adult) and overwinter survival (parr-to-smolt). This study provides crucial components required to meet these goals, namely estimates of spawning escapement, age-sex composition, and the coded wire tag (CWT) and adipose-finclip marked fractions for adults in the escapement. The Alaska Department of Fish and Game (ADF&G) uses these data to make regional management decisions, and the Pacific Salmon Commission (PSC) uses these data for coastwide management and stock assessment through the Chinook Technical Committee (CTC).

# BACKGROUND

The Unuk, Chickamin, Blossom, and Keta rivers are located on the mainland and traverse the Misty Fjords National Monument in southern Southeast Alaska (SEAK). The Unuk and Chickamin rivers produce the largest natural runs of Chinook salmon (*Oncorhynchus tshawytscha*) in this area and flow into Behm Canal near Ketchikan (Figure 1). These four rivers are “index streams" for the escapement estimation program for Chinook salmon in SEAK (Pahlke 1993), and are also 4 of the 50 “escapement indicator” stocks used annually by the CTC to judge stock status and management performance in Chinook salmon fisheries in the geographic area covered by the PSC (CTC 2001).

A drop in the indices of escapement (peak survey counts) in each of these four systems in the late 1980’s raised conservation concerns for these stocks, and historical data was reviewed to evaluate their status. During this review, the Division of Sport Fish (DSF) agreed to begin a more intensive stock assessment program on the Unuk River. This stock assessment program consists of 2 components: 1) an annual mark-recapture tagging project to estimate total escapement; and 2) an annual CWT project to estimate marine harvest and survival.

The Unuk River originates in a heavily glaciated area of northern British Columbia and flows for 129 km where it empties into Burroughs Bay approximately 85 km northeast of Ketchikan, Alaska. Only the lower 39 km of the river are in Alaska (Figure 2). Pahlke et al. (1996) estimated that 86% of all Chinook salmon spawning in 1994 occurred in U.S. tributaries, including Cripple, Genes Lake, Kerr, Clear, and Lake creeks, and the Eulachon River. Analysis of radio telemetry data collected in 2009 showed that 77.9 % of the spawning population occurred in U.S. tributaries (Weller and Evans 2012). It is likely that a majority of the juvenile Chinook salmon rear in the U.S portion of the Unuk River.

Aerial surveys of Cripple, Gene’s Lake, Clear, Kerr, and Lake creeks, and the Eulachon River have been conducted annually since 1977. Average distribution of peak survey counts in the Unuk River from 1977 to 2007, and 2009 to 2011 (2008 surveys were incomplete) was as follows: Cripple Creek (36.3%), Gene's Lake Creek (32.7%), Eulachon River (13.9%), Clear Creek (9.5%), Kerr Creek (4.1%), and Lake Creek (3.5%). All index areas are surveyed by helicopter, and due to heavy canopy cover Gene’s Lake and Cripple creeks, surveys are supplemented with foot surveys as needed.

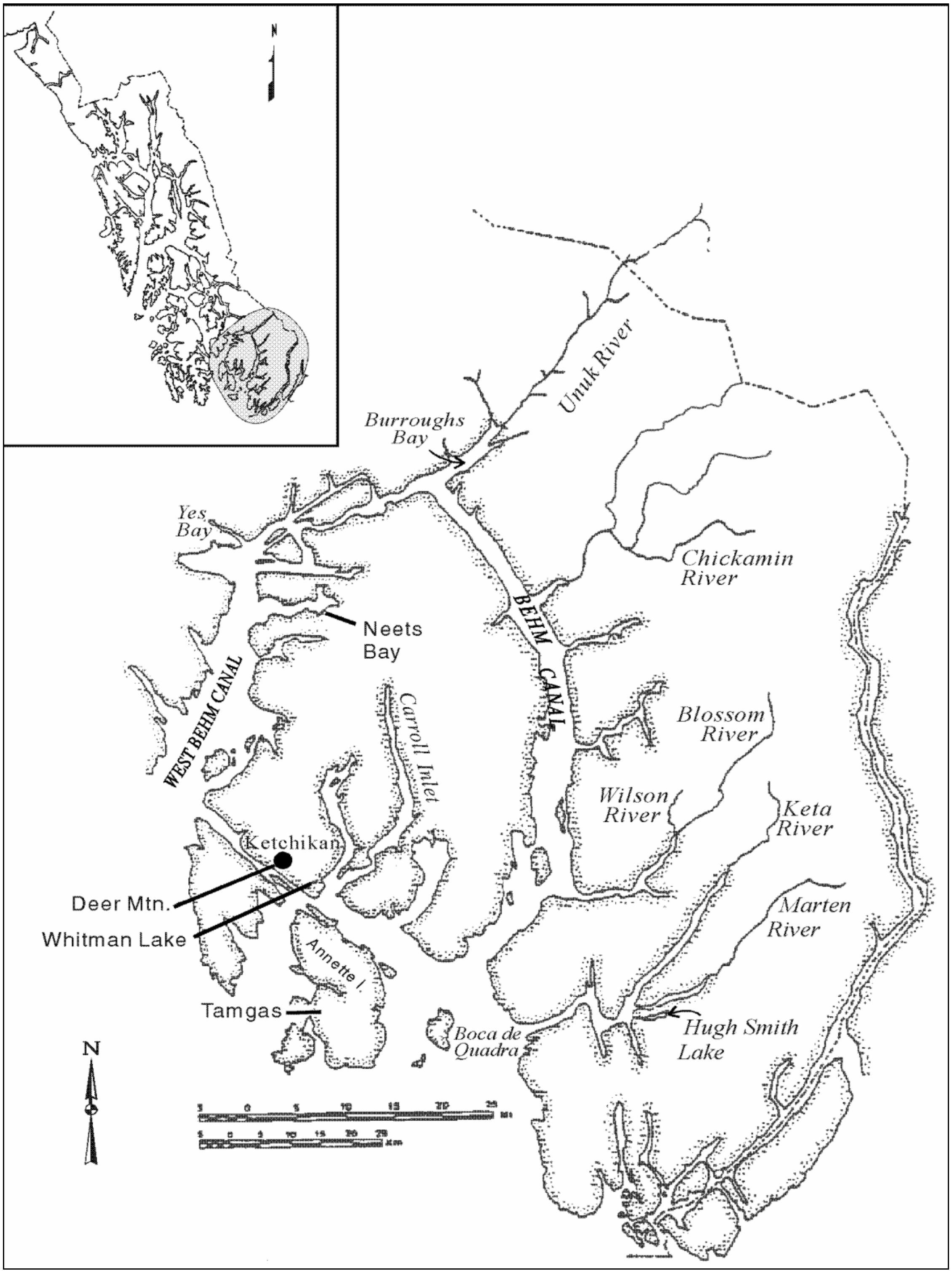


Figure 1.–Behm Canal area, showing major Chinook salmon systems and hatcheries.

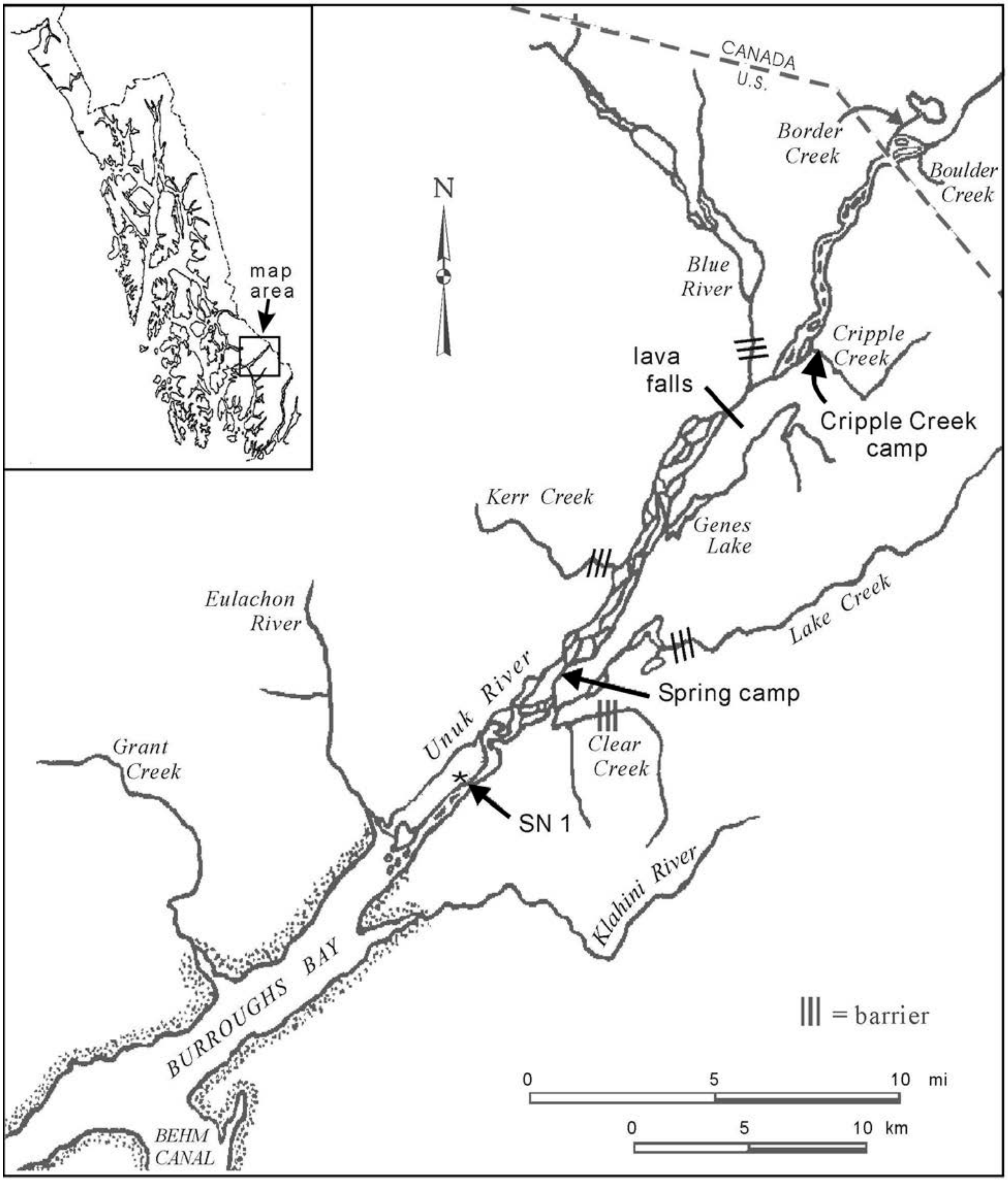


Figure 2.–Unuk River area in Southeast Alaska, showing major tributaries, barriers to salmon migration, and location of ADF&G research sites (SN1 = set net site).

Spawning abundance of large Chinook salmon was first estimated for the Unuk River in 1994, and then in 1997 through 2009 and 2011 using mark-recapture experiments. Estimating the annual escapements using mark-recapture methods is a substantial improvement over aerial surveys for population assessment and modeling (Jones III et al. 1998a). Concurrent estimation of escapement and peak survey counts also allows us to calculate an expansion factor that can be used to expand past and future survey counts when there are no mark-recapture estimates (e.g. 2010 and 2012) to estimate the spawning escapement. Mark-recapture experiments were not successful in 2010 and 2012. In 2010, the initial tests for complete mixing and equal capture proportions failed, and stratification was not successful, so the data were not used due to the unknown directional bias in the estimate. In 2012, expanded peak counts were used because a poor run and high water level resulted in low sample numbers and there were insufficient (only 5 recoveries) for the mark-recapture experiment. The average mark-recapture abundance estimate of large Chinook salmon from 1997 to 2009 and 2011 was 5,494, and ranged from 2,970 in 1997 to 10,541 fish in 2001 (Table 1; Jones III et al. 1998a; Jones and McPherson 1999, 2000, 2002; Pahlke et al. 1996; Weller and McPherson 2003a-b, 2004, 2006a-b; Weller and Evans 2009, 2012).

There are 14 years of relatively precise total escapement estimates and associated survey counts that were used to develop a predictive mean expansion factor (EF) of 5.89 for this stock (Eq. 6 in Appendix C1). The 2008, 2010, and 2012 data are excluded from the calculation. In 2008, peak survey counts were incomplete and the mark-recapture experiments in 2010 and 2012 failed to produce reliable estimates of escapement. The predictive mean EF enables us to estimatet escapement for the 1977–1996 calendar years in total large spawners from the peak survey counts.

A biological escapement goal (BEG) of 650–1,400 large fish counted in surveys was developed for this stock in 1997 from analysis of smolt and adult spawner-recruit data from 1977 to 1995 (McPherson and Carlile 1997); the BEG range was expressed as a peak count because the expansion factor was unknown at that time. A spawner-recruit analysis of the 1977–2004 data utilizing an expansion factor of 4.83 was used to revise the BEG. (Hendrich et al. 2008). The revised BEG of 1,800 to 3,800 large spawners (375 to 800 in peak survey counts) was approved in 2008 by ADF&G (McPherson et al. 2008.)

Harvest estimates are necessary in order to estimate total production, exploitation rates, and survival rates. A CWT program is used to estimate harvest parameters. A previous study on the Unuk River implanted CWTs in Chinook salmon juveniles from the 1982–1986 broods (Pahlke 1996). Indications from this research were that harvest rates on the Unuk River Chinook salmon stock (over all age classes, age-1.1 to age-1.5 fish) ranged from 14% to 24%. However, the precision of the harvest estimates was low.

In 1993, ADF&G resumed a CWT project on the Unuk River. Fish were marked at a much higher rate than was done previously. From 1993 to 2012, a total of 635,369 Chinook salmon (fall) parr have been tagged, with an annual average of 32,722 and a range of 13,656 (2012) to 61,905 (Pahlke et al. 1996; Jones III et al. 1998b; Jones III and McPherson 1999, 2000, 2002; Weller and McPherson 2003a-b, 2004, 2006a-b; Weller and Evans 2012).). Smolt tagging efforts commenced in the spring of 1994 and a total of 175,494 smolt have since been tagged for an

Table 1.–Peak survey counts, mark-recapture estimates of abundance, expansion factors, and associated statistics for large (≥660 mm MEF) Chinook salmon in the Unuk River in 1994, 1997–2009 and 2011, and the 1997–2009 and 2011 average.

| Year | Survey count | Mark-recapture (M-R) estimate | SE (M-R) | Survey count/M-R, % | CV (M-R), % | 95% RP (M-R) | Expansion factor (EF)[a] | SE (EF)[a] | CV (EF)[a], % | 95% RP (EF)[a], % | 95% CI (M-R) | Estimated bias, % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1994 | 711 | 4,623 | 1,266 | 15.4 | 27.4 | 53.7 | 6.50 | 1.78 | 27 | 54 | 2,992–9,425 | NA |
| 1997 | 636 | 2,970 | 277 | 21.4 | 9.3 | 18.3 | 4.67 | 0.44 | 9 | 18 | 2,499–3,636 | 0.1 |
| 1998 | 840 | 4,132 | 413 | 20.3 | 10.0 | 19.6 | 4.92 | 0.49 | 10 | 20 | 3,433–4,974 | 0.6 |
| 1999 | 680 | 3,914 | 490 | 17.4 | 12.5 | 24.5 | 5.76 | 0.72 | 13 | 25 | 3,110–5,071 | 1.5 |
| 2000 | 1,341 | 5,872 | 644 | 22.8 | 11.0 | 21.5 | 4.38 | 0.48 | 11 | 21 | 4,848–7,347 | 1.1 |
| 2001 | 2,019 | 10,541 | 1,181 | 19.2 | 11.2 | 22.0 | 5.22 | 0.58 | 11 | 22 | 8,665–13,541 | 1.0 |
| 2002 | 897 | 6,988 | 805 | 12.8 | 11.5 | 22.6 | 7.79 | 0.90 | 12 | 23 | 5,775–8,845 | 0.6 |
| 2003 | 1,121 | 5,546 | 433 | 20.2 | 7.8 | 15.3 | 4.95 | 0.39 | 8 | 15 | 4,814–6,530 | 0.0 |
| 2004 | 1,008 | 3,963 | 325 | 25.4 | 8.2 | 16.1 | 3.93 | 0.32 | 8 | 16 | 3,406–4,684 | 0.5 |
| 2005 | 929 | 4,742 | 396 | 19.6 | 8.4 | 16.4 | 5.10 | 0.43 | 8 | 16 | 4,094–5,579 | 0.5 |
| 2006 | 940 | 5,645 | 506 | 16.7 | 9.0 | 17.6 | 6.01 | 0.54 | 9 | 18 | 4,094–5,579 | 0.5 |
| 2007 | 709 | 5,668 | 446 | 12.5 | 7.9 | 15.4 | 7.99 | 1.32 | 17 | 32 | 4,900–6,685 | 0.3 |
| 2009 | 687 | 3,157 | 354 | 21.8 | 11.2 | 22.0 | 4.60 | 0.52 | 11 | 22 | 2,568–4,012 | 1.3 |
| 2011 | 431 | 3,195 | 655 | 13.5 | 20.5 | 40.2 | 7.41 | 1.52 | 21 | 40 | 1,911–4,479 | NA |
| Average | 971 | 5,494 | 567 | 17.7 | 10.6 | 20.8 | 5.89 | 0.83 | 14 | 28 | 4,470–6,65 | 0.59 |

[a] Average excludes 2008, 2010, and 2011.

*Note*: RP = relative precision.

annual average of 10,323 and a range of 2,642 smolt in 1994 to 17,119 smolt tagged in 1998 (Appendix A1). The first significant returns from this effort (age-1.3 fish from the 1992 brood year) returned in 1997. Escapement was estimated in 1994 and in 1997 through 2012, and will continue in years when CWT tagged fish return to allow estimation of total run size, exploitation rates, and harvest distribution (CWT marked fractions are determined from sampling during the mark-recapture study).

# OBJECTIVES

The research objectives for 2013 are to:

1. Estimate the abundance of large (≥660 mm MEF) Chinook salmon in the Unuk River such that the estimate is within 30% of the true abundance 95% of the time.
2. Estimate the age and sex compositions of large Chinook salmon in the Unuk River such that estimates are within 5 percentage points of the true values 95% of the time.
3. Estimate the reciprocal of the fraction of each brood stock (1/θ) marked with a coded wire tag such that each estimate for a completed brood year has a coefficient of variation (CV) ≤10%.

## SECONDARY OBJECTIVES

1. Estimate mean length-at-age and sex for the spawning population.
2. Refine the expansion factor for converting peak survey counts to escapement.
3. Estimate the age-sex composition of medium (≥400 to <660 mm MEF) and small (<400 mm MEF) Chinook salmon spawning in the Unuk River.
4. Estimate the abundance of medium Chinook salmon in the Unuk River using mark-recapture techniques. If mark-recapture data are insufficient to estimate the abundance of medium fish, abundance will be estimated based on the proportion of medium fish sampled on the spawning grounds.
5. Estimate the abundance of small Chinook salmon in the Unuk River based on the proportion of small fish sampled on the spawning grounds.

# METHODS

## STUDY DESIGN

### Event 1-Marking

Total immigration of Chinook salmon into the Unuk River in 2013 will be estimated using a two-event closed population mark-recapture experiment. Chinook salmon will be tagged at a set gillnet site (SN1, Figure 3) as they immigrate into the Unuk River. This site is located approximately 3 km (2 mi) upstream on the south channel or “mainstem” of the lower Unuk River, well below all known spawning areas, with the exception of the Eulachon River. Fishing

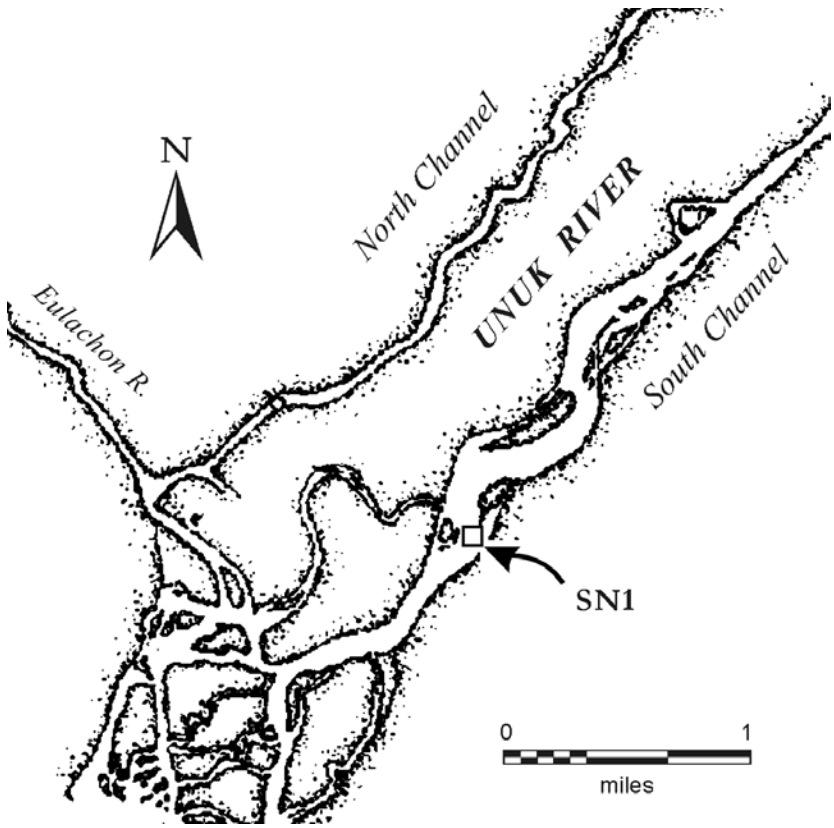


Figure 3.–Location of the set gillnet site (SN1) on the lower Unuk River.

effort will be applied uniformly in time and space to promote catching fish destined for each spawning location within the Unuk River drainage, in proportion to their abundance.

The set gillnets will be 37 m (120 ft) long by 4 m (14 ft) deep with 18 cm (7¼ in) stretch mesh hung loosely at a ratio of about 2.2:1. Two set gillnets will be fished at SN1 as described in Jones and McPherson (2000). One net will be attached to the shore and stretched directly across a small slough to a fixed buoy placed just downstream of a small island (i.e., perpendicular to the main flow of the Unuk River). Another net will be attached to the same fixed buoy and allowed to trail downstream (Figure 4). This net configuration produced catch rates that averaged 10.1% of the estimated abundance of large fish (all fish >660) during the 1997–2007, 2009, and 2011 projects.

Previous studies (Jones III et al. 1998a; Jones and McPherson 1999, 2000, 2002; Pahlke et al. 1996; Weller and McPherson 2003a-b, 2004, 2006a-b; Weller and Evans 2012) have shown that few returning adult Chinook salmon enter the Unuk River before June 10. Furthermore, on average, only 2% of the set gillnet catch occurred before June 15 in the 12 previous years of this mark-recapture project. From 1997–2012, the immigration into the lower river was largely (>97%) complete by August 1; however in 2007 and 2008 the return extended well into the first week of August.

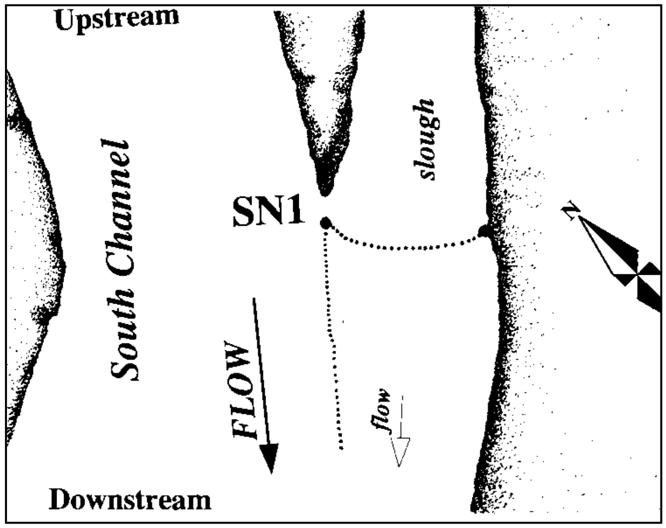


Figure 4.–Detailed drawing of the net placement used at the set gillnet site (SN1) on the lower Unuk River.

An orientation, logistics, and training meeting will take place at the Ketchikan ADF&G office on June 5. The crew will go into the field on approximately June 6, where there will be camp repairs and preparation for the setnet site. Fishing will begin as soon as possible or by June 11. Fishing will cease when the Chinook salmon immigration is considered negligible (<1% of the cumulative catch to date for 3 consecutive days) or by August 4, whichever comes first. The net will be attended to at all times to ensure that fish are immediately removed from the net, sampled, and released.

Two 2-person crews will fish exclusively at SN1. One crew, deemed C1, will fish in the mornings (i.e., approximately 0500 to 1000 hours) and the other crew, deemed C2, will fish in the afternoons (approximately 1001 to 1501 hours) 6 days per week. Crews will alternate days off to ensure that fishing occurs each and every day. Ideally, nets will be repaired while fishing is taking place (i.e., it should be possible to repair nets while watching for bobbing corks**).** Each crew will fish 5 hours per day (soak time). This time does not include process time (i.e., the time involved handling, marking, and releasing fish) and this is why each crew is scheduled for 7.5 hours during the morning or evening shift (in addition to soak time, this includes data entry, sampling preparations, and travel to and from setnet site)**.** Every fish captured, including Chinook salmon, will add 1 minute of process time. Additional time may be required if it is not possible to repair nets while fishing and the crew leader will adjust this accordingly. This also means that overtime may be required at times to adequately perform this project. This year we will be reducing the soak time from 6 to 5 hours to minimize overtime hours and to compensate for reductions in operational budgets. This reduction will result in an approximate loss of 98 hours of fishing time through event 1, while saving approximately 196 hours of overtime on the budget. We expect to see a reduction of catch at the net and in the marked fraction of approximately 17% (1/6). This reduction will make it more difficult for us to realize our objective criteria. The work schedules are as follows:

C1 = set gillnet crew 1 X1 = C1 day off

C2 = set gillnet crew 2 X2 = C2 day off

| Shift | Mon | Tue | Wed | Thu | Fri | Sat | Sun | Mon | Tue | Wed | Thu | Fri | Sat | Sun | Mon |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Morning | X1 | C1 | C1 | C1 | C1 | C1 | C1 | X1 | C1 | C1 | C1 | C1 | C1 | C1 | X1 |
| Evening | C2 | C2 | C2 | X2 | C2 | C2 | C2 | C2 | C2 | C2 | X2 | C2 | C2 | C2 | C2 |

Days off will be staggered approximately 7 days apart for each crew and 3 days apart between crews. This schedule will ensure that if a sudden surge of fish immigrates into the river, at least one crew will be fishing at that time and at no time will back-to-back days be taken off. The time that the set gillnet is more than 50% in the water and effectively fishing will be recorded to calculate CPUE. This value will be considered the EFFORT (in net hours) required to attain the CATCH. Thus, the actual time spent working the nets will vary slightly day to day. If more than 1/2 hour is missed on a given day, every attempt will be made to make it up the following day.

Every apparently healthy Chinook salmon captured, without regard to size, will be given 3 separate marks: a primary mark consisting of a uniquely numbered solid core spaghetti tag, a left axillary appendage (LAA) clip, and a 5-mm diameter upper left operculum punch (ULOP). The two secondary batch marks (LAA and ULOP) will be applied to increase the probability of correctly identifying fish that have lost their primary mark. Regardless of health, every captured fish will also be sampled prior to release to determine age (from scales), sex, and length (ASL, See Age-Sex-Length Sampling section below), condition, and presence or absence of an adipose fin (See Coded Wire Tag Sampling section below).

Each set gillnet crew will consist of a motor operator and a set gillnet operator. The motor operator is responsible for safe operation of the skiff, collecting scales, and recording all field data. The set gillnet operator is responsible for setting and retrieving the set gillnet, species identification, tagging fish, determining gender, and measuring length. Captured fish will be retrieved immediately after entanglement. All fish will be immediately and carefully untangled or cut loose and removed from the set gillnet.

## Event 2-Recapturing

Spawning ground sampling will begin approximately 26 July or after completion of the Event 1 marking and continue as long as sampling is effective (approximately August 24–31). The goal of sampling is 5-fold: 1) to estimate the fraction of fish marked at SN1; 2) to estimate the fraction of fish marked with adipose fin clips and CWTs; 3) to estimate ASL composition; 4) to report the numbers of fish seen; and 5) gather data to allow assumption testing.

All Chinook salmon found or captured on the spawning grounds, regardless of size, will be counted and examined for spaghetti tags, LAAs, ULOPs, ASL, and adipose fin clips. Presence or absence of each of these marks will be recorded for each fish inspected. Note that any fish not suitable for sampling (head or tail missing, mangled beyond accurate length measurement, etc.)

will be ignored and not sampled (See Age-Sex-Length Sampling and Coded Wire Tag Sampling sections below).

A variety of gear including dip nets, rod and reel snagging gear, short sections of netting, and spears (for dead fish) will be used to collect fish for sampling. Studies have shown this approach is effective at collecting an unbiased sample for age and sex composition (Jones III et al. 1998a; Jones and McPherson 1999, 2000, and 2002; McPherson et al. 1997). In order to prevent double sampling of fish on the spawning grounds, every live and dead fish sampled will be given a lower left operculum punch (LLOP) on the lower one-third (ventral side) of the left operculum. Additionally, every dead fish sampled will be slashed several times through the preferred area on the left side using a knife. Effort will be adjusted according to the relative number of fish present in each of the tributaries (i.e., those tributaries with more fish will have more effort, and vice-versa) to prevent depensatory sampling. Initial spawning ground surveys will focus on sampling live fish; later surveys will focus on dead and dying fish as they become more available. Historical peak spawning dates from Kissner (1984) and from surveys in 1997–2001 (see table below) suggest the likely timing of events. Actual survey dates in 2013 will be adjusted, by observed abundance and environmental conditions, to maximize the number of fish sampled.

Surveys will be conducted as follows:

*Cripple and Gene's Lake creeks*: 2 surveys each of large live and dead fish approximately 1 week apart near the peak of spawning (see table below). On Cripple and Gene's Lake creeks, crews will walk upstream through the index area and count large fish (live and dead) in route. Crews will then sample carcasses and live fish of all sizes as usual on the trip back downstream. Fish observed in the lake outlet will also be counted during the surveys.

*Eulachon River and Clear, Lake, Boundary, and Kerr creeks*: Live and dead large fish observed at each location will be counted while inspecting fish of all sizes for marks and collecting ASL samples.

All survey counts will be recorded on a Spawning Grounds Survey Form (Appendix B1).

| Location | Importance as spawning site (rank) | Historical survey date 1st | 2nd | Peak | Index area |
|---|---|---|---|---|---|
| Cripple Creek | 1 | 8/2 | 8/8 | 8/6 | Y |
| Gene's Lake Creek | 2 | 8/6 | 8/13 | 8/15 | Y |
| Eulachon River | 3 | 8/17 | 8/25 | 8/18 | Y |
| Clear Creek | 4 | 8/10 | 8/17 | 8/15 | Y |
| Lake Creek | 5 | 8/5 | 8/12 | 8/5–8/25 | Y |
| Kerr Creek | 5 | 8/16 | 8/23 | 8/17 | Y |
| Boundary Creek | 5 | 8/4 | 8/9 | 8/6 | N |

## Mark-Recapture Sample Sizes

Expected precision is based on assumptions concerning population size in 2013 and past performance (Table 1). For our purposes, Chinook salmon ≥660 mm MEF are considered large and generally consist of brood year returns of age-1.3 to age-1.5 fish. Based on a sibling analysis of the 1992–2008 brood year returns of age-1.2 to -1.4 Chinook salmon to the Unuk River, an estimated 2,895 age-1.3 and 1,614 age-1.4 fish are predicted to return in 2013. The average marine harvest rate from the 1992–2007 broods was 25% and 23% of age-1.3 and age-1.4 fish, respectively. Assuming an average marine harvest, we expect an inriver escapement of 2,171 age-1.3 and 1,243 age-1.4 fish to the Unuk River in 2013. On average, an estimated 37 age-1.5 fish returned to spawn in the Unuk River from 1997–2012. We therefore expect an inriver escapement of 3,451 large Chinook salmon in the Unuk River in 2013. In 2012, the sibling regression predicted that 3,314 large fish would return to spawn, while the expanded survey count was 956 large fish.

We expect that catch rates will be lower than the 1997–2011 (excluding 2008, 2010 and 2012) average where 10.1% of the estimated abundance of large fish was marked at the setnet site and 14.1% were examined on the spawning grounds. Thus, our expectation for 2013 is that we will capture and tag 289 (accounting for reduced sampling time at the net) large fish in the lower river using set gillnets (0.101 x 3,451 x (1 - 0.17) = 289) and sample 487 (0.141 x 3,451 = 487) on the spawning grounds. In the context of Petersen's estimator, the 95% relative precision (RP) is within 30% when the abundance of large fish is 3,451, number marked is 289, and number sampled on the spawning grounds is 487 (Robson and Regier 1964). Thus, the criterion for large fish in Objective 1 should be met. It is noted that recent low returns of Chinook salmon statewide may perpetuate into 2013, resulting in smaller sample sizes and reduced precision. We will make every effort to tag as many fish as possible and sample as many fish as possible, given budgetary constraints.

## Age Composition

Age compositions for fish in the lower river set gillnets and in each escapement sampling location (spawning tributary) will initially be estimated separately. Data for separate spawning tributaries will be pooled when compositions for large fish are not statistically different ($\alpha = 0.1$) as determined by contingency table analysis. Details of the analysis are given in the data analysis section.

Most Chinook salmon scales are readable: an average of 86% of the scales collected from 1995 to 2004 were successfully aged by ADF&G technicians, with a range of 83% in 2003 to 91% in 1998 (Jones III et al. 1998a; Jones and McPherson 1999, 2000, 2002; Weller and McPherson 2003a-b, 2004, 2006a). Also, comparing ages based on scales to known-age fish determined using decoded CWTs shows that aging fish from scales on the Unuk River is accurate (Figure 5).

Assuming no selectivity by sex, scale samples must be collected from 592 large fish (scale regeneration = 14%, no fpc) according to Thompson (1987). Because scales from 776 (487 + 289) large fish should be collected during the experiment, the criterion for large fish in Objective 2 should be met. All scales will be processed to determine age.

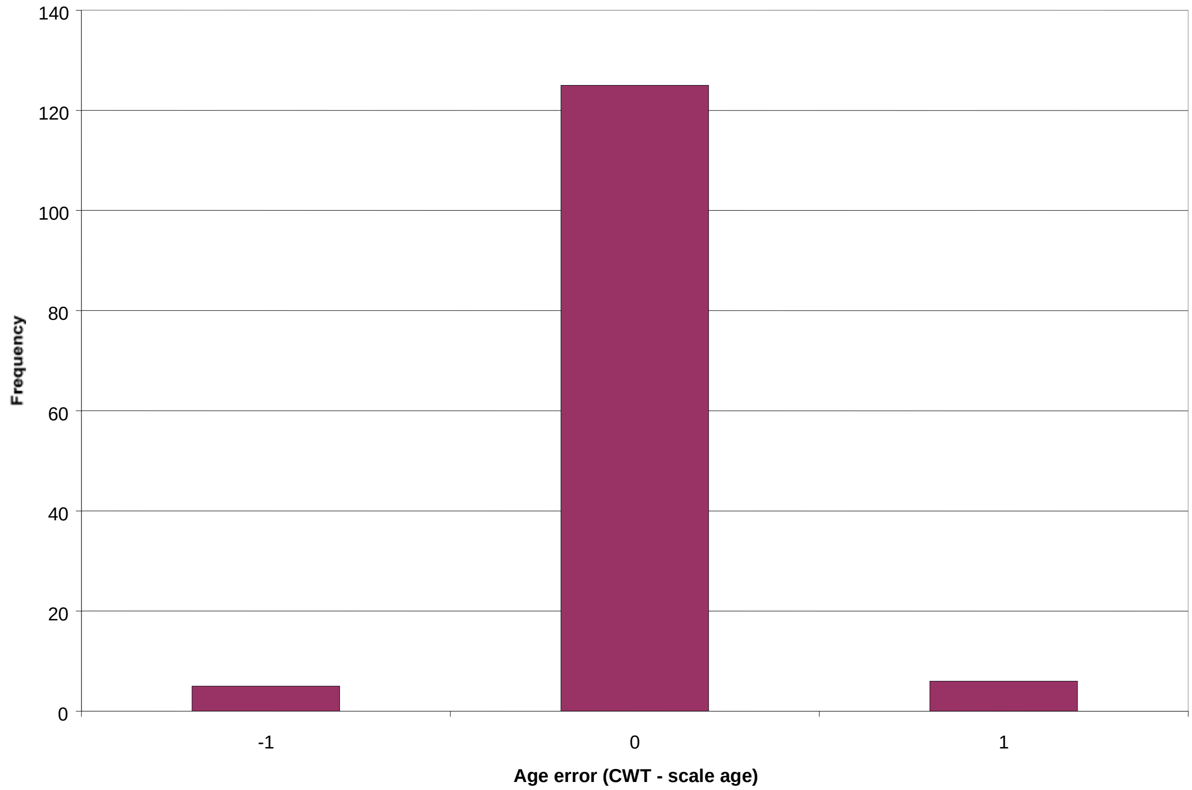


Figure 5.–Age errors encountered when comparing differences between coded wire tag (CWT) and scale ages from fish gathered on the Unuk River, 1996–1998.

## Estimation of Coded Wire Tag Marked Fraction in the 2006–2010 Broods

Harvest contributions of Unuk River Chinook salmon have been or will be estimated from recovery of Chinook salmon with CWTs sampled from fisheries. This estimation requires assessment of the CWT marked fraction by brood year. In 2013, ages 1.1 through 1.5 fish will be sampled from the Unuk inriver run from brood years 2006 through 2010. These tags were placed in parr in the fall of 2007 through 2011, and in smolt in the spring of 2008 through 2012. Note that the marked fraction for CWTs ($\theta$) is unknown until returning adults can be sampled inriver. As part of the sampling for the mark-recapture estimate in 2013, each captured fish will be inspected for the presence or absence of an adipose fin. Sampling of adipose-clipped fish is described in the Coded Wire Tag Sampling section below. Brood year-specific marked fractions will then be estimated as described in the Data Analysis section (Eq. 15). Estimates of $\theta$ for a given brood year will be updated as its age classes return. From 1997 to 2010, this project has sampled an average of 1,429 adults per brood year for adipose clips (brood years 1992–2006, Appendix A2). Given that we have tagged an average of about 8% of the outmigration for each brood year, a simulation shows that the CV of our estimate of the inverse of the marked fraction ($1/\theta$) should be about 9%, within the prescribed precision of Objective 3. The average CV of estimates of $1/\theta$ for brood years 2000 through 2006 is 12%. Previously assumed tagging and precision requirements, and adult sampling goals are described in separate operational plans for CWT tagging.

## DATA COLLECTION

### Event 1 - Marking

Effort and catch during set gillnet fishing at SN1 will be recorded daily on a Set Gillnet Recording Form (Appendix B2). Date, location, the initials of the crewmembers working, river height and temperature, start and end time, and other comments will be recorded on this form. Water level will be measured at a staff gauge permanently affixed to a rock or piling in the main channel of the lower Unuk River, at an accessible site near camp. Water temperature, measured to the nearest 1˚C, and depth will be measured at the same time (approximately 0800 hours) each day. The number of fish caught and the processing time for sampling fish or cleaning nets, etc. will also be recorded. Fishing effort will equal the difference between the start and end times minus processing time (i.e., 1 minute additional for each fish captured regardless of species and other delays such as net cleaning, taking lunch, or photos).

Regardless of size, each healthy Chinook salmon captured will be given 3 different marks: a primary mark consisting of a uniquely numbered solid core spaghetti tag, and the 2 batch marks (LAA and the ULOP). Each fish captured, regardless of health, will be sampled for ASL and CWTs (see Age-Sex-Length Sampling and Coded Wire Tag Sampling sections below). Data from Chinook salmon captured with set gillnets will be recorded on the Set Gillnet Age-Sex-Length Form (Appendix B3). This form includes the fish #, date, time caught, sex, length (mm MEF), spaghetti tag #, adipose clip cinch #, presence of lice, age, AEC (age error code), stream code (see Appendix B4), comments, and card #. Wounds, marks, and atypical circumstances will be recorded in the comment section. Tagged fish will be sequentially numbered, beginning with "1"; untagged fish will not be numbered. A Coded Wire Tag Sampling Form (Appendix B5) summarizing each day's set gillnet sampling must also be completed. We anticipate that approximately 9 fish will be sacrificed in the lower river set gillnets, of which nearly 100% will be age-.1 or -.2 males (see Coded Wire Tag Sampling section below).

### Event 2 - Recapturing

All Chinook salmon found or captured on the spawning grounds, regardless of size and that are suitable for sampling, will be counted and sampled for spaghetti tags, LAA, ULOP and lower left operculum (LLOP) punches, ASL, and adipose fin clips (see Coded Wire Tag Sampling section below for details on CWT recovery). Dip nets, rod and reel snagging gear, hands, short sections of netting, and spears (for dead fish) will be used to capture fish. In order to prevent double sampling of fish on the spawning grounds, every newly sampled fish will be given a LLOP. Additionally, each dead fish sampled will also be slashed several times with a knife through the preferred area.

Emphasis during spawning grounds surveys will be on inspecting fish for marks and collecting ASL data. Also, a count will be made of the total number of large fish seen by observers traversing an area on a single day; this count will be recorded on the Spawning Grounds Survey Form (Appendix B1) each day a survey count is made (see Study Design above for more details). The location, date, stream code (Appendix B4), survey #, surveyors, all water and weather conditions, total number of large fish, etc. will be recorded on this form. The percentage of fish the observer(s) believed were counted and why they thought so will also be recorded.

Data from fish sampled on the spawning grounds will be recorded on the Spawning Grounds Age-Sex-Length Form (Appendix B6). A Coded Wire Tag Sampling Form (Appendix B5) for each day's spawning grounds sampling for each location (e.g., Cripple Creek, Kerr Creek, etc.) must also be completed.

## Age-Sex-Length Sampling

All Chinook salmon caught in the lower river set gillnets and sampled on the spawning grounds will be sampled for ASL. Age compositions for the lower river set gillnet sampling and each escapement sampling location (tributary) will be tabulated separately using the Set Gillnet ASL and Capture Form (Appendix B3) and the Spawning Grounds ASL Form (Appendix B6). For age composition sampling, it is imperative that good scale samples be taken.

Five scales will be removed from the preferred area on the left side accordingly: 3 scales from 2 to 3 rows above the lateral line taken 1 in apart, and 2 scales 4 to 5 rows up and ½ in from one of the lower 3 scales (Welander 1940). In some cases the preferred area on the left side of the fish may be devoid of scales. In such instances, the preferred area on the right side of the fish should be sampled for scales and if this is devoid of adequate samples, then samples should be taken from the areas near the dorsal or anal fins on the left side of the fish. All scales will be carefully cleaned, mounted on scale gum cards, 5 per column, using methods described in ADF&G (*unpublished*)[1]. The gum cards will be labeled completely at the time of sampling, or shortly thereafter. Scale cards are sequentially numbered by sampling location, beginning with 001 at each sampling location. The correct ASL stream code (Appendix B4) should also be recorded on each card. Gender will be determined from secondary maturation characteristics and length will be taken to the nearest 5 mm MEF. Secondary maturation characteristics can include predominant snouts and compressiform bodies for males, abraded caudal fins (i.e., white tails) and prominent bellies for females. Scales will be cleaned and mounted neatly, without excess water, sand, or mucus. If it is not possible to mount the scales in this manner on site, then the scales will be stored in numbered plastic slide pockets and then mounted later that evening at camp with care taken to clean them properly and to label the gum cards completely, including last names of all samplers for that location for that day. If scales are not collected from a fish for any reason, note that in the comment column on the ASL form and make sure to skip that column on the gum card.

MOST IMPORTANTLY:

1) sample every Chinook salmon encountered on the spawning grounds, regardless of size, and record all data for each fish on the appropriate form;

[1] ADF&G (Alaska Department of Fish and Game). *Unpublished*. Length, sex, and scale sampling procedure for sampling using the ADF&G adult salmon age-length mark-sense form version 3.0. Division of Commercial, Douglas, AK.

2) check every fish for the presence or absence of all marks (i.e., spaghetti tags, ULOP, LLOP, LAA, adipose fin);

3) collect clean, readable scales from the preferred area (or other areas if necessary); and

4) collect heads and scales from all adipose-finclipped fish that are dead, post spawn, or <700 mm MEF.

### Coded Wire Tag Sampling

All fish sampled in the study will be inspected for adipose fin clips and sampled for ASL. The brood year of all fish (with and without adipose fins) will therefore be known and estimation of brood-year specific adipose-finclipped fractions will be possible. The large sample sizes and high value of θ (~0.1) would lead to excessive mortality if all live, adipose-finclipped fish were sacrificed to verify the presence of a valid Unuk River CWT. Therefore, only fish ≤700 mm MEF without adipose fins will be sacrificed to retrieve CWTs; this practice will be followed regardless of where or when these fish are encountered (i.e., in the event1 or event 2). This size limit for sampling live Chinook salmon will include almost all individuals through age-1.2 fish, a group that is almost exclusively male. All live, unspawned fish >700 mm MEF missing their adipose fin will be noted and released after sampling. Heads of all spawned-out fish >700 mm MEF, alive or dead, will be taken if the adipose fin is missing. Heads so collected will be given a uniquely numbered cinch strap obtained from the Division of Commercial Fisheries (DCF) Mark, Tag, and Age Laboratory, and will be attached to each head. The head will then be sent to the Mark, Tag, and Age Laboratory for dissection and decoding of tags. Results from the adipose fin clip, scale, and direct CWT sampling will be used to:

- estimate the CWT marked fraction by brood year, θ (using adipose fin clip, scale, and decoded CWT data); this fraction will be used to estimate marine harvest;
- compare ages derived from tags to ages determined from scales taken from the tagged fish (using scale and decoded CWT data);
- determine the incidence (if any) of strays from other tagged stocks (decoded CWT data);
- detect loss of CWTs (adipose fin clip and detected CWT data), and
- estimate abundance, return and survival rates of smolts and juveniles when combined with other project data analyses (adipose fin clip, scale, and decoded CWT data).

## DATA REDUCTION

It is the responsibility of the field crew leader to insure that all data are recorded on a daily basis. Data forms will be kept up to date at all times. If a computer is available in the field, data will be transferred from field forms to EXCEL®[2] database files. Otherwise, this will be performed later

[2] This product name is included for a complete description of the process and does not constitute product endorsement.

in the office. After this has been done, the original field forms will be compared with the electronic database files and error checked.

Inspection for errors will include: incorrect dates, transposed nonsensical lengths (i.e., 470 mm when the fish was actually 740 mm), correct length measurement method used (i.e., MEF or POH), etc. Scale cards will be checked to ensure that scales are clean and mounted correctly, and that the cards are correctly and completely labeled and matched up with the corresponding ASL data form. Data will be sent to the ADF&G office at regular intervals and inspected for accuracy and compliance with sampling procedures. Data will be transferred from field forms to EXCEL® database files. Scales will be pressed and ages estimated in the scale aging lab in Juneau. Scale ages will be entered into the spreadsheet files. When input is complete, data lists will be obtained and checked against the original field data. This will be performed 2 times to insure that data are error free.

The DCF Mark, Tag, and Age Laboratory is the clearinghouse for all information on CWTs. All CWT data (sampled fish, decoded tags, location, data type, samplers, etc.) are archived and accessible on a permanent ADF&G statewide database and once per year are provided to the permanent coastwide database at the Pacific States Marine Fisheries Commission. Completed CWT tagging summary and release information will be sent to the DCF Mark, Tag, and Age Laboratory, after first being given to the project leader and error checked using computer software.

A final, edited copy of the data, along with a data map, will be sent to DSF Research and Technical Services in Anchorage for electronic archiving when the report is submitted.

## DATA ANALYSIS

### Abundance-Medium or Large

Data collected in past studies (Jones III et al. 1998a; Jones and McPherson 1999, 2000, 2002; Pahlke et al. 1996) show that the marked fraction in samples collected in tributaries at the bottom of the drainage tends to be higher than in those collected from upper reaches ($\chi 2$ test of data pooled across years, $P < 0.001$, $df = 1$). We assume this result occurs because fish bound for lower river locations spend more time milling in the lower river (where the gillnet is located) than fish bound for upriver spawning areas, and are therefore subjected to a higher probability of capture. However, analysis of data pooled over years also shows that fish marked during the early, middle, and late segments of the immigration are equally likely to be recovered on the spawning grounds. Thus, we expect to estimate abundance using Chapman's (1951) nearly unbiased modification of the Petersen estimator (Seber 1982, p. 60); if the case of unequal recapture probabilities occurs in 2013, the Darroch estimator (Seber 1982, p. 433) will be used.

The abundance of large spawning Chinook salmon will be estimated using Chapman's modification of the Peterson estimator. Medium fish (≥400 mm and <660 mm MEF) will also be estimated with a Petersen estimator if a sufficiently large number of medium fish are tagged and recovered; otherwise the proportionality method, as described for small fish (<400 mm MEF) will be used. The abundance for fish of size class $k$ ($k$ = L (≥660 mm) or $k$ = M (≥400 to <660 mm) will be estimated:

$$\hat{N}_k = \frac{(n_{1k}+1)(n_{2k}+1)}{(m_{2k}+1)} - 1 \tag{1}$$

with variance estimated as:

$$\mathrm{var}(\hat{N}_k) = \frac{(n_{1k}+1)(n_{2k}+1)(n_{1k}-m_{2k})(n_{2k}-m_{2k})}{(m_{2k}+2)(m_{2k}+1)^2} \tag{2}$$

where $n_{1k}$ is the number of adults of size class *k* marked and released at SN1, $n_{2k}$ is the number of adults of size class *k* inspected for marks upstream, and $m_{2k}$ is the number in the subset of $n_{2k}$ inspected comprised of adults marked at SN1.

The conditions for accurate use of this methodology are:

a. every fish has an equal probability of being marked in event 1, or every fish has an equal probability of being captured in event 2, or marked fish mixed completely with unmarked fish in the population between events; and

b. there is no recruitment to the population between sampling events; and

c. there is no mark induced mortality; and

d. fish do not lose their marks in the time between the two events; and

e. all marked fish are recognized.

Several tests will be used to investigate assumption *a*. Size selectivity will be evaluated using two Kolmogorov-Smirnov tests ($\alpha = 0.1$, Appendix D1). If there is no size selectivity during either or both sampling events, then no stratification in estimates beyond large and medium fish is needed. If size selectivity is indicated during both sampling events for either large or medium fish, then the estimate will be further stratified for large or medium fish.

Sampling data for the experiment will be summarized and analyzed by the computer program Stratified Population Analysis System (SPAS; Arnason et al. 1996). Data will be stratified by marking period (early, middle, and late) and recovery area (upstream versus downstream) in SPAS. Pooling data over all marking and recovery strata leads to a pooled Petersen estimator, which is desired if experimental assumptions of the estimator are met. Two chi-square tests for adequacy of a pooled Petersen estimator are provided for in SPAS: 1) that immigrants marked in the different initial strata are recaptured with equal probability (the "Mixing Test" as described in Arnason et al. 1996); and 2) that marked fractions are similar in each recovery strata (the "Equal Proportions Test", as described in Arnason et al. 1996). If either of these tests yields nonsignificant results, the pooled Petersen estimator is appropriate (Arnason et al. 1996). A meta-analysis of data collected between 1997 and 2000 (as noted above) suggests the Petersen estimator has been appropriate for this experiment. If a stratified model is necessary, partial pooling of strata may be used to improve fit, provide admissible estimates, or to overcome numerical estimation problems. Goals in this case are always that animals within the pooled stratum should be as homogeneous as possible with respect to capture, migration, and recapture (Arnason et al. 1996). The estimated proportions of marked fish in each area and the physical proximity of the areas will guide partial pooling of recovery strata. Pooling of marking strata will be used to break trends in the fractions marked over time and will be guided by the size and length of the strata and environmental conditions on the river (river stage height and rainfall). A Goodness of Fit (GOF) test (provided in SPAS) that compares the observed and predicted statistics will indicate the adequacy of a stratified model. In general, pooling would be manipulated to yield admissible (non-negative) estimates, reduce the number of estimated parameters, and increase precision while finding no evidence of lack of fit. Sex selectivity will also be investigated using chi-square test equivalents of the size-selectivity tests described in Appendix D1 ($\alpha = 0.1$).

The life history of Chinook salmon isolates fish returning to the Unuk River, so recruitment into the population is not expected (assumption b). For assumption c, we assume tagged and untagged fish experience the same mortality or emigration due to natural causes. As evidence for this conclusion, 88.7% (94 of 106) and 87.1% (122 of 140) of Chinook salmon captured in 1994 and 2009, respectively, with methods similar to those proposed here and fitted with radio transmitters were found to survive to spawn (Pahlke et al. 1996; Weller and Evans 2012). Assuming that only a portion of the 11% of the tagged fish that were not found to spawn suffered handling mortality, and also that some of the handling mortality was due to radio tag implantation versus the less intrusive spaghetti tagging, it appears that effect of spaghetti tagging on survival is minimal. Also note that the estimates are germane to the time of tagging, not recapture.

Fish will be tripled marked, so any tag loss will be accounted for (assumption d). Each fish captured in the set gillnet will be checked carefully for the presence or absence of a primary mark and 2 secondary marks, and careful inspection of each fish on the spawning grounds will ensure detection of at least one of the marks (assumption e).

Bootstrapping (Efron and Tibshirani 1993), following the methods in Buckland and Garthwaite (1991), will be used to derive (potentially asymmetric) confidence intervals for the abundance estimates. The fate of the estimated $\hat{N}_k$ in the experiment will be divided into capture histories (see below) to form an empirical probability distribution (*epd*). A bootstrap sample of $\hat{N}_k$ will be drawn from the *epd* with replacement. From the resulting collection of resampled capture histories, $n_{1k}^*$, $n_{2k}^*$, $m_{2k}^*$, and $\hat{N}^*_k$ will be calculated. A large number ($B$) of bootstrap samples will be so drawn. The percentile method will be used to estimate 95% confidence intervals for abundance.

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Fates of Chinook salmon in the mark-recapture experiment.

| | | |
|---|---|---|
| 1. | Marked | and never seen again |
| 2. | Marked | and recaptured in tributaries |
| 3. | Unmarked | and unseen upstream |
| 4. | Unmarked | and inspected in tributaries |

---

## Abundance-Small

The abundance of small-sized fish (<400 mm; $k$ = S; $\hat{N}_S$ ), will be estimated indirectly:

$$\hat{N}_S = \hat{N}_L \frac{\hat{\phi}_S}{\hat{\phi}_L} \tag{3}$$

where $\hat{\phi}_K$ is the estimated fraction of $k$-sized (small or large) fish in the Chinook salmon spawning population:

$$\hat{\phi}_k = \frac{n_k}{n_{sp}} \tag{4}$$

where,

$n_{sp}$ = number of fish sampled on the spawning grounds

$n_k$ = number of $k$ -sized fish found in $n_{sp}$,

with variance estimated as:

$$\text{var}(\hat{\phi}_k) = \frac{\hat{\phi}_k(1-\hat{\phi}_k)}{n_{sp}-1} \tag{5}$$

The variance of the abundance of small fish will be estimated:

$$\text{var}(\hat{N}_S) = \hat{N}_L{}^2 \,\text{var}\left(\frac{\hat{\phi}_S}{\hat{\phi}_L}\right) + \left(\frac{\hat{\phi}_S}{\hat{\phi}_L}\right)^2 \text{var}(\hat{N}_L) - \text{var}\left(\frac{\hat{\phi}_S}{\hat{\phi}_L}\right)\text{var}(\hat{N}_L) \tag{6}$$

where by the delta method (note that $C\hat{o}v(\hat{\phi}_S, \hat{\phi}_L) = -\frac{\hat{\phi}_S \hat{\phi}_L}{n_{sp}}$ ),

$$\text{var}\left(\frac{\hat{\phi}_S}{\hat{\phi}_L}\right) \approx \left(\frac{\hat{\phi}_S}{\hat{\phi}_L}\right)^2 \left(\frac{\text{var}(\hat{\phi}_S)}{\hat{\phi}_S^2} + \frac{\text{var}(\hat{\phi}_L)}{\hat{\phi}_L^2} + \frac{2}{n_{sp}}\right) \tag{7}$$

Equations 3–7 will also be used to estimate the abundance of medium fish, with appropriate substitutions, if we recapture an insufficient number of medium fish to allow a robust mark-recapture estimate.

## Abundance-All

The abundance of all fish will be estimated as:

$$\hat{N}_{ALL} = \sum_k \hat{N}_k \tag{8}$$

If medium fish are estimated using mark recapture techniques, then:

$$\mathrm{var}(\hat{N}_{ALL}) = \sum_k \mathrm{var}(\hat{N}_k) \tag{9}$$

If medium fish are estimated using the proportionality method, then:

$$\mathrm{var}(\hat{N}_{ALL}) = \mathrm{var}(\hat{N}_L)\left[\frac{1}{\hat{\phi}_L}\right]^2 + \hat{N}_L^{\,2}\,\mathrm{var}\left[\frac{1}{\hat{\phi}_L}\right] - \mathrm{var}(\hat{N}_L)\,\mathrm{var}\left[\frac{1}{\hat{\phi}_L}\right] \tag{9}$$

where,

$$\mathrm{var}\left(\frac{1}{\hat{\phi}_L}\right) \approx \left[\frac{1}{\hat{\phi}_L}\right]^4 \mathrm{var}(\hat{\phi}_L) \tag{10}$$

## Age and Sex Composition of Escapement

Age and sex composition will be estimated separately for large, medium, and small fish. Fish ages will be determined from scales according to the procedures in (Olsen 1992). Methodology for estimation of age and sex composition will depend on whether the mark-recapture abundance estimators require further stratification beyond the large, and medium designations (i.e., further stratification within the ‘large’ or ‘medium’ size groups), as described in Appendix D1 (chi-square equivalents of the KS tests will be used to assess sex selectivity).

If the mark-recapture abundance estimators do not need to be further stratified by size (within the ‘large’ or ‘medium’ size groups), proportions by age (or by sex) for the large and medium size classes will be estimated from the appropriate sampling event(s) in which there is no evidence of selectivity. Proportions by age (or by sex) within the small size class will be estimated from the spawning ground samples. These fish are rarely caught by the set gill nets in the marking event.

The proportion of the inriver run composed of a given age *c* within a size class *k* (large (≥660 mm) medium (≥400 to <660) or small (<400 mm)) will be estimated as a binomial variable:

$$\hat{p}_{kc} = \frac{n_{kc}}{n_k}, \tag{11}$$

$$\mathrm{var}(\hat{p}_{kc}) = \frac{\hat{p}_{kc}(1-\hat{p}_{kc})}{n_k - 1} \tag{12}$$

where $n_{kc}$ is the number of Chinook salmon of age $c$ of size group $k$ in $n_k$, the number of Chinook salmon sampled of size group $k$. Numbers of fish by age will be estimated as the sum of the products of estimated age composition and estimated abundance within a size category:

$$\hat{N}_c = \sum_k (\hat{p}_{kc}\hat{N}_k) \tag{13}$$

The $\hat{N}_k$ in Eq. 8 are correlated. $\hat{N}_S$ (and possibly $\hat{N}_M$ if insufficient recaptures are found) is estimated from $\hat{N}_L$ by Eq 3. The $\mathrm{var}(\hat{N}_c)$ will therefore be estimated by simulation. The stochastic components in the simulation will be: $\hat{N}_L \sim N(\hat{N}_L, \hat{\sigma}_{\hat{N}_L})$, $\underline{\hat{\phi}} \sim multinomial(n_{sp}, \underline{\hat{\phi}})/n_{sp}$, and the vector of age-sex proportions for the $k^{th}$ size group as $\underline{\hat{p}}_k \sim multinomial(n_k, \underline{\hat{p}}_k)/n_k$. The above equations will be applied to each set of simulated values. The simulated variance of $\hat{N}_c$ will be taken as the sample variance of the simulated $\hat{N}_c$'s.

The proportion of the inriver run (overall size classes) composed of a given age will be estimated as:

$$\hat{p}_c = \frac{\hat{N}_c}{\hat{N}_{ALL}} \tag{14}$$

The $\text{var}(\hat{p}_c)$ will be estimated as the sample variance of the $\hat{p}_c$ generated in the simulation described above.

Sex composition and age-sex composition for the entire spawning population and its associated variances will be estimated using the above equations by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_g$, where $g$ denotes gender (male or female), such that $\sum_g \hat{p}_g = 1$, and by age-sex $\hat{p}_{cg}$, such that $\sum_{cg} \hat{p}_{cg} = 1$.

If selectivity is evident in both the gillnetting and spawning ground samples for either the large or medium abundance estimates in 2013, such that stratification is recommended, but the experiment fails to recapture enough marked fish on the spawning grounds to allow stratification, then the techniques of Pahlke et al. (1996, Appendix E2) will be used to estimate age and sex composition.

Standard sample summary statistics will be used to calculate estimates of mean length at age and its variance (Cochran 1977).

## Expansion Factor

An expansion factor will be calculated to expand past survey counts in the Unuk River when no other escapement estimate was available. The methods used in Appendix C1 will be used for this purpose.

## Estimation of Fraction of Adults Bearing Coded Wire Tags

Experience has shown that estimates of the proportion of adults from a given brood year with CWTs does not change appreciably over return years, and thus the fraction of adults from brood year *i* that are marked with a CWT will be estimated from pooled data as:

$$\hat{\theta}_i = \frac{\sum_{j=1}^{L} a_j \hat{\rho}_j}{\sum_{j=1}^{L} n_j} \tag{15}$$

where

$a_j =$ number of adipose fin clips observed in returning adults in year *j*;

$\hat{\rho}_j = \frac{x_j}{s_j} =$ estimated proportion of sacrificed adults with adipose fin clips in year *j* ($s_j$) that also possess a valid CWT ($x_j$);

$n_j =$ number of adults examined for adipose fin clips in year *j*; and

$L =$ number of years over which fish from a given brood year return (maximum = 5).

The variance of $\hat{\theta}_i$ will be estimated by simulation. For each year of recovery *j*:

- Adipose fin clips will be generated: $a_j^*$~binomial($n_j$, $a_j/n_j$)
- CWTs will be generated: $x_j^*$~hypergeometric (m= $\hat{\rho}_j a_j^*$, n= $a_j^*$- $\hat{\rho}_j a_j^*$, k = $a_j^* s_j/a_j$); parameter notation (m, n, and k) is as described in R (The R Foundation for Statistical Computing).

$\rho_j^*$ will then be calculated as $\rho_j^* = \frac{x_j}{s_j / a_j \, a_j^*}$, and $\hat{\theta}_i^*$ as:

$$\hat{\theta}_i^* = \frac{\sum_{j=1}^{L} a_j^* \rho_j^*}{\sum_{j=1}^{L} n_j} \qquad (16)$$

Many values of $\hat{\theta}_i^*$ will be simulated and the variance of $\hat{\theta}_i$ estimated as the sample variance of the simulated values.

# SCHEDULE AND DELIVERABLES

Adult tagging efforts will begin approximately June 18 and end approximately 1 August. Spawning grounds work is scheduled from late July through August. Raw field data will be entered and error checked by November 30, 2013. An ADF&G Fishery Data Series report will be prepared by June 1, 2014

# RESPONSIBILITIES

Todd Johnson, Fisheries Biologist II (project leader)

Duties: This position is responsible for supervising all aspects of the project, including planning, budget, sample design, permits, equipment, personnel, and training. Supervises Dreyer, Sanguinetti, and the three vacant technician positions; will adjust field operations with their consultation. Maintains regular contact with field crew. Will track budget and stay within allocations. Will analyze all smolt and harvest contribution data and will be the lead author on reports. May assist with fieldwork and will arrange logistics with field crew and Sanguinetti. Will conduct a start-of-project meeting with the field crew and Sanguinetti. Follows departmental and state policy in all matters.

David Evans, Biometrician III

Duties: Provides input to and approves the sampling design. Reviews and provides biometric support for operational plan, data analysis, and final report.

Philip Richards, FB III

Duties: Supervises Johnson. Will oversee or assign aerial Chinook salmon index surveys and may assist with field work.

Ed Jones, Salmon Research Coordinator

Duties: This position is the Salmon Research Coordinator for salmon stock assessment and provides program and budget planning oversight. Also reviews the operational plan, data analysis, and final report.

Micah Sanguinetti, Fish and Wildlife Technician IV (project expeditor)

Duties: This position serves as the assistant project leader and is responsible for expediting project activities from Ketchikan, from June 1 through the end of the project. Responsible for daily radio call, arranging logistics with field crew and project leader, purchasing supplies, loading and unloading supply planes, proper conduct in the public's eye, and following department guidelines supplied by the project leader. Responsible for supervising field crew in absence of Johnson, assists with field operations as necessary, makes recommendations on logistics to the project leader, adjusts personnel hours and schedules as appropriate. Enters field data into spreadsheets and edits and summarizes data.

David Dreyer, Fish and Wildlife Technician IV (crew leader)

Duties: This position is responsible for directing all field aspects of the project under directions from the project leader. Will ensure that all crew members are trained in the proper operation of all aspects of the project including boating safety, fish handling, data collection and recording, conduct in the public's eye, and adherence to department policies. Position will be responsible for equipment maintenance and proper operation, fieldwork schedules, scheduling of flights with Sanguinetti, and submitting data accurately and timely. With the project leader and Sanguinetti, will attempt to resolve as many personnel and administrative items as is possible and is responsible for submitting inventories at the end of the season to Sanguinetti. This position is also responsible for reports to be submitted to the project leader weekly, and daily satellite phone calls or emails to Sanguinetti and Johnson. Position functions as lead technician on the morning set net crew. Follows departmental and state policy in all matters.

Vacant, Fish and Wildlife Technician III.

Duties: This position is responsible for assisting in all aspects of escapement spawning grounds sampling including safe operation of riverboats and all other equipment and various data collection and conduct in the public's eye. Follows departmental and state policy in all matters.

Vacant, Fish and Wildlife Technician III.

Duties: This position is responsible for assisting in all aspects of escapement spawning grounds sampling including safe operation of riverboats and all other equipment and various data collection and conduct in the public's eye. Follows departmental and state policy in all matters.

Vacant, Fish and Wildlife Technician II.

Duties: This position is responsible for assisting in all aspects of adult tagging and escapement spawning grounds sampling including safe operation of riverboats and all other equipment and various data collection, and conduct in the public's eye. Follows departmental and state policy in all matters.

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# APPENDIX A

Appendix A1.–Numbers of Unuk River Chinook salmon fall fry and spring smolt captured and tagged with coded wire tags, 1992 brood year to present.

| Brood year | Year tagged | Fall/ spring | Tag code | Dates tagged | Number of Chinook salmon released with adipose clips | Estimated number of Chinook salmon released with valid CWTs and adipose clips |
|---|---|---|---|---|---|---|
| 1992 | 1993 | Fall | 04-38-03 | 10/13–10/22/93 | 10,304 | 10,263 |
| 1992 | 1993 | Fall | 04-38-04 | 10/25/1993 | 439 | 433 |
| 1992 | 1993 | Fall | 04-38-05 | 10/16–10/21/93 | 3,192 | 3,093 |
| 1992 | 1994 | Spring | 04-42-06 | 5/05–5/23/94 | 2,642 | 2,642 |
| 1992 brood year total | | | | | 16,577 | 16,431 |
| 1993 | 1994 | Fall | 04-33-49 | 10/07–10/24/94 | 1,706 | 1,700 |
| 1993 | 1994 | Fall | 04-33-50 | 10/07–10/22/94 | 11,152 | 11,139 |
| 1993 | 1994 | Fall | 04-35-57 | 10/22–11/01/94 | 7,688 | 7,687 |
| 1993 | 1995 | Spring | 04-42-13 | 4/10–5/05/95 | 3,227 | 3,227 |
| 1993 brood year total | | | | | 23,773 | 23,753 |
| 1994 | 1995 | Fall | 04-35-56 | 10/07–10/10/95 | 11,537 | 11,476 |
| 1994 | 1995 | Fall | 04-35-58 | 10/11–10/16/65 | 11,645 | 11,645 |
| 1994 | 1995 | Fall | 04-35-59 | 10/17–10/24/95 | 11,100 | 10,825 |
| 1994 | 1995 | Fall | 04-42-31 | 10/25–10/26/95 | 6,324 | 6,260 |
| 1994 | 1996 | Spring | 04-42-07 | 4/13–4/23/96 | 6,099 | 6,099 |
| 1994 | 1996 | Spring | 04-42-08 | 4/23–4/27/96 | 1,357 | 1,357 |
| 1994 brood year total | | | | | 48,062 | 47,662 |
| 1995 | 1996 | Fall | 04-47-12 | 9/30–9/15/96 | 24,224 | 24,224 |
| 1995 | 1996 | Fall | 04-42-36 | 10/16–10/19/96 | 11,200 | 11,200 |
| 1995 | 1996 | Fall | 04-42-18 | 10/20–10/21/96 | 3,753 | 3,753 |
| 1995 | 1997 | Spring | 04-38-29 | 3/31–4/18/97 | 12,517 | 12,517 |
| 1995 brood year total | | | | | 51,694 | 51,694 |
| 1996 | 1997 | Fall | 04-47-13 | 10/04–10/11/97 | 24,303 | 24,176 |
| 1996 | 1997 | Fall | 04-47-14 | 10/06–10/11/97 | 22,975 | 22,583 |
| 1996 | 1997 | Fall | 04-47-15 | 10/11–10/20/97 | 15,396 | 15,146 |
| 1996 | 1998 | Spring | 04-46-46 | 3/29-–4/05/98 | 11,188 | 11,134 |
| 1996 | 1998 | Spring | 04-43-39 | 4/08–4/13/98 | 5,987 | 5,987 |
| 1996 brood year total | | | | | 79,849 | 79,026 |
| 1997 | 1998 | Fall | 04-01-39 | 10/04–10/13/98 | 22,374 | 22,366 |
| 1997 | 1998 | Fall | 04-01-40 | 10/13–10/23/98 | 11,640 | 11,522 |
| 1997 | 1999 | Spring | 04-01-44 | 4/08–5/01/99 | 7,948 | 7,948 |
| 1997 brood year total | | | | | 41,962 | 41,836 |
| 1998 | 1999 | Fall | 04-01-42 | 10/04–10/17/99 | 16,661 | 16,661 |
| 1998 | 2000 | Spring | 04-02-56 | 4/01–4/27/00 | 11,124 | 11,124 |
| 1998 | 2000 | Spring | 04-02-57 | 4/29–5/4/00 | 2,209 | 2,209 |
| 1998 brood year total | | | | | 29,994 | 29,994 |
| 1999 | 2000 | Fall | 04-03-74 | 10/06–10/20/00 | 21,853 | 21,853 |
| 1999 | 2000 | Fall | 04-02-88 | 10/20–10/29/00 | 10,072 | 10,072 |
| 1999 | 2001 | Spring | 04-01-45 | 4/2–4/23/01 | 16,561 | 16,561 |
| 1999 brood year total | | | | | 48,486 | 48,486 |

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Appendix A1.–Page 2 of 3.

| Brood year | Year tagged | Fall/ spring | Tag code | Dates tagged | Number of Chinook salmon released with adipose clips | Estimated number of Chinook salmon released with valid CWTs and adipose clips |
|---|---|---|---|---|---|---|
| 2000 | 2001 | Fall | 04-02-92 | 9/29–10/05/01 | 10,950 | 10,950 |
| 2000 | 2001 | Fall | 04-04-57 | 10/05–10/09/01 | 11,231 | 11,231 |
| 2000 | 2001 | Fall | 04-04-58 | 10/09–10/14/01 | 11,223 | 11,200 |
| 2000 | 2001 | Fall | 04-04-60 | 10/14–10/23/01 | 10,990 | 10,990 |
| 2000 | 2002 | Spring | 04-05-38 | 4/4–4/24/02 | 10,904 | 10,904 |
| 2000 | 2002 | Spring | 04-05-39 | 4/25–4/26/02 | 1,067 | 1,067 |
| 2000 brood year total | | | | | 56,365 | 56,342 |
| 2001 | 2002 | Fall | 04-05-23 | 9/28–10/05/02 | 11,402 | 11,402 |
| 2001 | 2002 | Fall | 04-05-24 | 10/05–10/13/02 | 11,538 | 11,538 |
| 2001 | 2002 | Fall | 04-05-25 | 10/13–10/17/02 | 11,778 | 11,778 |
| 2001 | 2002 | Fall | 04-05-26 | 10/17–10/20/02 | 11,425 | 11,425 |
| 2001 | 2002 | Fall | 04-46-52 | 10/20–10/25/02 | 8,403 | 8,403 |
| 2001 | 2003 | Spring | 04-08-07 | 4/8–5/10/03 | 11,354 | 11,354 |
| 2001 | 2003 | Spring | 04-08-03 | 5/10/2003 | 483 | 483 |
| 2001 brood year total | | | | | 66,383 | 66,383 |
| 2002 | 2003 | Fall | 04-08-42 | 9/29–10/10/03 | 23,255 | 23,255 |
| 2002 | 2003 | Fall | 04-08-10 | 10/10–10/14/03 | 11,464 | 11,464 |
| 2002 | 2003 | Fall | 04-04-61 | 10/14-–10/18/03 | 9,779 | 9,779 |
| 2002 | 2004 | Spring | 04-09-75 | 03/29–04/10/04 | 11,666 | 11,666 |
| 2002 | 2004 | Spring | 04-09-76 | 04/10–04/17/04 | 2,730 | 2,730 |
| 2002 brood year total | | | | | 58,894 | 58,894 |
| 2003 | 2004 | Fall | 04-09-77 | 9/19–10/03/04 | 11,789 | 11,789 |
| 2003 | 2004 | Fall | 04-09-78 | 10/03–10/19/04 | 11,417 | 11,417 |
| 2003 | 2004 | Fall | 04-09-81 | 10/19–10/21/04 | 3,923 | 3,923 |
| 2003 | 2005 | Spring | 04-09-80 | 4/10–4/28/05 | 8,618 | 8,585 |
| 2003 brood year total | | | | | 35,747 | 35,714 |
| 2004 | 2005 | Fall | 04-11-55 | 9/24–10/18/05 | 23,330 | 23,330 |
| 2004 | 2005 | Fall | 04-11-56 | 10/18/05 | 941 | 941 |
| 2004 | 2006 | Spring | 04-11-52 | 4/2–4/23/06 | 16,371 | 16,269 |
| 2004 brood year total | | | | | 40,642 | 40,540 |
| 2005 | 2006 | Fall | 04-13-05 | 10/3–10/12/06 | 23,406 | 23,406 |
| 2005 | 2006 | Fall | 04-11-51 | 10/12–10/19/06 | 9,393 | 9,393 |
| 2005 | 2007 | Spring | 04-12-81 | 4/9–4/27/07 | 4,731 | 4,721 |
| 2005 brood year total | | | | | 37,530 | 37,520 |
| 2006 | 2007 | Fall | 04-12-82 | 9/30–10/03/07 | 11,777 | 11,777 |
| 2006 | 2007 | Fall | 04-12-83 | 10/03–10/07/07 | 11,716 | 11,716 |
| 2006 | 2007 | Fall | 04-12-84 | 10/07–10/13/07 | 11,756 | 11,756 |
| 2006 | 2007 | Fall | 04-12-85 | 10/13–10/21/07 | 9,840 | 9,840 |
| 2006 | 2008 | Spring | 04-14-62 | 4/19–4/27/08 | 10,489 | 10,489 |
| 2006 brood year total | | | | | 55,578 | 55,578 |
| 2007 | 2008 | Fall | 04-14-65 | 10/03–10/21/08 | 16,595 | 16,595 |
| 2007 | 2009 | Spring | 04-14-63 | 4/17–5/02/09 | 5,578 | 5,573 |
| 2007 brood year total | | | | | 22,173 | 22,168 |

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Appendix A1.–Page 3 of 3.

| Brood year | Year tagged | Fall/ spring | Tag code | Dates tagged | Number of Chinook salmon released with adipose clips | Estimated number of Chinook salmon released with valid CWTs and adipose clips |
|---|---|---|---|---|---|---|
| 2008 | 2009 | Fall | 04-13-87 | 9/28–10/01/09 | 10,963 | 10,933 |
| 2008 | 2009 | Fall | 04-13-88 | 10/02–10/05/09 | 11,289 | 11,289 |
| 2008 | 2009 | Fall | 04-13-89 | 10/05–-10/09/09 | 11,556 | 11,556 |
| 2008 | 2009 | Fall | 04-13-85 | 10/09–10/14/09 | 11,149 | 11,149 |
| 2008 | 2010 | Spring | 04-13-86 | 4/9–4/24/10 | 8,190 | 8,190 |
| 2008 brood year total | | | | | 53,147 | 53,117 |
| 2009 | 2010 | Fall | 04-13-90 | 9/26–10/17/10 | 11,630 | 11,619 |
| 2009 | 2010 | Fall | 04-09-95 | 10/17–10/22/10 | 4,117 | 4,115 |
| 2009 | 2011 | Spring | 04-09-99 | 4/11–4/27/11 | 10,216 | 10,216 |
| 2009 brood year total | | | | | 25,950 | 25,950 |
| 2010 | 2011 | Fall | 04-09-93 | 10/05–10/09/09 | 11,466 | 11,466 |
| 2010 | 2011 | Fall | 04-09-94 | 10/09–10/14/09 | 2,211 | 2,211 |
| 2010 | 2012 | Spring | 04-14-66 | 4/16–4/28/12 | 3,942 | 3,942 |
| 2010 brood year total | | | | | 17,619 | 17,619 |
| 2011 | 2012 | Fall | 04-09-91 | 10/3–10/8/12 | 10,364 | 10,364 |
| 2011 | 2012 | Fall | 04-14-67 | 9-27–10/10/12 | 3,292 | 3,292 |
| 2011 | 2013 | Spring | – | – | | – |
| 2011 brood year total | | | | | 13,656 | 13,656 |

[a] *Note*: An en-dash (–) indicates the data were not available at the time of plan preparation.

Appendix A2.–Numbers of adult Unuk River Chinook salmon examined for adipose finclips, sacrificed for coded wire tag sampling purposes, valid coded wire tags decoded, percent of the marked fraction carrying germane coded wire tags, percent adipose clipped, and estimated fraction of the sample carrying valid coded wire tags, 1992 brood year to present (2010 return year).

| Brood year | Age class | Year examined | Number examined | Adipose clips | Number sacrificed | Number of valid tags: Fall | Spring | Total | Valid adipose clips (%) | Percent adipose clips (%) | Marked fraction (q): Valid (%) | Event |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 | 1.2 | 1996 | 33 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1992 | 1.3 | 1997 | 436 | 11 | 11 | 10 | 1 | 11 | 100.0 | 2.5 | 2.5 | 1&2 |
| 1992 | 2.2 | 1997 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | –! | 1&2 |
| 1992 | 1.4 | 1998 | 324 | 15 | 11 | 4 | 4 | 8 | 72.7 | 4.6 | 3.4 | 1&2 |
| 1992 | 1.5 | 1999 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | –! | 1&2 |
| 1992 brood year total | | | 795 | 26 | 22 | 14 | 5 | 19 | 86.4 | 3.3 | 2.8 | 1&2 |
| 1993 | 1.1 | 1996 | 4 | 1 | 1 | 1 | 0 | 1 | 100.0 | 25.0 | 25.0 | 1&2 |
| 1993 | 1.2 | 1997 | 300 | 35 | 35 | 28 | 3 | 31 | 88.6 | 11.7 | 10.3 | 1&2 |
| 1993 | 1.3 | 1998 | 736 | 63 | 48 | 36 | 8 | 44 | 91.7 | 8.6 | 7.8 | 1&2 |
| 1993 | 2.2 | 1998 | 1 | 0 | 0 | 0 | 0 | 0 | –! | 0.0 | – | 1&2 |
| 1993 | 1.4 | 1999 | 325 | 34 | 19 | 14 | 4 | 18 | 94.7 | 10.5 | 9.9% | 1&2 |
| 1993 | 1.5 | 2000 | 9 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1993 brood year total | | | 1,375 | 133 | 103 | 79 | 15 | 94 | 91.3 | 9.7 | 8.8 | 1&2 |
| 1994 | 1.1 | 1997 | 56 | 4 | 4 | 2 | 2 | 4 | 100.0 | 7.1 | 7.1 | 1&2 |
| 1994 | 1.2 | 1998 | 311 | 31 | 28 | 14 | 11 | 25 | 89.3 | 10.0 | 8.9 | 1&2 |
| 1994 | 2.1 | 1998 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1994 | 1.3 | 1999 | 421 | 45 | 14 | 6 | 5 | 11 | 78.6 | 10.7 | 8.4 | 1&2 |
| 1994 | 1.4 | 2000 | 247 | 12 | 7 | 3 | 3 | 6 | 85.7 | 4.9 | 4.2 | 1&2 |
| 1994 | 1.5 | 2001 | 4 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1994 brood year total | | | 1,040 | 92 | 53 | 25 | 21 | 46 | 86.8 | 8.8 | 7.7 | 1&2 |
| 1995 | 1.1 | 1998 | 81 | 15 | 14 | 8 | 5 | 13 | 92.9 | 18.% | 17.2 | 1&2 |
| 1995 | 0.2 | 1998 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1995 | 1.2 | 1999 | 462 | 54 | 45 | 29 | 16 | 45 | 100.0 | 11.7 | 11.7 | 1&2 |
| 1995 | 1.3 | 2000 | 742 | 77 | 20 | 9 | 7 | 16 | 80.0 | 10.4 | 8.3% | 1&2 |
| 1995 | 1.4 | 2001 | 512 | 53 | 19 | 12 | 7 | 19 | 100.0 | 10.4 | 10.4% | 1&2 |
| 1995 | 1.5 | 2002 | 6 | 1 | 1 | 1 | 0 | 1 | 100.0 | 16.7 | 16.7 | 1&2 |
| 1995 | 2.4 | 2002 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1995 brood year total | | | 1,805 | 200 | 99 | 59 | 35 | 94 | 94.9 | 11.1 | 10.5 | 1&2 |
| 1996 | 0.1 | 1998 | 2 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1996 | 1.1 | 1999 | 65 | 6 | 6 | 4 | 1 | 5 | 83.3 | 9.2 | 7.7 | 1&2 |
| 1996 | 1.2 | 2000 | 541 | 69 | 49 | 33 | 14 | 47 | 95.9% | 12.8 | 12.2 | 1&2 |
| 1996 | 1.3 | 2001 | 1,177 | 137 | 43 | 27 | 11 | 38 | 88.4 | 11.6 | 10.3 | 1&2 |
| 1996 | 1.4 | 2002 | 551 | 58 | 15 | 11 | 4 | 15 | 100.0 | 10.5 | 10.5 | 1&2 |
| 1996 | 1.5 | 2003 | 7 | 1 | 0 | 0 | 0 | 0 | – | 14.3 | – | 1&2 |
| 1996 brood year total | | | 2,343 | 271 | 113 | 75 | 30 | 105 | 92.9 | 11.6 | 10.7 | 1&2 |

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Appendix A2.–Page 2 of 4.

| Brood year | Age class | Year examined | Number examined | Adipose clips | Number sacrificed | Number of valid tags Fall | Spring | Total | Valid adipose clips (%) | Percent adipose clips (%) | Marked fraction (q) Valid (%) | Event |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1997 | 1.1 | 2000 | 12 | 1 | 1 | 0 | 1 | 1 | 100.0 | 8.3 | 8.3 | 1&2 |
| 1997 | 1.2 | 2001 | 189 | 26 | 23 | 12 | 5 | 17 | 73.9 | 13.8 | 10.2 | 1&2 |
| 1997 | 0.4 | 2002 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1997 | 1.3 | 2002 | 598 | 56 | 7 | 4 | 3 | 7 | 100.0 | 9.4 | 9.4 | 1&2 |
| 1997 | 2.2 | 2002 | 1 | 0 | 0 | 0 | 0 | 0 | –! | 0.0 | – | 1&2 |
| 1997 | 1.4 | 2003 | 379 | 31 | 6 | 4 | 0 | 4 | 66.7 | 8.2 | 5.5 | 1&2 |
| 1997 | 1.5 | 2004 | 6 | 2 | 0 | 0 | 0 | 0 | – | 33.3 | – | 1&2 |
| 1997 brood year total | | | 1,186 | 116 | 37 | 20 | 9 | 29 | 78.4 | 9.8 | 7.7 | 1&2 |
| 1998 | 1.1 | 2001 | 31 | 3 | 3 | 0 | 3 | 3 | 100.0 | 9.7 | 9.7 | 1&2 |
| 1998 | 1.2 | 2002 | 419 | 26 | 21 | 12 | 9 | 21 | 100.0 | 6.2 | 6.2 | 1&2 |
| 1998 | 0.4 | 2003 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1998 | 1.3 | 2003 | 1,112 | 117 | 28 | 11 | 17 | 28 | 100.0 | 10.5 | 10.5 | 1&2 |
| 1998 | 2.2 | 2003 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1998 | 1.4 | 2004 | 542 | 51 | 1 | 1 | 0 | 1 | 100.0 | 9.4 | 9.4 | 1&2 |
| 1998 | 1.5 | 2005 | 6 | 1 | 0 | 0 | 0 | 0 | – | 16.7 | – | 1&2 |
| 1998 brood year total | | | 2,112 | 198 | 53 | 24 | 29 | 53 | 100.0 | 9.4 | 9.4 | 1&2 |
| 1999 | 0.2 | 2002 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1999 | 1.1 | 2002 | 3 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1999 | 1.2 | 2003 | 147 | 15 | 13 | 7 | 5 | 12 | 92.3 | 10.2 | 9.4 | 1&2 |
| 1999 | 1.3 | 2004 | 396 | 49 | 3 | 2 | 1 | 3 | 100.0 | 12.4 | 12.4 | 1&2 |
| 1999 | 2.3 | 2005 | 4 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1999 | 1.4 | 2005 | 200 | 15 | 6 | 1 | 3 | 4 | 66.7 | 7.5 | 5.0 | 1&2 |
| 1999 | 1.5 | 2006 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 1999 brood year total | | | 752 | 79 | 22 | 10 | 9 | 19 | 86.4% | 10.5 | 9.1 | 1&2 |
| 2000 | 1.1 | 2003 | 72 | 4 | 4 | 2 | 2 | 4 | 100.0% | 5.6 | 5.6 | 1&2 |
| 2000 | 1.2 | 2004 | 804 | 62 | 52 | 29 | 22 | 51 | 98.1% | 7.7 | 7.6% | 1&2 |
| 2000 | 2.2 | 2005 | 1 | 1 | 1 | 1 | 0 | 1 | 100.0 | 100.0 | 100.0 | 1&2 |
| 2000 | 1.3 | 2005 | 1,158 | 107 | 15 | 10 | 3 | 13 | 86.7 | 9.2 | 8.0 | 1&2 |
| 2000 | 1.4 | 2006 | 529 | 46 | 2 | 2 | 0 | 2 | 100.0% | 8.7 | 8.7 | 1&2 |
| 2000 | 2.3 | 2006 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2000 | 1.5 | 2007 | 8 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2000 brood year total | | | 2,573 | 220 | 74 | 44 | 27 | 71 | 95.9% | 8.6% | 8.2% | 1&2 |
| 2001 | 1.1 | 2004 | 36 | 7 | 7 | 5 | 2 | 7 | 100.0 | 19.4 | 19.4 | 1&2 |
| 2001 | 1.2 | 2005 | 186 | 20 | 17 | 11 | 5 | 16 | 94.1 | 10.8 | 10.1 | 1&2 |
| 2001 | 1.3 | 2006 | 618 | 57 | 7 | 5 | 1 | 6 | 85.7 | 9.2 | 7.9 | 1&2 |
| 2001 | 2.2 | 2006 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2001 | 1.4 | 2007 | 272 | 29 | 4 | 2 | 2 | 4 | 100.0 | 10.7 | 10.7 | 1&2 |
| 2001 | 2.3 | 2007 | 2 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2001 | 1.5 | 2008 | 4 | 1 | 1 | 0 | 0 | 0 | 0.0 | 25.0 | 0.0 | 1&2 |
| 2001 brood year total | | | 1,119 | 114 | 36 | 23 | 10 | 33 | 91.7 | 10.2 | 9.3 | 1&2 |

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| Brood year | Age class | Year examined | Number examined | Adipose clips | Number sacrificed | Number of valid tags Fall | Spring | Total | Valid adipose clips (%) | Percent adipose clips (%) | Marked fraction (q) Valid (%) | Event |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2002 | 1.1 | 2005 | 70 | 5 | 5 | 1 | 1 | 2 | 40.0 | 7.1 | 2.9 | 1&2 |
| 2002 | 1.2 | 2006 | 794 | 58 | 46 | 21 | 14 | 35 | 76.1 | 7.3 | 5.6 | 1&2 |
| 2002 | 1.3 | 2007 | 1,266 | 120 | 19 | 10 | 4 | 14 | 73.7 | 9.5 | 7.0 | 1&2 |
| 2002 | 1.4 | 2008 | 423 | 48 | 4 | 3 | 0 | 3 | 75.0 | 11.3 | 8.5 | 1&2 |
| 2002 | 1.5 | 2009 | 4 | 1 | 0 | 0 | 0 | 0 | – | 25.0 | – | 1&2 |
| 2002 brood year total | | | 2,557 | 232 | 74 | 35 | 19 | 54 | 73.0 | 9.1 | 6.6 | 1&2 |
| 2003 | 1.1 | 2006 | 28 | 2 | 2 | 1 | 1 | 2 | 100.0 | 7.1 | 7.1 | 1&2 |
| 2003 | 1.2 | 2007 | 218 | 22 | 21 | 8 | 10 | 18 | 85.7 | 10.1 | 8.7 | 1&2 |
| 2003 | 2.1 | 2007 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2003 | 1.3 | 2008 | 324 | 30 | 2 | 1 | 1 | 2 | 100.0 | 9.3 | 9.3 | 1&2 |
| 2003 | 1.4 | 2009 | 151 | 14 | 3 | 1 | 2 | 3 | 100.0 | 9.3 | 9.3 | 1&2 |
| 2003 | 2.3 | 2009 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2003 | 1.5 | 2010 | 3 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2003 brood year total | | | 726 | 68 | 28 | 11 | 14 | 25 | 89.3 | 9.4 | 8.4 | 1&2 |
| 2004 | 0.2 | 2007 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2004 | 0.2 | 2007 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0% | – | 1&2 |
| 2004 | 1.1 | 2007 | 38 | 5 | 5 | 2 | 3 | 5 | 100.0 | 13.2 | 13.2% | 1&2 |
| 2004 | 0.3 | 2008 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2004 | 1.2 | 2008 | 216 | 18 | 14 | 4 | 4 | 8 | 57.1 | 8.3 | 4.8 | 1&2 |
| 2004 | 1.3 | 2009 | 581 | 57 | 15 | 4 | 5 | 9 | 60.0% | 9.8 | 5.9 | 1&2 |
| 2004 | 2.3 | 2010 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2004 | 1.4 | 2010 | 161 | 7 | 2 | 1 | 1 | 2 | 100.0 | 4.3 | 4.3 | 1&2 |
| 2004 | 1.5 | 2011 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2004 brood year total | | | 1,000 | 87 | 36 | 11 | 13 | 24 | 66.7 | 8.7 | 5.8 | 1&2 |
| 2005 | 0.1 | 2007 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2005 | 1.1 | 2008 | 25 | 2 | 2 | 2 | 0 | 2 | 100.0 | 8.0 | 8.0 | 1&2 |
| 2005 | 1.2 | 2009 | 582 | 44 | 43 | 20 | 16 | 36 | 83.7 | 7.6 | 6.3 | 1&2 |
| 2005 | 2.2 | 2010 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2005 | 1.3 | 2010 | 663 | 51 | 7 | 5 | 1 | 6 | 85.7 | 7.7 | 6.6 | 1&2 |
| 2005 | 1.4 | 2011 | 143 | 16 | 2 | 2 | 0 | 2 | 100.0 | 11.2 | 11.2 | 1&2 |
| 2005 | 1.5 | 2012 | 0 | 0 | 0 | 0 | 0 | 0 | – | – | – | 1&2 |
| 2005 brood year total | | | 1,415 | 113 | 54 | 29 | 17 | 46 | 85.2% | 8.0% | 6.8% | 1&2 |
| 2006 | 1.1 | 2009 | 20 | 2 | 2 | 1 | 0 | 1 | 50.0 | 10.0 | 5.0 | 1&2 |
| 2006 | 0.3 | 2010 | 1 | 0 | 0 | 0 | 0 | 0 | – | 0.0 | – | 1&2 |
| 2006 | 1.2 | 2010 | 222 | 13 | 12 | 7 | 3 | 10 | 83.3 | 5.9 | 4.9 | 1&2 |
| 2006 | 1.3 | 2011 | 354 | 17 | 5 | 5 | 0 | 5 | 100.0 | 4.8 | 4.8 | 1&2 |
| 2006 | 1.4 | 2012 | 44 | 4 | 3 | 2 | 1 | 3 | 100.0 | 9.1 | 9.1 | 1&2 |
| 2006 | 1.5 | 2013 | | | | | | | – | – | – | 1&2 |
| 2006 brood year total | | | 641 | 36 | 22 | 15 | 4 | 19 | 86.4% | 5.6% | 4.9% | 1&2 |
| 2007 | 1.1 | 2010 | 23 | 1 | 1 | 1 | 0 | 1 | 100.0 | 4.3 | 4.3 | 1&2 |
| 2007 | 1.2 | 2011 | 172 | 5 | 5 | 3 | 1 | 4 | 80.0 | 2.9 | 2.3 | 1&2 |
| 2007 | 1.3 | 2012 | 199 | 8 | 2 | 1 | 1 | 2 | 100.0 | 4.0 | 4.0 | 1&2 |
| 2007 | 1.4 | 2013 | | | | | | | – | – | – | 1&2 |
| 2007 | 1.5 | 2014 | | | | | | | – | – | – | 1&2 |

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Appendix A2.–Page 4 of 4.

| Brood year | Age class | Year examined | Number examined | Adipose clips | Number sacrificed | Number of valid tags Fall | Spring | Total | Valid adipose clips (%) | Percent adipose clips (%) | Marked fraction (q) Valid (%) | Event |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 brood year total | | | 394 | 14 | 8 | 5 | 2 | 7 | 87.5 | 3.6 | 3.1 | 1&2 |
| 2008 | 1.1 | 2011 | 11 | 0 | 0 | 0 | 0 | 0 | – | – | – | 1&2 |
| 2008 | 1.2 | 2012 | 117 | 16 | 16 | 5 | 10 | 15 | 93.8 | 13.7 | 12.8 | 1&2 |
| 2008 | 1.3 | 2013 | – | – | – | – | – | – | – | – | – | 1&2 |
| 2008 | 1.4 | 2014 | – | – | – | – | – | – | – | – | – | 1&2 |
| 2008 | 1.5 | 2015 | – | – | – | – | – | – | – | – | – | 1&2 |
| 2008 brood year total | | | 128 | 16 | 16 | 5 | 10 | 15 | 93.8 | 12.5 | 11.7 | 1&2 |
| 2009 | 1.1 | 2012 | 23 | 1 | 1 | 0 | 1 | 1 | 100.0 | 4.3 | 4.3 | 1&2 |
| 2009 | 1.2 | 2013 | – | – | – | – | – | – | – | – | – | 1&2 |
| 2009 | 1.3 | 2014 | – | – | – | – | – | – | – | – | – | 1&2 |
| 2009 | 1.4 | 2015 | – | – | – | – | – | – | – | – | – | 1&2 |
| 2009 | 1.5 | 2016 | – | – | – | – | – | – | – | – | – | 1&2 |
| 2009 brood year total | | | 23 | 1 | 1 | 0 | 1 | 1 | 100.0 | 4.3 | 4.3 | 1&2 |

[a] *Note*: An en-dash (–) either indicates that the quantity could not be calculated (division by zero), or the data have not been collected yet.

# APPENDIX B

Appendix B1.–Unuk River spawning ground survey form, 2013.

Location ***Cripple Creek*** (101-75-10300-2030) Date ***August 8, 2013***

Survey Number ***1st*** (1st or 2nd, etc.)

Surveyors: **Dave Magnus**

Water Conditions (Clarity, Water Level, Temp., etc.:

***Clear, low, temperature of 40°F***

Weather Conditions: ***Sky partly cloudy, wind calm, sunlight is good for visibility, and tons of bugs***

A. Total number of large-size fish counted ***Counted 72 large fish; saw 12 jacks (also 2 sockeyes, and lots of Dolly's)***

B. Rate survey conditions on a scale of 1-10 (10=Best) **8**

C. What % of the fish present do you think you counted? **85%**

Why? ***Because the visibility was so good and the fish were spread out and not spooked; the low water helped quite a bit too.***

D. Percent of fish counted that were fresh **10%**

E. Percent of fish counted that were spawned out **35%**

F. Percent of fish counted that were dead **5%**

G. Predation ***There was quite a lot of bear sign including dead fish along the banks; eagles were doing a good job of cleaning up after the bears; Dolly's were everywhere***

Other notes and comments: ***A large pool has formed at the base of a fresh deadfall spruce that fell near the mouth; a few fish were present but likely more will move in.***

Appendix B2.–Unuk River set gillnet recording form, 2013.

| Date | Location | Crew | Water Temp. | Water Depth | Weather Comments |
|---|---|---|---|---|---|
| | | | | | *Sunny, clear skies, calm wind* |
| *7/2* | *SN1* | *Magnus, Schantz* | *8* | *62"* | |
| **Tide/Time** | **Total Time on Site (start/end)*** | **Total Process Time (minutes)** | **Fishing Effort (hrs.)** | **Number Caught** | **Fishing Comments: (Numbers and kinds of fish etc)** |
| | | | | | *6 Chum, 1 pink* |
| *16.1'/1148* | *0940-1547* | *7* | *6.1* | *0* | |

* = process time + fishing effort

| Date | Location | Crew | Water Temp. | Water Depth | Weather Comments |
|---|---|---|---|---|---|
| | | | | | *Mostly cloudy, rain* |
| *7/3* | *SN1* | *Sanguinetti, Johnson* | *7* | *60.5* | |
| **Tide/Time** | **Total Time on Site (start/end)*** | **Process Time** | **Fishing Effort (hrs.)** | **Number Caught** | **Fishing Comments: (Numbers and kinds of fish etc)** |
| | | | | | *1 Large Chinook tagged, 14 Chum* |
| *16.5'/1134* | *0540-1115* | *15* | *6.25* | *1* | |

* = process time + fishing effort

| Date | Location | Crew | Water Temp. | Water Depth | Weather Comments |
|---|---|---|---|---|---|
| | | | | | *Rain, calm, foggy* |
| *7/4* | *SN1* | *Dreyer Duncan* | *8* | *73* | |
| **Tide/Time** | **Total Time on Site (start/end)*** | **Process Time** | **Fishing Effort (hrs.)** | **Number Caught** | **Fishing Comments: (Numbers and kinds of fish etc)** |
| | | | | | *7 Large Chinook tagged, 1 medium Chinook tagged* |
| *16.4'/1121* | *0545-1202* | *17* | *6.3* | *8* | *6 Chum, 3 Pinks* |

* = process time + fishing effort

| Date | Location | Crew | Water Temp. | Water Depth | Weather Comments |
|---|---|---|---|---|---|
| | | | | | *Rain, river rising, pulled nets early due to near flood conditions* |
| *7/4* | *SN1* | *Dreyer, Duncani* | *7* | *96"* | |
| **Tide/Time** | **Total Time on Site (start/end)*** | **Process Time** | **Fishing Effort (hrs.)** | **Number Caught** | **Fishing Comments: (Numbers and kinds of fish etc)** |
| | | | | | *1 Large Recap Chinook* |
| *0.4'/1733* | *1203-1415* | *1* | *2.2* | *0* | |

* = process time + fishing effort

Appendix B3.–Unuk River set gillnet age-sex-length form, 2013.

Location: ______________________ Year: 2013

Stream code: ____________________ Gear type: Set gillnet

Species: ________________________

| Cum Fish # | Date | Time Caught | Sex | Card # | Scale # | Length MEF (mm) | Age FW | Age SW | AEC | Spaghetti Tag # | LAA | UOP | Ad Clip Cinch # | Comments (Lice, recap, adclip info) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10-Jun-13 | 10:50 | F | 1 | 1 | 670 | | | | 9001 | Y | Y | | LP |
| 2 | 13-Jun-13 | 13:20 | M | 1 | 2 | 785 | | | | 9002 | Y | Y | YES | LP, Adclip released |
| 3 | 15-Jun-13 | 06:45 | M | 1 | 3 | 585 | | | | 9003 | Y | Y | | LP |
| 4 | 15-Jun-13 | 10:32 | F | 1 | 4 | 905 | | | | 9004 | Y | Y | | NL |
| 5 | 15-Jun-13 | 12:39 | M | 1 | 5 | 855 | | | | 9005 | Y | Y | | LP |
| - | 15-Jun-13 | 14:42 | - | - | - | - | | | | 9001 | Y | Y | | Recap, NL |
| 6 | 15-Jun-13 | 16:02 | M | 1 | 6 | 860 | | | | 9006 | Y | Y | | LP |
| 7 | 16-Jun-13 | 05:55 | F | 1 | 7 | 665 | | | | 9007 | Y | Y | | LP |
| 8 | 16-Jun-13 | 06:15 | M | 1 | 8 | 765 | | | | 9008 | Y | Y | | LP |
| 9 | 16-Jun-13 | 10:45 | M | 1 | 9 | 675 | | | | 9009 | N | Y | | Escaped before LAA |
| - | 17-Jun-13 | 07:30 | F | 1 | 10 | 755 | | | | - | Y | Y | | Net mort, NL |
| 10 | 17-Jun-13 | 11:10 | F | 2 | 1 | 720 | | | | 9010 | Y | Y | | LP |
| - | 17-Jun-13 | 15:24 | F | 2 | 2 | 655 | | | | - | - | - | 456221 | NL, Adclip sacrificed |
| 11 | 17-Jun-13 | 16:55 | M | 2 | 3 | 855 | | | | 9011 | Y | Y | | LP |
| 12 | 17-Jun-13 | 17:28 | M | 2 | 4 | 960 | | | | 9012 | Y | Y | | LP |
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Appendix B4.–Coded wire tag (CWT) anadromous stream numbers, coded wire tag sample numbers, and age-sex-length (ASL) stream codes for the Unuk River and its tributaries.

| Location | CWT Anadromous Stream # | Sample numbers | ASL stream code |
|---|---|---|---|
| Unuk River | 101-75-10300 | 06930xxx | 101-75-030 |
| Boulder Creek | 101-75-10300-BOULDER | 0693975x | 101-75-030-BOULDER |
| Boundary Creek | 101-75-10300-2999 | 06939xxx | 101-75-30B |
| Chum Creek | 101-75-10300-CHUM | 069305xx | 101-75-030-CHUM |
| Clear Creek | 101-75-10300-2014-3004 | 06933xxx | 101-75-30C |
| Cripple Creek | 101-75-10300-2030 | 06938xxx | 101-75-30Q |
| Cutthroat Slough | 101-75-10300-CUTTHROAT | 069325xx | 101-75-030-CUTTHROAT |
| Eulachon River | 101-75-10150 | 06932xxx | 101-75-015 |
| Genes Lake Creek | 101-75-10300-2022 | 06937xxx | 101-75-30G |
| Grizzly Slough | 101-75-10300-GRIZZLY | 069315xx | 101-75-030-GRIZZLY |
| Hell Roaring Creek | 101-75-10300-HELLROARING | 069395xx | 101-75-030-HELLROARING |
| Kerr Creek | 101-75-10300-2019 | 06936xxx | 101-75-30K |
| Lake Creek | 101-75-10300-2014 | 06934xxx | 101-75-30L |
| Rockface | 101-75-10300-ROCKFACE | 069335xx | 101-75-030-ROCKFACE |

Appendix B5.–Coded wire tag sampling form.

# Alaska Department of Fish and Game

## Coded Wire Tag Sampling Form

**Hatchery Rack and Escapement Survey**
**Southeast Region**

SAMPLE NUMBER: 9 _ _ _ _ _ _ _ PROJECT CODE (TAG LAB USE ONLY): ____ PAGE ___ OF ___ PAGES

HARVEST TYPE: (circle one) hatchery-rack escapement-survey

SURVEY SITE: ______________________

SAMPLE TYPE: random select

SAMPLER: ______________________

DATE SAMPLED: __ __ - __ __ - 9 _

### SAMPLING INFORMATION

THIS BOX IS TO BE COMPLETED ONLY FOR RANDOM SAMPLES

| SPECIES (CODE) | TOTAL # FISH COUNTED | # ADIPOSE CLIPS SEEN | WERE ALL SAMPLED? |
|---|---|---|---|
| (410)CHIN | ______ | ______ | y n |
| (411)JACK CHIN-ONLY | ______ | ______ | y n |
| (420)SOCK | ______ | ______ | y n |
| (430)COHO | ______ | ______ | y n |
| (440)PINK | ______ | ______ | y n |
| (450)CHUM | ______ | ______ | y n |
| (540)STHD | ______ | ______ | y n |

### COMMENTS

### AREA INFORMATION (DISTRICT - SUBDISTRICT)

| | | | | | |
|---|---|---|---|---|---|
| 101- | 106- | 111- | 116- | 157- | 191- |
| 102- | 107- | 112- | 150- | 181- | 192- |
| 103- | 108- | 113- | 152- | 182- | OTHER DISTRICTS |
| 104- | 109- | 114- | 154- | 183- | ______ |
| 105- | 110- | 115- | 156- | 189- | ______ |

NAME OF PLACE SURVEYED: (NAME OF HATCHERY OR STREAM) ______________________

WATER TYPE: saltwater freshwater

ANADROMOUS STREAM# (FRESHWATER-ONLY) ___ - __ - _____ - _____ - _____ -
_____ - _____ - _____ - _____ - _____

### HEAD RECOVERY INFORMATION

| ✓ | HEAD NUMBER | SPECIES CODE | FORK LENGTH (mid-eye to fork in mm) | CLIP | SEX |
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Appendix B6.–Unuk River spawning grounds age-sex-length form, 2013.

Location: ______________________ Year: 2013

Stream code: ___________________

Species: _______________________

| Fish # | Date | Sex | Length MEF (mm) | Card # | Scale # | Age FW | Age MW | AEC | Spaghetti tag # | LAA | UOP | Ad Clip Cinch # | Gear type | Fish condition | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8/3 | M | 860 | 1 | 1 | | | | | N | N | YES | Lure | Pre | Adclip released |
| 2 | 8/4 | F | 720 | 1 | 2 | | | | | N | N | | Lure | Pre | |
| 3 | 8/4 | F | 865 | 1 | 3 | | | | | N | N | | Lure | Active | |
| 4 | 8/4 | M | 585 | 1 | 4 | | | | 9321 | Y | Y | | Lure | Active | Spag tag |
| 5 | 8/4 | F | 720 | 1 | 5 | | | | | N | N | | Snag | Pre | |
| 6 | 8/4 | M | 655 | 1 | 6 | | | | | N | N | 433110 | Lure | Active | Adclip sacrificed (adsac) |
| 7 | 8/19 | F | 945 | 1 | 7 | | | | | N | N | | Snag | Active | |
| 8 | 8/19 | M | 880 | 1 | 8 | | | | | N | N | | Dipnet | Active | |
| 9 | 8/19 | M | 725 | 1 | 9 | | | | 9123 | Y | Y | YES | Snag | Active | Adclip released, spag tag |
| 10 | 8/19 | M | 1005 | 1 | 10 | | | | | N | N | | Carcass | Dead | |
| 11 | 8/19 | F | 820 | 2 | 11 | | | | | N | N | | Snag | Post | |
| 12 | 8/19 | F | 785 | 2 | 12 | | | | | N | N | | Snag | Post | |
| 13 | 8/24 | F | 820 | 2 | 13 | | | | | N | N | 433111 | Snag | Post | Adsac |
| 14 | 8/24 | M | 345 | 2 | 14 | | | | | N | N | | Carcass | Dead | |
| 15 | 8/24 | M | 785 | 2 | 15 | | | | | N | U | | Carcass | Dead | Opercle plate missing |
| 16 | 8/26 | M | 865 | 2 | 16 | | | | | N | N | 433126 | Carcass | Dead | Adsac, SELECT, LLOP |
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# APPENDIX C

The expansion factor provides a means of predicting escapement in years where only an index count of the escapement is available, i.e. no weir counts or mark-recapture experiments were conducted. The expansion factor is the average over several years of the ratio of the escapement estimate (or weir count) to the index count.

Systems where escapement is known

On systems where escapement can be completely enumerated with weirs or other complete counting methods, the expansion factor is an estimate of the expected value of the "population" of annual expansion factors ($\pi$'s) for that system:

$$\bar{\pi} = \frac{\sum_{y=1}^{k} \pi_y}{k} \qquad (1)$$

where $\pi_y = N_y / C_y$ is the observed expansion factor in year $y$, $N_y$ is the known escapement in year $y$, $C_y$ is the index count in year $y$, and $k$ is the number of years for which these data are available to calculate an annual expansion factor.

The estimated variance for expansion of index counts needs to reflect two sources of uncertainty for any predicted value of $\pi$, ($\pi_p$). First is an estimate of the process error ($var(\pi)$-the variation across years in the $\pi$'s, reflecting, for example, weather or observer-induced effects on how many fish are counted in a survey for a given escapement) ), and second is the sampling variance of $\bar{\pi}$ ($var(\bar{\pi})$), which will decline as we collect more data pairs.

The variance for prediction will be estimated (Neter et al. 1990):

$$v\hat{a}r(\pi_p) = v\hat{a}r(\pi) + v\hat{a}r(\bar{\pi}) \qquad (2)$$

where

$$v\hat{a}r(\pi) = \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k-1} \qquad (3)$$

and

$$v\hat{a}r(\bar{\pi}) = \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k(k-1)} \qquad (4)$$

such that

$$v\hat{a}r(\pi_p) = \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k-1} + \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k(k-1)} \qquad (5)$$

Systems where escapement is estimated

On systems where escapement is estimated, the expansion factor is an estimate of the expected value of the "population" of annual expansion factors ($\pi$'s) for that system:

$$\bar{\pi} = \frac{\sum_{y=1}^{k} \hat{\pi}_y}{k} \qquad (6)$$

where $\hat{\pi}_y = \hat{N}_y / C_y$ is the estimate of the expansion factor in year *y*, $\hat{N}_y$ is the estimated escapement in year *y*, and other terms are as described above.

The variance for prediction will again be estimated:

$$v\hat{a}r(\pi_p) = v\hat{a}r(\pi) + v\hat{a}r(\bar{\pi}) \qquad (7)$$

The estimate of *var*( $\pi$ ) should again reflect only process error. Variation in $\hat{\pi}$ across years, however, represents process error plus measurement error within years (e.g. the mark-recapture induced error in escapement estimation) and is described by the relationship (Mood et al. 1974):

$$V(\hat{\pi}) = V[E(\hat{\pi})] + E[V(\hat{\pi})] \qquad (8)$$

This relationship can be rearranged to isolate process error, that is:

$$V[E(\hat{\pi})] = V[\hat{\pi}] - E[V(\hat{\pi})] \qquad (9)$$

An estimate of *var*( $\pi$ ) representing only process error therefore is:

$$v\hat{a}r(\pi) = v\hat{a}r(\hat{\pi}) - \frac{\sum_{y=1}^{k} v\hat{a}r(\hat{\pi}_y)}{k} \qquad (10)$$

where $v\hat{a}r(\hat{\pi}_y) = v\hat{a}r(\hat{N}_y) / C_y^2$ and $v\hat{a}r(\hat{N}_y)$ is obtained during the experiment when $N_y$ is estimated.

We can calculate:

$$v\hat{a}r(\hat{\pi}) = \frac{\sum_{y=1}^{k} (\hat{\pi}_y - \bar{\pi})^2}{k-1} \qquad (11)$$

and we can estimate $var(\bar{\pi})$ similarly to as we did above:

$$v\hat{a}r(\bar{\pi}) = \frac{\sum_{y=1}^{k} (\hat{\pi}_y - \bar{\pi})^2}{k(k-1)} \qquad (12)$$

where both process and measurement errors need to be included.

For large *k* (*k* > 30), equations (11) and (12) provide reasonable parameter estimates, however for small *k* the estimates are imprecise and may result in negative estimates of variance when the results are applied as in equation (7).

Because $k$ is typically < 10, we will estimate $var(\hat{\pi})$ and $var(\overline{\pi})$ using parametric bootstrap techniques Efron and Tibshirani 1993. The sampling distributions for each of the $\hat{\pi}_y$ are modeled using Normal distributions with means $\hat{\pi}_y$ and variances $v\hat{a}r(\hat{\pi}_y)$. At each bootstrap iteration, a bootstrap value $\hat{\pi}_{y(b)}$ is drawn from each of these Normal distributions and the bootstrap value $\hat{\pi}_{(b)}$ is randomly chosen from the $k$ values of $\hat{\pi}_{y(b)}$. Then, a bootstrap sample of size $k$ is drawn from the $k$ values of $\hat{\pi}_{y(b)}$ by sampling with replacement, and the mean of this bootstrap is the bootstrap value $\overline{\pi}_{(b)}$. This procedure is repeated $B$ = 1,000,000 times. We can then estimate $var(\hat{\pi})$ using:

$$v\hat{a}r_B(\hat{\pi}) = \frac{\sum_{b=1}^{B}(\hat{\pi}_{(b)} - \overline{\hat{\pi}_{(b)}})^2}{B-1} \tag{13}$$

where

$$\overline{\hat{\pi}_{(b)}} = \frac{\sum_{b=1}^{B}\hat{\pi}_{(b)}}{B} \tag{14}$$

and we can calculate $var_B(\overline{\pi})$ using equations (13) and (14) with appropriate substitutions. The variance for prediction is then estimated:

$$v\hat{a}r(\pi_p) = v\hat{a}r_B(\hat{\pi}) - \frac{\sum_{y=1}^{k}\mathrm{v\hat{a}r}(\hat{\pi}_y)}{k} + v\hat{a}r_B(\overline{\pi}) \tag{15}$$

As the true sampling distributions for the $\hat{\pi}_y$ are typically skewed right, using a Normal distribution to approximate these distributions in the bootstrap process will result in estimates of $var(\hat{\pi})$ and $var(\overline{\pi})$ that are biased slightly high, but simulation studies using values similar to those realized for this application indicated that the bias in equation (15) is < 1%.

Predicting Escapement

In years when an index count ($C_p$) is available but escapement ($N_p$) is not known, it can be predicted:

$$\hat{N}_p = \overline{\pi}\, C_p \tag{16}$$

and

$$v\hat{a}r(\hat{N}_p) = C_p^2 v\hat{a}r(\pi_p) \tag{17}$$

# APPENDIX D

Appendix D1.–Detection of size and/or sex selective sampling during a two-sample mark recapture experiment and its effects on estimation of population size and population composition.

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Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling: Contingency table analysis ($Chi^2$-test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather an observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two sample test (e.g. Student's t-test).

---

| **M vs. R** | **C vs. R** | **M vs. C** |
|---|---|---|
| *Case I:* | | |
| Fail to reject $H_o$ | Fail to reject $H_o$ | Fail to reject $H_o$ |

There is no size/sex selectivity detected during either sampling event.

*Case II:*

| | | |
|---|---|---|
| Reject $H_o$ | Fail to reject $H_o$ | Reject $H_o$ |

There is no size/sex selectivity detected during the first event but there is during the second event sampling.

*Case III:*

| | | |
|---|---|---|
| Fail to reject $H_o$ | Reject $H_o$ | Reject $H_o$ |

There is no size/sex selectivity detected during the second event but there is during the first event sampling.

*Case IV:*

Reject $H_o$ Reject $H_o$ Either result possible

There is size/sex selectivity detected during both the first and second sampling events.

*Evaluation Required:*

Fail to reject $H_o$ Fail to reject $H_o$ Reject $H_o$

Sample sizes and powers of tests must be considered:

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C test are very large, the M vs. C test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the second event which the M vs. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less), and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the first event which the C vs. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), the rejection of the null in the M vs. C test may be the result of size/sex selectivity during both events which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

---

*Case I*. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

*Case II*. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Appendix D1.–Page 3 of 3.

*Case III*. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

*Case IV*. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

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If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameters ($p_k$) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \text{ ; and,} \tag{1}$$

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \sum_{i=1}^{j} \left( \hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + \left(\hat{p}_{ik} - \hat{p}_k\right)^2 \hat{V}[\hat{N}_i] \right). \tag{2}$$

where: $j$ = the number of sex/size strata;

$\hat{p}_{ik}$ = the estimated proportion of fish that were age or size *k* among fish in stratum *i*;

$\hat{N}_i$ = the estimated abundance in stratum *i*; and,

$\hat{N}_\Sigma$ = sum of the $\hat{N}_i$ across strata.