**Fishery Data Series No. 06-66**

# Smolt Production, Adult Harvest, and Spawning Escapement of Coho Salmon from Nakwasina River in Southeast Alaska, 2003-2004

**by**

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

# Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

**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 Department of Fish and Game | ADF&G |
| 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) |

**Measures (fisheries)**

| | |
|---|---|
| fork length | FL |
| mideye-to-fork | MEF |
| mideye-to-tail-fork | METF |
| standard length | SL |
| total length | TL |

**Mathematics, statistics**

| | |
|---|---|
| *all standard mathematical signs, symbols and abbreviations* | |
| alternate hypothesis | $H_A$ |
| base of natural logarithm | *e* |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, etc.) |
| confidence interval | CI |
| correlation coefficient (multiple) | R |
| correlation coefficient (simple) | r |
| covariance | cov |
| degree (angular ) | ° |
| degrees of freedom | df |
| expected value | *E* |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $log_2$, etc. |
| minute (angular) | ' |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| variance | |
| population | Var |
| sample | var |

# *FISHERY DATA SERIES NO. 06–66*

## SMOLT PRODUCTION, ADULT HARVEST, AND SPAWNING ESCAPEMENT OF COHO SALMON FROM NAKWASINA RIVER IN SOUTHEAST ALASKA, 2003-2004

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# ABSTRACT

In 1998, a coded wire tag (CWT) project was initiated for coho salmon *Oncorhynchus kisutch* in Nakwasina River near Sitka, Alaska to supplement a continuing regionwide effort to assess the status of key coho salmon stocks in Southeast Alaska. During spring 2003, 15,762 coho salmon smolt ≥65-mm fork length (FL) were captured in minnow traps, marked with an adipose fin clip, given a CWT, and released. A weighted variation of the modified Peterson model was used to estimate smolt abundance in 2003 at 55,424 (SE = 4,023). In fall 2004, beach seines, gillnets, and hook-and-line gear were used to capture immigrant coho salmon. During the course of the experiment, 1,078 coho salmon were examined, 749 were released with Floy™ tags, and 156 were subsequently recaptured. Using a Jolly-Seber model, the estimated escapement was 3,867 (SE = 937). The peak foot survey count of the mainstem river was 399 adult coho salmon, or 10% of the estimated escapement. An estimated 1,645 (SE = 178) coho salmon of Nakwasina River origin were harvested in Southeast Alaska marine fisheries in 2004. The marine sport fishery harvested an estimated 200 fish, or 12.2% of the total harvest, while the commercial fisheries harvested 84% (troll) and 3.8% (seine). The total run (i.e., escapement plus harvest) for all coho salmon bound for Nakwasina River was 5,512, the marine survival rate was 9.9%, and the marine fishery exploitation was 29.8%.



Key words: coho salmon, *Oncorhynchus kisutch*, Nakwasina River, harvest, troll fishery, sport fishery, migratory timing, return, exploitation rate, marine survival, coded wire tag, mark-recapture experiment, spawning escapement, smolt abundance, Southeast Alaska


# INTRODUCTION

Coho salmon *Oncorhynchus kisutch* produced by Nakwasina River and thousands of other coastal river systems in Southeast Alaska collectively support the region’s mixed stock commercial troll and net fisheries and freshwater and marine sport fisheries. The Alaska Department of Fish and Game (ADF&G) has conducted comprehensive coded wire tag (CWT) assessment projects on a long-term basis to evaluate the effects of Southeast Alaska fisheries on specific coho stocks native to streams in northern and inside areas of Southeast Alaska (Yanusz et al. 1999), but stock-specific information is more limited for outside, central, and southern areas. To bridge geographic areas, projects have been implemented more recently for specific stocks, including the Unuk River in southern Southeast (Jones III et al. 1999, 2001; Weller et al. 2002, 2003) and Slippery Creek in central Southeast (Beers 1999). Along the outer coast, the first comprehensive CWT program began at Ford Arm in 1982 and has continued through 2004 (Shaul and Crabtree 1998; Leon Shaul, personal communication, Alaska Department of Fish and Game, Commercial Fisheries Division, Douglas). In southern Southeast, Chuck Creek has been included as a coho stock assessment project. The Division of Sport Fish also conducted a CWT project to assess fishery impacts to Salmon Lake (near Sitka) coho salmon from 1983 to 1990 and again in 1994–1995 (Schmidt 1996). The Salmon Lake CWT project was initiated again in 2001 and returns of adults with CWTs are expected through 2005.

Beginning in 1998, Sport Fish Division has conducted a coho salmon CWT project in Nakwasina River (Figure 1) to supplement the regionwide effort to assess the status of key coho salmon stocks in central Southeast Alaska (Brookover et al. 1999, 2000, 2003; Tydingco 2003, 2005a,b). Estimated smolt abundance from 1998 through 2002 ranged from 22,472 (SE = 1,660) in 2002 to 102,794 (SE = 15,255) in 1998. Estimated harvests of returning adults in 1999–2003 ranged from 604 fish (SE = 110) in 2003 to 1,983 (SE = 605) in 1999 (Table 1).

The objectives of this study were to: (1) estimate the number of coho salmon smolt leaving Nakwasina River in 2003; (2) estimate the marine harvest of coho salmon from Nakwasina River in 2004 via recovery of CWTs applied in 2003; and (3) estimate spawning escapement in 2004. An additional task of this project was to define the relationship between the estimated escapement and peak foot survey count.

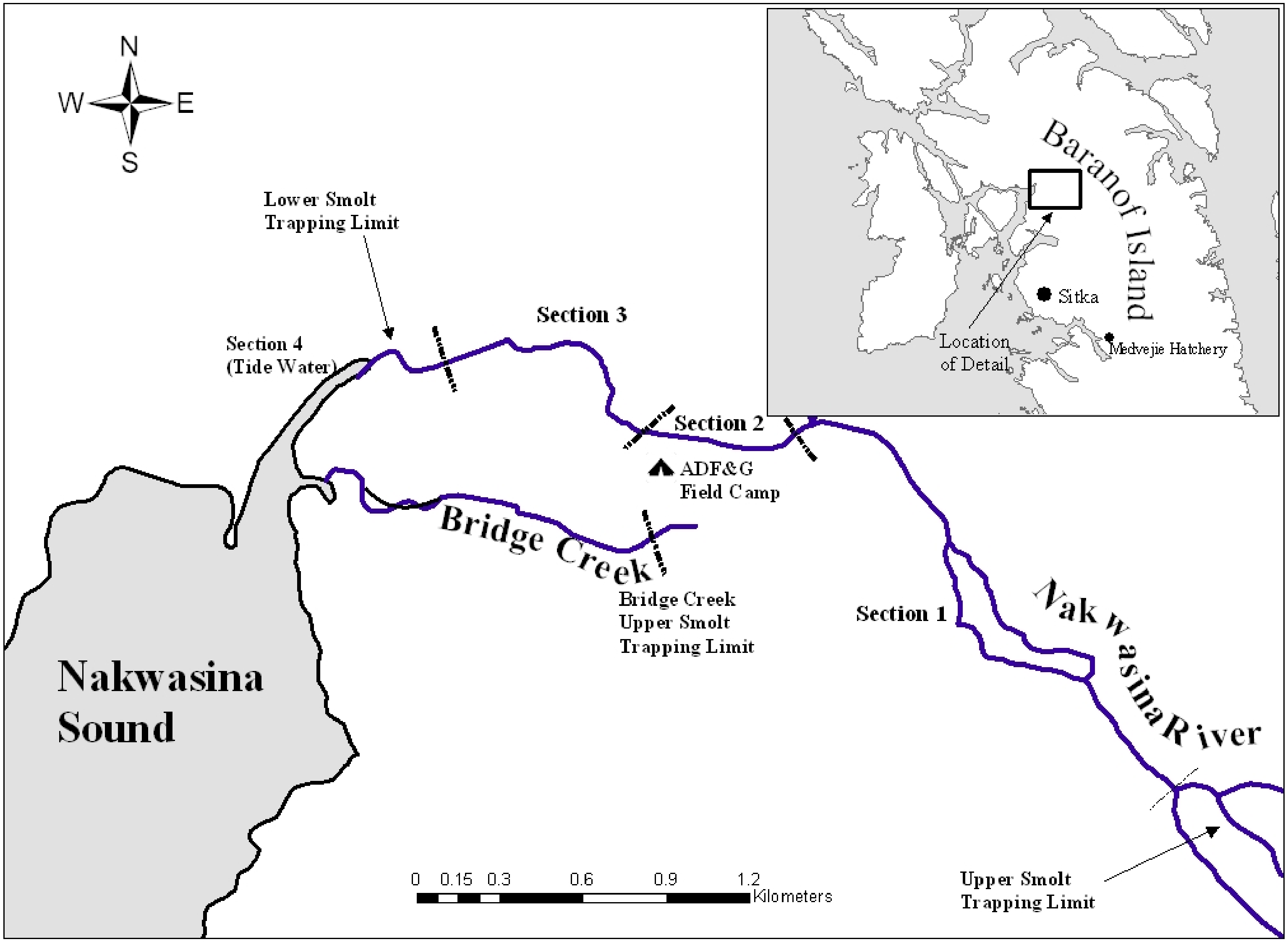


**Figure 1.**–Map showing Nakwasina River area, including major tributaries and location of ADF&G research sites and stream sections.

**Table 1.–**Summaries of estimated smolt abundance, harvest, escapement, exploitation, and stream counts in Nakwasina River 1998–2004.

| Year | Smolt tagged | Smolt abundance estimate | Smolt SE | Adult escapement | Adult escapement SE | Harvest | Harvest SE | Exploitation | Marked fraction, theta | Stream survey peak count | Proportion of escapement estimate | Estimated marine survival |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | 9,985 | 102,794 | 15,255 | - | - | - | - | - | - | 653 | - | |
| 1999 | 3,971 | 47,571 | 6,402 | - | - | 1,983 | 605 | - | 0.095 | 291 | - | |
| 2000 | 10,228 | 46,575 | 2,722 | 2,000 | 261 | 1,219 | 231 | 0.37 | 0.082 | 419 | 0.21 | 6.8 |
| 2001 | 10,381 | 39,461 | 3,057 | 2,992 | 510 | 1,439 | 155 | 0.325 | 0.221 | 753 | 0.252 | 9.5 |
| 2002 | 5,286 | 22,472 | 1,660 | 3,141 | 661 | 731 | 109 | 0.178 | 0.237 | 713 | 0.227 | 9.8 |
| 2003 | 15,761 | 55,424 | 4,023 | 2,063 | 233 | 604 | 110 | 0.226 | 0.203 | 440 | 0.213 | 11.9 |
| 2004 | | | | 3,867 | 937 | 1,645 | 178 | 29.8 | 0.286 | 399 | 0.970 | 9.9 |
| Averages | 9,269 | 52,383 | 5,520 | 2,813 | 520 | 1,270 | 231 | 6.18 | 0.19 | 524 | 0.20 | 9.6 |

# STUDY AREA

Nakwasina River is located on the outer coast of Baranof Island in Southeast Alaska (Figure 1). It is about 13 km long, and the anadromous portion ranges between 6 and 30 m wide, and up to 3 m deep. It empties into Nakwasina Sound (57° 15'16.8"W/135° 20'41.5"N) about 23 km north of Sitka. Nakwasina River drains approximately 8,600 square hectares and is one of the larger river systems on Baranof Island. Average daily flow rates between 1976 and 1982 ranged from 100 $ft^3/s$ to 1,200 $ft^3/s$. Maximum and minimum average daily flows during this time period ranged from a low of 22 $ft^3/s$ to a high of 3,400 $ft^3/s$.

Nakwasina River is known locally for its freshwater sport fisheries for coho salmon and Dolly Varden (*Salvelinus malma)*. Because Nakwasina River is easily accessed by boat and it supports one of the largest populations of coho salmon in Sitka Sound, it is one of the few rivers near Sitka that attracts freshwater sport fishing effort for coho salmon. Although the number of respondents was low in the Statewide Harvest Survey (SWHS), estimated annual harvests of coho salmon in Nakwasina Sound, including Nakwasina River, ranged from 0 to 182 fish between 1984 and 2003 and estimated angler effort expended in Nakwasina Sound and River (for all fish species) ranged from 31 to 891 angler days (Howe et al. 1995, 1996, 2001a-d; Jennings et al. 2004, 2006a,b; Mills 1985-94; Walker et al. 2003).

In the 1960s, the majority of riparian area in the anadromous portion of Nakwasina River valley was clearcut to the streambank (Greg Killinger, personal communication, Sitka Ranger District, U.S. Forest Service, Sitka). Nakwasina River coho salmon are of special concern because of the potential risk of excessive exploitation in combination with the potential negative impacts to the stock from habitat damage due to logging.

Since 1980, visual surveys have been conducted by foot on Nakwasina River to provide an indication of trends in the annual abundance of coho escapement. Annual peak counts in Nakwasina River represent the largest of five systems surveyed annually in the Sitka area. Surveys conducted from 1980 to 2004 have documented 47 (1987) to 753 (2001) adult coho salmon spawners (Table 2).

# METHODS

## SMOLT TAGGING AND SAMPLING

From April 17 to May 15, 2003, between 50 and 100 G-40 minnow traps were baited with salmon roe and fished daily in Nakwasina River. Traps were fished for 24 hours per day, approximately 6 days per week and checked at least once each day. Traps were set along mainstem banks and in backwater areas of the lower river between the estuary and approximately 6 km upstream. Traps were distributed and redistributed opportunistically to maximize catch by targeting areas of likely rearing habitat, unfished areas, and areas known to produce relatively high catch rates. Coho salmon smolt ≥65 mm FL were removed from minnow traps and transported to holding pens at the campsite each day. Other species (primarily Dolly Varden) and coho fry <65 mm FL were counted and released on site.

Every 2–3 days, all live coho salmon smolt ≥65 mm FL were anesthetized with a solution of tricane methane-sulfonate (MS-222) and injected with a CWT with one of the following codes: 04-08-17, 04-08-18, or 04-08-19. Fish were then marked externally by excising the adipose fin. Tagging and marking followed the methods of Koerner (1977). All tagged fish were held overnight in a net pen to test for mortality, tag retention, and adipose fin clip status and released. To test for tag retention, 100 fish were randomly selected and passed through a Northwest Marine Mark IV Portable Sampling Detector™[1]. If tag retention was 98% or greater, all fish were counted, mortalities recorded, and released. If tag retention was 97% or less, all untagged fish were retagged. The number of fish tagged, number of tagging-related mortalities, and number of fish that had shed their tags were recorded on *ADF&G Tagging Summary and Release Information Forms* which were submitted to ADF&G Commercial Fisheries Division (CFD) Mark, Tag and Age Laboratory (Tag Lab) in Juneau when fieldwork ended.

[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

**Table 2.**–Peak escapement counts of coho salmon in the Sitka Area, 1980–2004.

| | Sinitsin Creek | | | St. John Baptist Bay Creek | | | Starrigavan River | | | Eagle River | | | Black River | | | Nakwasina River | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Survey type | Peak survey date | No. of Coho | Survey type | Peak survey date | No. of Coho | Survey type | Peak survey date | No. of Coho | Survey type | Peak survey date | No. of Coho | Survey type | Peak survey date | No. of Coho | Survey type | Peak survey date | No. of Coho |
| 1980 | Foot | 30-Sep | 39 | Foot | 9-Oct | 26 | Foot | | | | | | Foot | 26-Oct | 328 | Foot | 29-Oct | 70 |
| 1981 | Foot | 6-Oct | 85 | Foot | 14-Oct | 51 | Foot | 20-Oct | 170 | Foot | 22-Sep | 27 | | | | Foot | 7-Oct | 780 |
| 1982 | Foot | 20-Oct | 46 | Foot | | | Foot | 21-Oct | 317 | | | | | | | | | |
| 1983 | Foot | 27-Sep | 31 | Foot | 13-Oct | 12 | Foot | 6-Oct | 45 | | | | | | | Foot | 14-Oct | 217 |
| 1984 | Foot | 10-Oct | 160 | Foot | 10-Oct | 154 | Foot | 10-Oct | 385 | | | | Helo | 3-Oct | 425 | Foot | 17-Oct | 715 |
| 1985 | Foot | 15-Oct | 144 | Foot | 8-Oct | 109 | Foot | 11-Oct | 193 | | | | Helo | 7-Oct | 1,628 | Foot | 7-Oct | 408 |
| 1986 | Foot | 30-Sep | 4 | Foot | 10-Oct | 9 | Foot | 10-Oct | 57 | Foot | 26-Sep | 245 | Helo | 10-Oct | 312 | Foot | 28-Oct | 275 |
| 1987 | Foot | 23-Sep | 32 | Foot | 23-Sep | 9 | Foot | 9-Oct | 36 | Foot | 24-Sep | 167 | Helo | 9-Oct | 262 | Foot | 30-Oct | 47 |
| 1988 | Foot | 3-Oct | 56 | Foot | 3-Oct | 71 | Foot | 12-Oct | 45 | Foot | 2-Sep | 10 | Helo | 10-Oct | 280 | Foot | 27-Oct | 104 |
| 1989 | Foot | 5-Oct | 76 | Foot | 5-Oct | 89 | Foot | 13-Oct | 101 | Foot | 2-Oct | 130 | Helo | 13-Oct | 181 | Foot | 19-Oct | 129 |
| 1990 | Foot | 1-Oct | 80 | Foot | 1-Oct | 35 | Foot | 17-Oct | 39 | Snorkel | 2-Oct | 214 | Helo | 4-Oct | 842 | Foot | 31-Oct | 195 |
| 1991 | Foot | 1-Oct | 186 | Foot | 10-Oct | 107 | Foot | 2-Oct | 142 | Snorkel | 17-Oct | 454 | Helo | 17-Oct | 690 | Foot | 25-Oct | 621 |
| 1992 | Foot | 23-Sep | 265 | Foot | 14-Oct | 110 | Foot | 12-Oct | 241 | Snorkel | 6-Oct | 629 | Helo | 6-Oct | 866 | Foot | 30-Oct | 654 |
| 1993 | Foot | 7-Oct | 213 | Foot | 6-Oct | 90 | Foot | 13-Oct | 256 | Snorkel | 13-Oct | 513 | Helo | 7-Oct | 764 | | | |
| 1994 | Foot | 30-Sep | 313 | Foot | 30-Sep | 227 | Foot | 11-Oct | 304 | Snorkel | 1-Oct | 717 | Helo | 14-Oct | 758 | Foot | 14-Oct | 404 |
| 1995 | Foot | 26-Sep | 152 | Foot | 5-Oct | 99 | Foot | 6-Oct | 272 | Snorkel | 5-Oct | 336 | Helo | 27-Sep | 1265 | Foot | 29-Sep | 626 |
| 1996 | Foot | 2-Oct | 150 | Snorkel | 2-Oct | 201 | Foot | 17-Oct | 59 | Snorkel | 30-Sep | 488 | Helo | 30-Sep | 385 | Foot | 30-Oct | 553 |
| 1997 | Foot | 29-Sep | 90 | Snorkel | 30-Sep | 68 | Foot | 27-Oct | 55 | Snorkel | 30-Sep | 296 | Helo | 30-Sep | 686 | Foot | 14-Nov | 239 |
| 1998 | Foot | 1-Oct | 109 | Snorkel | 9-Oct | 57 | Foot | 8-Oct | 123 | Snorkel | 9-Oct | 300 | Helo | 8-Oct | 1,520 | Foot | 2-Nov | 653 |
| 1999 | Snorkel | 11-Oct | 48 | Snorkel | 29-Oct | 25 | Snorkel | 8-Oct | 166 | | | | Helo | 4-Oct | 1,590 | Snorkel | 12-Nov | 291 |
| 2000 | Foot | 26-Sep | 48 | Snorkel | 26-Oct | 32 | Snorkel | 8-Oct | 144 | snorkel | 29-Sep | 108 | Helo | 2-Oct | 880 | Foot | 8-Nov | 419 |
| 2001 | Foot | 5-Oct | 62 | Snorkel | 4-Oct | 80 | Snorkel | 8-Oct | 430 | snorkel | 4-Oct | 417 | Helo | 4-Oct | 1,080 | Foot | 14-Nov | 753 |
| 2002 | Foot | 10-Oct | 169 | Snorkel | 2-Oct | 100 | Foot | 10-Oct | 227 | snorkel | 10-Oct | 659 | Helo | 3-Oct | 1,994 | Foot | 5-Nov | 713 |
| 2003 | Foot | 29-Oct | 102 | Snorkel | 30-Sep | 91 | Foot | 2-Oct | 95 | snorkel | 9-Oct | 375 | Helo | 2-Oct | 1,055 | Foot | 31-Oct | 440 |
| 2004 | Foot | 3-Oct | 106 | Snorkel | 1-Oct | 52 | Foot | 2-Oct | 121 | snorkel | 11-Oct | 391 | Helo | 7-Oct | 380 | Foot | 8-Nov | 399 |
| Average (1980-2004) | | | 111 | | | 79 | | | 168 | | | 341 | | | 826 | | | 422 |
| 5-yr average (1998-2004) | | | 97 | | | 71 | | | 203 | | | 390 | | | 1,078 | | | 545 |

Three separate tag codes were used to identify different components of the smolt run. Small smolt (≥65 mm but less than 85 mm FL) were tagged with code 04-08-17, while large smolt (≥85 mm FL) were tagged with code 04-08-18. These two tag codes were used to identify differential survival based on size at smolting. A third tag code (04-08-19) was used for all fish ≥65 mm that were captured in an unnamed tributary to Nakwasina River (Figure 1) that is connected only intermittently. This tributary, referred to as "Bridge Creek," empties into salt water approximately ½ km from the outlet of Nakwasina River, except at high tides when the two appear to be connected by a small freshwater passage. This third tag code was used to determine if fish emigrating from this tributary spawn in the mainstem of Nakwasina and to examine differential survival by location of capture.

Coho salmon smolt were measured from snout to fork of tail (FL) to the nearest 1 mm, weighed to the nearest 0.1 g, and sampled for scales. Twelve to 15 scales were removed from the preferred area on the left side following procedures described by Scarnecchia (1979). Scales were sandwiched between two 1x3-in microscope slides and numbered consecutively for each sampled fish. Slides were taped together and the number and length of each fish was written on the frosted portion of the bottom slide according to scale position on the slide.

## INSTREAM MARK-RECAPTURE SAMPLING, CODED WIRE TAG RECOVERY, AND MARINE HARVEST SAMPLING

An open population mark-recapture experiment was used to estimate escapement. This was done in conjunction with CWT recovery efforts that provided information for estimation of smolt abundance with a closed population model. Requirements of the open-population experiment demanded more intensive sampling, therefore an open population experimental design was used.

Sampling occurred during 2 or 3-day periods once each week from September 10 through December 8, 2004. Adult coho salmon were captured using a 3.6 x 22.5-m, 3.75-cm mesh beach seine and a 3.0 x 35-m, 7.5-cm mesh gillnet. Hook and line gear was also used to supplement net captures. Carcasses were sampled opportunistically when observed.

The stream was divided into four sections (Figure 1). Section 1 extended from river kilometer (rkm) 7.75 downstream to rkm 4.1. The portion of the river upstream of rkm 7.75 was not included because few fish have been observed in this area, and the presence of excessive amounts of woody debris and undercut banks were not conducive to capturing fish. Section 2 extended from rkm 4.1 downstream to rkm 3.7, and section 3 extended from rkm 3.7 to rkm 3.4. Section 4 extended from rkm 3.4 to tide water. Sampling was concentrated in sections 2 and 3 because two large pools located there contained the majority of adult coho salmon visible in the river at any given time. These pools enabled effective deployment of the beach seine and gillnet. Little sampling occurred below rkm 3.4 in order to avoid potential mortality associated with capturing coho salmon that had recently entered fresh water (Vincent-Lang et al. 1993).

All coho captured were examined for presence or absence of their adipose fin. Between September 10 and December 8, all coho missing adipose fins were sacrificed, their heads removed, and sent to the Tag Lab for dissection and decoding. All captured coho salmon were also examined for an anchor tag and opercle punch combination. All coho salmon absent this combination were measured to the nearest mm MEF, tagged with uniquely numbered Floy™ T-bar anchor tags, given a secondary mark (opercle punch) to permit estimation of tag loss, examined to determine sex and condition, and sampled to collect scales for aging. Tags were inserted just posterior of and 1 cm below the dorsal fin on the left side of the fish. Secondary marks included various combinations of opercle punches that consisted of 0.6 cm diameter holes. The condition of each fish was determined from external characteristics using the following convention:

1) Bright: Ocean bright or nearly ocean bright;
2) Blush: Some color (primarily blush red);
3) Dark: Dark color (primarily red);

4) LPS (live post-spawner): Spawned out but not yet dead;
5) Carcass: Dead spawned fish; and,
6) Mortality: Dead unspawned fish.

For fish captured with a Floy™ tag, the location, gear used, tag number, and condition were recorded and the fish was released. If an opercle punch but no anchor tag was present, the fish was recorded as a valid tag recovery (indicating the tag was shed), retagged, and examined for condition.

All carcasses that could be retrieved were also inspected for marks and recorded. Heads were removed if the adipose fin was missing. Subsequent sampling of these carcasses was prevented by slashing the left side of the fish. These carcasses were not counted as observations for estimating spawning abundance.

Sex was determined from external characteristics. Scale samples, consisting of 4 scales from the preferred area near the lateral line on an imaginary line from the insertion of the posterior dorsal fin to the anterior origin of the anal fin (Scarnecchia 1979), were collected and affixed to a gum card in the field. Post-season, scale images were impressed on acetate cards and ages were determined by examining the impressions under a microscope. Criteria used to assign ages were similar to those of Mosher (1968).

Harvest in 2004 of coho salmon originating from Nakwasina River was estimated from fish sampled in both commercial and marine sport fisheries. Fisheries personnel with the ADF&G CFD port-sampling program examined commercially caught fish at processing locations and recovered coho with missing adipose fins (Oliver *Unpublished*). Similarly, the Division of Sport Fish employed a creel survey program to examine fish caught in the sport fishery (Hubartt et al. 2001). When possible, heads of fish without an adipose fin were removed and sent to the Tag Lab for tag detection and decoding. Because multiple fisheries exploited coho salmon over several months in 2004, harvest was estimated over several strata, each a combination of time, area, and type of fishery. Statistics from the commercial troll fishery were stratified by fishing period and by fishing quadrant. Statistics from the marine sport fishery were stratified bi-weekly.

## Foot Survey Counts

Adult coho salmon in Nakwasina River were counted visually on October 11 and again on November 8, 2004. Visual counts were conducted by two experienced observers either during or one day after instream sampling efforts. Only fish positively identified as coho salmon were counted. Counts were conducted between the uppermost portion of the survey area (rkm 7.75) and a pool near the high tide mark at rkm 0.25. Uncontrolled variables included observer abilities, weather conditions, and water clarity. Weather conditions, water clarity, and counts were recorded by stream section.

Bridge Creek was examined opportunistically during the course of sampling to determine if coho salmon used it for spawning or rearing.

## Estimate of Smolt Abundance and Size

Chapman's modification of the Petersen estimator (Seber 1982) was used to estimate smolt abundance. Several conditions must be met for unbiased estimates:

1. There is no recruitment or immigration to the population–only fish that were present in the population during the smolt marking are present in the population of fish inspected for marks as adults;
2. There is no tagging induced behavior or mortality-tagged fish behave the same as untagged fish after the marking event;
3. Fish do not lose their marks and all marks are recognizable;
4. Tag codes and release locations can be correctly determined for all adult fish observed with missing adipose fins; and
5. All fish marked as juveniles are smolt.

In addition, at least one set of conditions on mortality and sampling must be met. Because significant mortality occurs between sampling events, these conditions must be evaluated and satisfied concurrently. At least one of the following sets of conditions must be met:

S1. All fish have an equal probability of being captured and marked during the first event; or

S2. All fish have the same probability of surviving between events whether marked or unmarked and across all tagging groups and complete mixing of marked and unmarked fish occurs prior to the second event; or

S3. All fish have the same probability of surviving between events whether marked or unmarked and across all tagging groups and all fish have an equal probability of being captured and inspected for marks during the second event.

These conditions were evaluated, where possible, using experimental data and in some cases by indirect knowledge or exercising control over experimental procedures. Equal survival between tagging groups was evaluated using contingency table analysis to test for lack of independence between tagging group and probability of recovery during adult sampling. Contingency table analysis was also used to test for lack of independence between sampling events and freshwater age.

If survival rates for large and small smolt tagged in Nakwasina River were significantly different such that smolt in either size group survived differently, condition S2 would not be satisfied. Further, if smolt of one group or another were more or less likely to be captured in 2003 than another, condition S1 would not be satisfied, but the experimental design did not provide for evaluation of this. Also, there was no test to evaluate equal tagging probability between Bridge Creek and Nakwasina River smolt.

When one of the above conditions regarding mortality and sampling are met, a modified Petersen estimator is generally used, however when these conditions are violated, no clearly unbiased estimate of smolt abundance can be calculated. The best, albeit biased, estimator for which the potential biases can be described is a weighted variant of Chapman's modification of the Petersen estimator:

$$\hat{N} = \frac{(\hat{A}M_1 + M_2 + 1)(C+1)}{\hat{A}(R_1 + \hat{\pi}_1 R_3) + (R_2 + \hat{\pi}_2 R_3) + 1} - 1 \qquad (1)$$

where $M_i$ is the number of Nakwasina River smolts marked by size group (1 = small smolt, 2 = large smolt), $C$ is the number of adults inspected for marks, $R_i$ is the number of recaptures by size group (3 = unknown size), $A$ is the ratio of the catchability coefficients for small and large smolt, and $\pi_i$ is the fraction of adults that were small or large smolts. Smolt tagged in Bridge Creek in 2003 were not used in this estimator, although observed adults were used to estimate the $\pi_i$ parameters.

The estimate of $A$ is used to adjust for differences in catchability such that $A > 1$ when large smolt are more catchable, and < 1 when larger smolt are less catchable. Because some recaptured fish were not sacrificed to find tags or some marked adults did not contain tags, $\pi_i$'s were used to assign recaptured fish of unknown pedigree to the appropriate smolt size group. An estimate of $\pi_i$ is:

$$\hat{\pi}_i = \frac{T_i}{T_1 + T_2 + T_{BC}} \qquad (2)$$

where $T_i$ is the number of tag recoveries representing a smolt size group ($i$ = 1, 2) regardless of how or where they were recovered, and $T_{BC}$ is the number of adults tagged as smolt in Bridge Creek.

The relative catchability of small and large smolt can be described accordingly. If $\hat{p}$ is the estimated fraction of all adults that are of age-1., $\hat{\phi}_1$ is the estimated fraction of smolts in the smaller-size group that were age-1., and $\hat{\phi}_2$ is the estimated fraction of smolts in the larger-size group that were age-1., then an estimate of the ratio of catchability coefficients for larger to smaller smolt is:

$$\hat{A} = \frac{T_2(\hat{\phi}_2 - \hat{p})}{T_1(\hat{p} - \hat{\phi}_1)} \qquad (3)$$

(see Appendix A3 in Tydingco 2005b for derivation of equation 3). From tagging records, $\hat{\phi}_1$ = 333/333 = 1.0 and $\hat{\phi}_2$ = 77/87 = 0.8851. Of the 851 adults sampled for age in Nakwasina River in 2004 (Table 3), 840 were age 1.1, making $\hat{p}$ = 0.9871. Given that $T_1$ = 232 and $T_2$ = 99 in 2004, $\hat{A}$ = 3.37. Simulations (see below) indicate

**Table 3.**–Estimated fork length, weight, and age of coho salmon smolt from Nakwasina River and Bridge Creek in 2003.

| | Nakwasina | | | | | | Bridge Creek | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Age-1. | | Age-2. | | Combined | | Age-1. | | Age-2. | |
| Statistic | Length* | Weight* | Length | Weight | Length | Weight | Length | Weight | Length | Weight |
| Mean | 77.9 | 4.9 | 103.8 | 10.4 | 78.6 | 5.0 | 78.5 | 4.7 | 99 | 9.2 |
| Standard Error | 0.37 | 0.08 | 1.84 | 0.62 | 0.42 | 0.09 | 0.81 | 0.21 | | |
| Sample Size | 410 | 409 | 10 | 10 | 420 | 419 | 105 | 52 | 1 | 1 |
| | % age-1. fish in Nakwasina = 98% | | | | | | % age-1. fish in Bridge Creek = 99% | | | |

*Length measured to the nearest millimeter and weight to the nearest 10th gram.

that this estimated rate is statistically different from 1. Variance and 95% credibility interval ($CI_{MCMC}$) for the estimator (equation 1) were estimated using empirical Bayesian methods (Carlin and Louis 2000). Using Markov Chain Monte-Carlo techniques, posterior distributions for $\hat{N}$ and $\hat{A}$ were generated by collecting 100,000 simulated values of $\hat{N}'$ and $\hat{A}'$ which were calculated using equations (1) and (3) from simulated values of equation parameters. Simulated values were modeled from observed data (Appendix A1).

Estimates of mean smolt length and weight-at-age and their variances were calculated with standard sample summary statistics (Cochran 1977).

## ESTIMATE OF HARVEST

The contribution ($r_{ij}$) of release group $j$ to a fishery stratum $i$ was estimated as:

$$\hat{r}_{ij} = N_i \left[ \frac{m_{ij}}{\lambda_i n_i} \right] \theta_j^{-1}; \qquad \lambda_i = \frac{a_i' t_i'}{a_i t_i} \tag{4}$$

where:

- $N_i$ = total harvest in fishery stratum $i$,
- $n_i$ = number of fish inspected in fishery stratum $i$ (the sample),
- $a_i$ = number of fish which were missing an adipose fin,
- $a_i'$ = number of heads that arrived at the lab,
- $t_i$ = number of heads with CWTs detected,
- $t_i'$ = number of CWTs that were dissected from heads and decoded,
- $m_i$ = number of CWTs with code(s) of interest, and
- $\theta_j$ = fraction of the cohort tagged with code(s) of interest.

When $N_i$ and $\theta_j$ are known without error, an unbiased estimate of the variance of $\hat{r}_{ij}$ can be calculated as shown by Clark and Bernard (1987). However, $N_i$ is estimated with error in sport fisheries, and $\theta_j$ is estimated with error on Nakwasina River since wild stocks are tagged. Because of these circumstances, estimates of the variance of $\hat{r}_{ij}$ based on large sample approximations were obtained using the appropriate equations in Bernard and Clark (1996).

The total harvest for a cohort was calculated as the sum of strata estimates:

$$\hat{H} = \sum_i \sum_j \hat{r}_{ij} \tag{5}$$

$$Var\left[\hat{H}\right] = \sum_i \sum_j v\left[\hat{r}_{ij}\right] \tag{6}$$

## SPAWNING ESCAPEMENT

The escapement of adult (age-.1) coho salmon in Nakwasina River was estimated from a Jolly-Seber (JS) experiment (Seber 1982) using the model described by Schwarz et al. (1993). Sub-adult (age-.0) coho salmon were much smaller than adults and were ignored. Weekly sampling trips spanning the time of immigration were conducted to mark and recapture adults. Following the work of Sykes and Botsford (1986), repeated recaptures of carcasses "captured" in a decayed condition were not included. Carcasses found were slashed along the midline to prevent re-sampling.

In general, escapement ($E$) is the total number of immigrants ($B_i$) between the first and last sampling occasion, including fish that enter the system and die between any two sampling occasions ($i$), and fish that enter before the first sampling occasion ($B_0$) and after the last sampling occasion ($B_s$): $\hat{E} = \hat{B}_0 + ... + \hat{B}_{s-2} + \hat{B}_{s-1} + B_s$. Because we began sampling early in immigration and continued until it was virtually over, we estimated $B_0 + B_1$ from an estimate of abundance just before the second JS sampling event ($\hat{N}_2$) and ignored immigration $B_{s+1}$ and beyond as suggested by Schwarz et al. (1993). The resulting (albeit negatively biased) estimator is thus:

$$\hat{E} = \hat{N}_2\left(\frac{\log\hat{\phi}_1}{\hat{\phi}_1 - 1}\right) + \hat{B}_2\left(\frac{\log\hat{\phi}_2}{\hat{\phi}_2 - 1}\right) + ... + \hat{B}_{s-2}\left(\frac{\log\hat{\phi}_{s-2}}{\hat{\phi}_{s-2} - 1}\right) \quad (7)$$

where $\hat{B}_i$ are JS estimates of the number of fish present at sample time $i+1$ that immigrated between $i$ and $i+1$, $\hat{\phi}_i$ is the survival rate from $i$ to $i+1$, and the factors $\frac{log(\phi_i)}{\phi_i - 1}$ account for fish that enter and die between samples under the assumption that mortality is uniformly distributed between sampling events. The population analysis computer program POPAN (Arnason and Schwarz 1995) was used to estimate the JS parameters, and out-of-bounds estimates were constrained to admissible values (Schwarz and Arnason 1996; Schwarz et al. 1993). Variance of escapement was estimated using the delta method and the asymptotic variance and covariances in Schwarz et al. (1993), and expected values of the sampling statistics from POPAN.

Assumptions of the standard (full) JS model (Seber 1982) include:

1. Every fish in the population has the same probability of capture in the $i^{th}$ sample;
2. Every marked fish has the same probability of surviving from the $i^{th}$ to the $(i+1)^{th}$ sample and being in the population at the time of the $(i+1)^{th}$ sample;
3. Every fish caught in the $i^{th}$ sample has the same probability of being returned to the population;
4. Marked fish do not lose their marks between sampling events and all marks are reported on recovery; and
5. All samples are instantaneous (sampling time is negligible).

Chi-square goodness-of-fit tests were used to test for homogenous capture and survival probabilities by tagged status (Pollock et al. 1990). The first test is equivalent to the Robson (1969) test for short-term mortality. The second test is reported to be better at detecting heterogeneous survival probabilities (Pollock et al. 1990). The sum of the chi-squares from each test is an overall test statistic for violations of the first three assumptions above (equal probability of capture, survival, and return to the population).

The equal probability of capture assumption can also be violated if sampling is size or sex selective. Although differences in the size of adult coho salmon are small, a hypothesis that fish of different sizes were captured with equal probabilities was tested by using Kolmogorov-Smirnov (K-S) 2-sample tests (Conover 1980). Sex selective sampling was investigated using contingency table analysis with a $\chi^2$ test statistic (Cochran 1977) comparing the number of males and females marked with those recaptured.

Assumptions 3, 4, and 5 were thought to be robust in this experiment. With regard to assumption 3, the only fish that are not returned to the experiment during sampling are those with missing adipose fin, indicating the presence of a coded wire tag. There is no reason to believe the presence or absence of a coded wire tag imbedded deep in cartilage has any effect on adult inriver survival, spawning activity, or the probability that a fish is captured during in-river sampling. With regard to assumption 4, the combination of opercle punch and anchor tag marks and diligent inspection of all fish sampled has been sufficient to ensure that an accurate capture history is recorded for each fish sampled. With regard to assumption 5, the ability to observe multiple recaptures over the course of the experiment indicates that fish persist in the sampling area across several sampling events, so while sampling events occupy 2-3 days per week, the potential for bias due to sampling not being "instantaneous" is negligible.

### AGE AND SEX COMPOSITION

The proportion of the spawning population composed of a given age or sex was estimated as (Cochran 1977):

$$\hat{p}_j = \frac{n_j}{n} \quad (8)$$

$$Var(\hat{p}_j) = \frac{\hat{p}_j(1-\hat{p}_j)}{n-1} \quad (9)$$

where:

$p_j$ =the proportion in the population in group $j$;
$n_j$ =the number in the sample of group $j$; and
$n$ =sample size.

To reduce bias due to inseason changes in age composition, samples were obtained systematically.

### ESTIMATES OF TOTAL RUN, EXPLOITATION, AND MARINE SURVIVAL

Estimates of total run (i.e., harvest and escapement) for coho salmon returning to Nakwasina River in 2004 and the associated exploitation rate in commercial and sport fisheries are based on the sum of the estimated harvest and escapement:

$$\hat{N}_R = \hat{H} + \hat{E}\ . \quad (10)$$

The variance of the estimated run was calculated as the sum of the variances for estimated escapement and harvest:

$$Var[\hat{N}_R] = Var[\hat{H}] + Var[\hat{E}]. \quad (11)$$

The estimate of exploitation rate and variance were calculated using (Mood et al. 1974):

$$\hat{U} = \frac{\hat{H}}{\hat{N}_R} \quad (12)$$

$$Var[\hat{U}] \approx \frac{Var[\hat{H}]\hat{E}^2}{\hat{N}_R^4} + \frac{Var[\hat{E}]\hat{H}^2}{\hat{N}_R^4}\ . \quad (13)$$

The estimated survival rate of smolt to adults and variance were calculated using (Mood et al. 1974):

$$\hat{S} = \frac{\hat{N}_R}{\hat{N}_s} \quad (14)$$

$$Var[\hat{S}] \approx \hat{S}^2 \left[ \frac{Var[\hat{N}_R]}{\hat{N}_R^2} + \frac{Var[\hat{N}_s]}{\hat{N}_s^2} \right] \quad (15)$$

# RESULTS

### SMOLT TAGGING, SAMPLING, AND ABUNDANCE IN 2003

Smolt abundance in 2003, based on fish tagged in Nakwasina River, is 55,424 (SE = 4,023; 95% $CI_{MCMC}$ = 48,200-63,940). Between April 17 and May 15, 2003, 15,813 coho smolt from Nakwasina River and its tributaries were captured and tagged. Tag retention was 99.9% with ten overnight mortalities. This left 15,762 valid tag releases. Of these, 9,925 (63%) were small smolt captured in the mainstem of Nakwasina River, while 2,533 (16%) were large smolt. Twenty-one percent (21%), or 3,304, were fish ≥65 mm captured in Bridge Creek.

Smolt captured and sampled in the mainstem of Nakwasina River that were age-1. fish (those rearing for one year in fresh water) comprised 98% and averaged 77.9 mm FL (SE = 0.37) and 4.9 g (SE = 0.08, Table 3). Age-2. coho smolt from the mainstem Nakwasina River averaged 103.8 mm FL (SE = 1.84) and 10.4 g (SE = 0.62). The combined catch averaged 78.6 mm FL (SE = 0.42) and 5.0 g (SE = 0.09). Average length and weight of captured coho remained approximately the same throughout the tagging effort.

Age-1. fish from Bridge Creek comprised 99% of sampled smolt and averaged 78.5 mm FL (SE = 0.81) and 4.7 g (SE = 0.21, Table 3). One age-2. coho smolt was captured and sampled from Bridge Creek and was 99 mm and weighed 9.2 g.

The proportions of smolt tagged in 2003 with each of three tag codes were significantly different than that observed in the spawning escapement in 2004 ($\chi^2$ = 23.65, P < 0.0001, Table 4). However, no differences were detected when large and small smolt from Nakwasina were combined and compared to those tagged in Bridge Creek ($\chi^2$ = 3.62, P = 0.057, Table 4). The smaller tag group apparently had lower survival based on rates of recovery of tagged adult fish ($\chi^2$ = 18.09,

**Table 4.**–Numbers and $\chi^2$ tests for independence for smolt and adult coho salmon from Nakwasina River and Bridge Creek, 2000–2004.

| Year | ≥70 mm[a] | ≥85 mm | Bridge Creek | Total | ≥70 mm[a] | ≥85 mm | Bridge Creek |
|---|---|---|---|---|---|---|---|
| **Spring smolt releases** | | | | | Percentage of Total | | |
| 2000 | 5,446 | 1,831 | 3,042 | 10,319 | 53% | 18% | 29% |
| 2001 | 6,979 | 1,434 | 1,986 | 10,399 | 67% | 14% | 19% |
| 2002 | 3,566 | 874 | 1,246 | 5,686 | 63% | 15% | 22% |
| 2003 | 9,925 | 2533 | 3,304 | 15,762 | 63% | 16% | 21% |
| **Adult escapement recoveries** | | | | | | | |
| 2001 | 75 | 35 | 40 | 150 | 50% | 23% | 27% |
| 2002 | 146 | 39 | 15 | 200 | 73% | 20% | 8% |
| 2003 | 145 | 28 | 24 | 197 | 74% | 14% | 12% |
| 2004 | 180 | 77 | 44 | 301 | 60% | 26% | 15% |
| **Adult fisheries recoveries** | | | | | | | |
| 2001 | 48 | 22 | 29 | 99 | 48% | 22% | 29% |
| 2002 | 27 | 22 | 5 | 54 | 50% | 41% | 9% |
| 2003 | 28 | 8 | 14 | 50 | 56% | 16% | 28% |
| 2004 | 52 | 22 | 24 | 98 | 53% | 22% | 24% |
| **All adults combined** | | | | | | | |
| 2001 | 123 | 57 | 69 | 249 | 49% | 23% | 28% |
| 2002 | 173 | 61 | 20 | 254 | 68% | 24% | 8% |
| 2003 | 173 | 36 | 38 | 247 | 70% | 15% | 15% |
| 2004 | 232 | 99 | 68 | 399 | 58% | 25% | 17% |

| Component 1 | Component 2 | $\chi 2$ | p |
|---|---|---|---|
| Smolt 2000 | All adults 2001 | 4.63 | 0.099 |
| Smolt 2000 | Adult escapement 2001 | 3.11 | 0.191 |
| Adult fisheries 2001 | Adult escapement 2001 | 0.21 | 0.901 |
| Smolt 2001 | All adults 2002 | 36.95 | 0.000 |
| Smolt 2001 | Adult escapement 2002 | 20.24 | 0.000 |
| Adult fisheries 2002 | Adult escapement 2002 | 11.46 | 0.003 |
| Smolt 2002 | All adults 2003 | 7.34 | 0.026 |
| Smolt 2002 | Adult escapement 2003 | 12.85 | 0.002 |
| Adult fisheries 2003 | Adult escapement 2003 | 8.34 | 0.016 |
| Nakwasina smolt 2002 | Nakwasina adults 2003 | 0.84 | 0.360 |
| Nakwasina smolt 2002 | Nakwasina escapement 2003 | 1.39 | 0.238 |
| Nakwasina fisheries 2003 | Nakwasina escapement 2003 | 0.76 | 0.383 |
| Adult fisheries 2004 | Adult escapement 2004 | 5.1 | 0.078 |
| Nakwasina smolt 2003 | Nakwasina adults 2004 | 23.98 | 0.000 |
| Nakwasina smolt 2003 | Nakwasina escapement 2004 | 23.65 | 0.000 |
| Nakwasina smolt 2003 | Bridge Creek smolt 2003 | 3.62 | 0.057 |
| Nakwasina small smolt 2003 | Nakwasina large smolt 2003 | 18.09 | 0.000 |
| Nakwasina fisheries 2004 | Nakwasina escapement 2004 | 5.1 | 0.078 |

[a] In 2003 smolt ≥65 mm were tagged.

$P < 0.0001$, Table 4). Tagged adults from Bridge Creek were not used to estimate smolt abundance because their survival may have been different than fish tagged in Nakwasina River, and we have no data to evaluate if the probability of a smolt being tagged was the same for both rearing areas.

Because tagged fish from Bridge Creek were treated as unmarked fish for this estimate, it is necessary that Bridge Creek smolt have the same survival as Nakwasina River smolt for this estimate to be unbiased. Further, because fish tagged in Bridge Creek spawned in Nakwasina River and none were found spawning in Bridge Creek, Bridge Creek was assumed to be a part of the Nakwasina River rearing area. From the tag recovery data (Table 4), it appears that survival of Bridge Creek smolt was approximately 65% of that for Nakwasina River smolt. However, when smolt survival from Nakwasina River tagging groups is adjusted for relative probability of sampling during the tagging event, it appears the Bridge Creek smolt survival was approximately 76% of that for Nakwasina River smolt.

## INSTREAM CODED WIRE TAG RECOVERY AND AGE-SEX COMPOSITION

The fraction of CWT adult coho salmon sampled in Nakwasina River during 2003 was 0.286. Of the 1,074 adult coho salmon examined, 307 had an adipose fin clip. Of these, all but 6 were found to contain a valid coded-wire tag.

The proportion of freshwater age-1. fish was not significantly different ($\chi^2$ = 1.32, P = 0.25) between smolt sampled in 2003 and adults sampled inriver during 2004 (Table 5; Appendix A2). Both groups were predominately (>97%) freshwater age-1. fish. Additionally, no differences were detected in freshwater age by sex ($\chi^2$ = 0.08, P = 0.78).

## CONTRIBUTION OF SMOLT TAGGED IN 2003 TO MARINE FISHERIES IN 2004

The estimated harvest of Nakwasina River coho salmon in sampled marine fisheries in 2004 was 1,645 (SE = 178, Table 6). Nakwasina coho contributed less than 1% of the combined sport, troll, and seine harvest (1,425,980, Table 6) for the areas in which Nakwasina River fish were recovered. The estimated total contribution to the marine sport fishery by Nakwasina coho was 200 fish. Sport-caught Nakwasina coho salmon comprised 12.2% of the harvest in the sampled marine fisheries, but relative contributions were higher for the sport harvest (0.37%) than the troll harvest (0.10%). Freshwater harvest of coho salmon in Nakwasina River will not be available until the Division of Sport Fish publishes the results of its annual mail-out angler survey (SWHS).

In 2004, 97 CWTs from Nakwasina River and Bridge Creek were randomly recovered from 307,168 coho salmon sampled in commercial and

**Table 5.**–Number of age-1. and age-2. Nakwasina River coho salmon smolt and adults, 2000–2004

| | | Brood year and age class | | | |
|---|---|---|---|---|---|
| | | 2002 | 2001 | 2000 | |
| | | 1.0 | 1.1 | 2.1 | Total aged |
| Females | Sample size | | 332 | 4 | 336 |
| | % age comp | | 98.8 | 1.2 | |
| | SE of % | | 0.6 | 0.6 | |
| | Average length | | 640 | 615 | |
| | SE | | 2 | 27 | |
| Males | Sample size | 20 | 488 | 7 | 515 |
| | % age comp | 3.9 | 94.8 | 1.4 | |
| | SE of % | 0.9 | 1.0 | 0.5 | |
| | Average length | 327 | 626 | 636 | |
| | SE | 5 | 3 | 25 | |
| All Fish | Sample size | 20 | 820 | 11 | 851 |
| | % age comp | 2.4 | 96.4 | 1.3 | |
| | SE of % | 0.5 | 0.6 | 0.4 | |
| | Average length | 327 | 632 | 629 | |
| | SE | 5 | 2 | 18 | |
| | | **Freshwater age**[a] | | | |
| | | 1 | 2 | $\chi2$ | P-value |
| Adults 2004 | | 840 | 11 | 1.32 | 0.25 |
| Smolt 2003 | | 515 | 11 | | |
| Adults 2003 | | 681 | 13 | 0.20 | 0.65 |
| Smolt 2002 | | 210 | 3 | | |
| Adult 2002 | | 663 | 25 | 18.53 | 0.00 |
| Smolt 2001 | | 368 | 41 | | |
| Adult 2001 | | 701 | 19 | 0.27 | 0.60 |
| Smolt 2000 | | 397 | 13 | | |
| 2004 Adult Males | | 488 | 7 | 0.08 | 0.78 |
| 2004 Adult Females | | 332 | 4 | | |

[a] Differences between $\chi^2$ observations and age class sample sizes are due to unreadable fresh or saltwater ages.

sport fisheries and nine additional CWTs were recovered incidentally (Appendix A3). Eighty-five coho salmon bearing CWTs with a Nakwasina River code were recovered randomly from Southeast Alaska's commercial troll fisheries. One fish was not used because it did not have quadrant recovery information. Of the 84 random recoveries with quadrant information, all but two were caught in the Northwest Quadrant (Figure 2) of Southeast Alaska between July 1 and September 30, 2004. Nine coho salmon bearing CWTs with a Nakwasina River code were recovered in the Sitka sport fishery between July 4 and September 26. Three coho salmon bearing CWTs were recovered in the Elfin Cove sport fishery between August 15 and August 30, and one fish was randomly recovered in the commercial seine fishery in the Northwest Quadrant in stat week 31.

**Table 6.–**Estimated harvest of adult Nakwasina River coho salmon (tag codes 04-08-17, 04-08-18, and 04-08-19) in sport and commercial fisheries sampled in 2004.

| | | | TROLL FISHERY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Period | Dates | Quadrant | Estimated harvest | Inspected | a | a' | t | t' | m | r | SE{r} |
| 3 | 7/1–8/9 | NW | 547,304 | 118,686 | 1,587 | 1,560 | 1,230 | 1,229 | 18 | 296 | 69 |
| 4 | 8/12–9/30 | NE | 131,422 | 27,257 | 443 | 436 | 333 | 332 | 2 | 34 | 24 |
| 4 | 8/12–9/30 | NW | 690,256 | 149,828 | 2,760 | 2,710 | 2,229 | 2,228 | 64 | 1,051 | 137 |
| Subtotal Troll Fishery | | | 1,368,982 | 295,771 | 4,790 | 4,706 | 3,792 | 3,789 | 84 | 1,381 | 156 |
| | | | PURSE SEINE FISHERY | | | | | | | | |
| Week | Dates | Quadrant | Estimated harvest | Inspected | a | a' | t | t' | m | r | SE{r} |
| 31 | 7/25–7/31 | NW | 3,503 | 194 | 9 | 9 | 8 | 8 | 1 | 63 | 63 |
| Subtotal Seine Fishery | | | 3,503 | 194 | 9 | 9 | 8 | 8 | 1 | 63 | 63 |
| | | | SPORT FISHERY | | | | | | | | |
| Bi-week | Dates | Area | Estimated harvest | Inspected | a | a' | t | t' | m | r | SE{r} |
| 14 | 7/4–7/18 | SITKA | 11,105 | 2,297 | 18 | 18 | 16 | 16 | 1 | 17 | 16 |
| 15 | 7/19–8/1 | SITKA | 8,126 | 1,465 | 18 | 18 | 15 | 15 | 1 | 19 | 19 |
| 16 | 8/2–8/15 | SITKA | 11,438 | 2,200 | 33 | 32 | 29 | 29 | 3 | 56 | 32 |
| 17 | 8/16–8/29 | SITKA | 14,453 | 3,488 | 52 | 51 | 48 | 48 | 2 | 30 | 20 |
| 19 | 9/13–9/26 | SITKA | 381 | 48 | 4 | 4 | 4 | 4 | 1 | 28 | 27 |
| 16 | 8/2–8/15 | ELFIN COVE | 1,210 | 464 | 16 | 16 | 14 | 14 | 1 | 9 | 9 |
| 18 | 8/30–9/12 | ELFIN COVE | 972 | 385 | 13 | 13 | 12 | 12 | 2 | 18 | 12 |
| 18 | 8/30–9/12 | SITKA | 5,810 | 856 | 23 | 23 | 16 | 16 | 1 | 24 | 23 |
| Subtotal sport fishery | | | 53,495 | 11,117 | 177 | 175 | 154 | 154 | 12 | 200 | 54 |
| Total all fisheries | | | 1,426,980 | 307,168 | 4,976 | 4,890 | 3,954 | 3,951 | 97 | 1,645 | 178 |

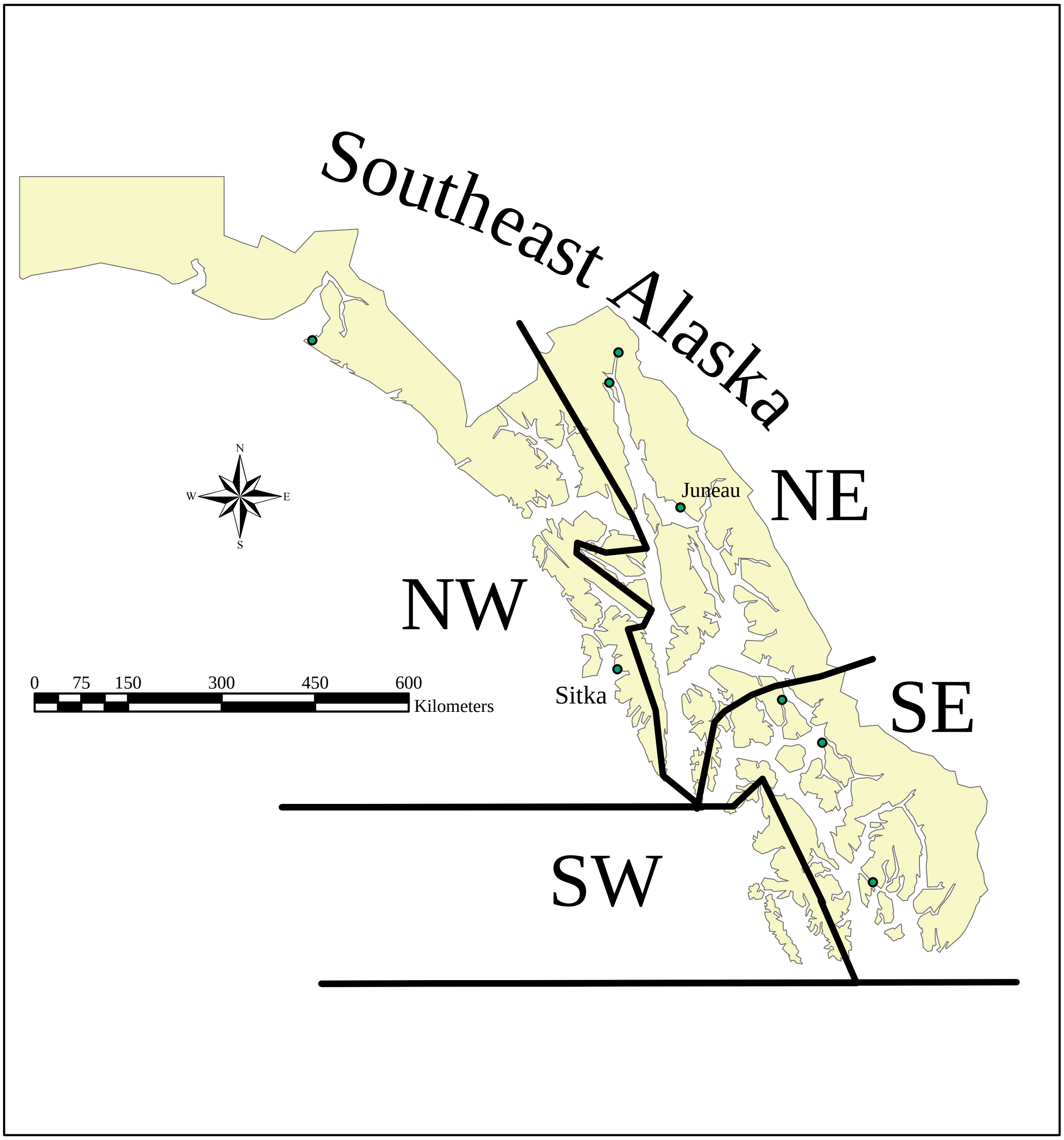


**Figure 2.–**Map of Southeast Alaska showing the boundaries for CWT quadrants.

Coho salmon bearing CWTs with a Nakwasina River code recovered in the commercial and sport fisheries averaged 645 mm FL (SE = 5.01).

## ESTIMATED SPAWNING ESCAPEMENT, TOTAL RUN, AND MARINE SURVIVAL

The estimated spawning escapement of coho salmon in Nakwasina River was 3,867 fish (SE = 937). Coho salmon were marked and recaptured in all 13 weeks of the study. Altogether, 1,074 unique adults were captured and examined, 905 were released, and 156 were recaptured (Table 7; Appendix A4). Only 9 recaptured fish had lost their numbered tag as evidenced by the operculum punches. A total of 325 fish were sacrificed for their CWTs or died on capture. No fish died upon recapture. Most (971) adult coho captured in Nakwasina River in 2004 were captured with either the beach seine or gillnet, while 103 were captured with hook and line. Hook and line gear was moderately effective at capturing fish but only when water conditions allowed for sighting fish.

**Table 7.–**Summarized mark-recapture data for Nakwasina River coho salmon, 2004. Notation follows that in Seber (1982).

| Week | Number captured | Number released | Number marked caught in $m_i$ | Losses on capture | Subsequently recaptured |
|---|---|---|---|---|---|
| 37 | 3 | 3 | | | 1 |
| 38 | 15 | 12 | | 3 | 1 |
| 40 | 33 | 12 | | 21 | 4 |
| 41 | 122 | 85 | 1 | 38 | 27 |
| 42 | 150 | 115 | 14 | 49 | 31 |
| 43 | 212 | 181 | 20 | 51 | 45 |
| 44 | 126 | 111 | 26 | 41 | 11 |
| 45 | 110 | 85 | 10 | 35 | 24 |
| 46 | 211 | 202 | 49 | 58 | 8 |
| 47 | 39 | 40 | 13 | 12 | 3 |
| 48 | 34 | 38 | 14 | 10 | 1 |
| 49 | 14 | 17 | 6 | 3 | |
| 50 | 5 | 4 | 3 | 4 | |
| Grand total | 1,074 | 905 | 156 | 325 | 156 |

Instream abundance peaked at 1,929 adults in week 6 and declined to 13 fish in week 13 (Table 8). Period-to-period survival rates varied from 0.023 (constrained) to 1.0 (Table 8). Four estimates of survival and six estimates of recruitment were constrained to yield admissible (realistic) values during the estimation procedure.

Goodness-of-fit tests suggested some potential for capture heterogeneity or handling mortality. Specifically, it appears that fish first captured during period 4 (week 6) of the experiment may have had a different probability of survival and/or subsequent recapture than fish caught prior to period 4 (Table 9, component 1). While the p-values of the test statistics warranted further attention (0.06 for $\chi^2$, 0.08 for Fisher's Exact Test), the test doesn't indicate significant potential for bias in the abundance estimates. In component 2 (Table 9), the $\chi^2$ test statistic for period 5 was significant (p = 0.05), however the sample sizes in the 2x2 contingency table were small, suggesting the $\chi^2$ statistic was biased. However, Fisher's Exact Test yielded a non-significant test result (p = 0.21), and the individual contribution of the period 5 observations was not large enough to influence the overall component 2 test result (p = 0.39). Therefore, the potential for bias from capture or survival heterogeneity was small, and the reported estimate is considered reliable for management purposes.

Twenty percent (20%) of the sample was captured or recovered in section 1, 38% at location 2, 39.4% at location 3, and 2.6% at tidewater (Table 10). In total, 28.6% of the fish inspected for Floy™ tags had either a Floy™ tag or a secondary mark. The probability of capturing a tagged fish was significantly different in section 1 versus section 2 ($\chi^2$ = 4.04, P = 0.045) and section 1 versus section 3 ($\chi^2$ = 19.8, P < 0.0001).

Length distributions of adult coho salmon captured in 2004 in Nakwasina River were not different between gear type used for capture, capture and recapture, or time of capture (Table 11, Figure 3). The average length of female and male coho salmon was 638 mm FL (SE = 1.9) and 626 mm FL (SE = 2.16), respectively. The proportions of males and females captured at locations 1, 2, and 3 were not significantly different ($\chi^2$ = 5.33 P = 0.070, Table 12), but recapture rates were significantly different ($\chi^2$ = 11.27 P < 0.001, Table 12). Based on an escapement estimate of 3,867, a coho salmon marine harvest of 1,645 fish, and smolt abundance of 55,424, the estimated total run in 2004 was 5,512 (SE = 954) and ocean survival was 9.9% (SE = 1.9%). Total exploitation was estimated to be 29.8% (SE = 5.6%).

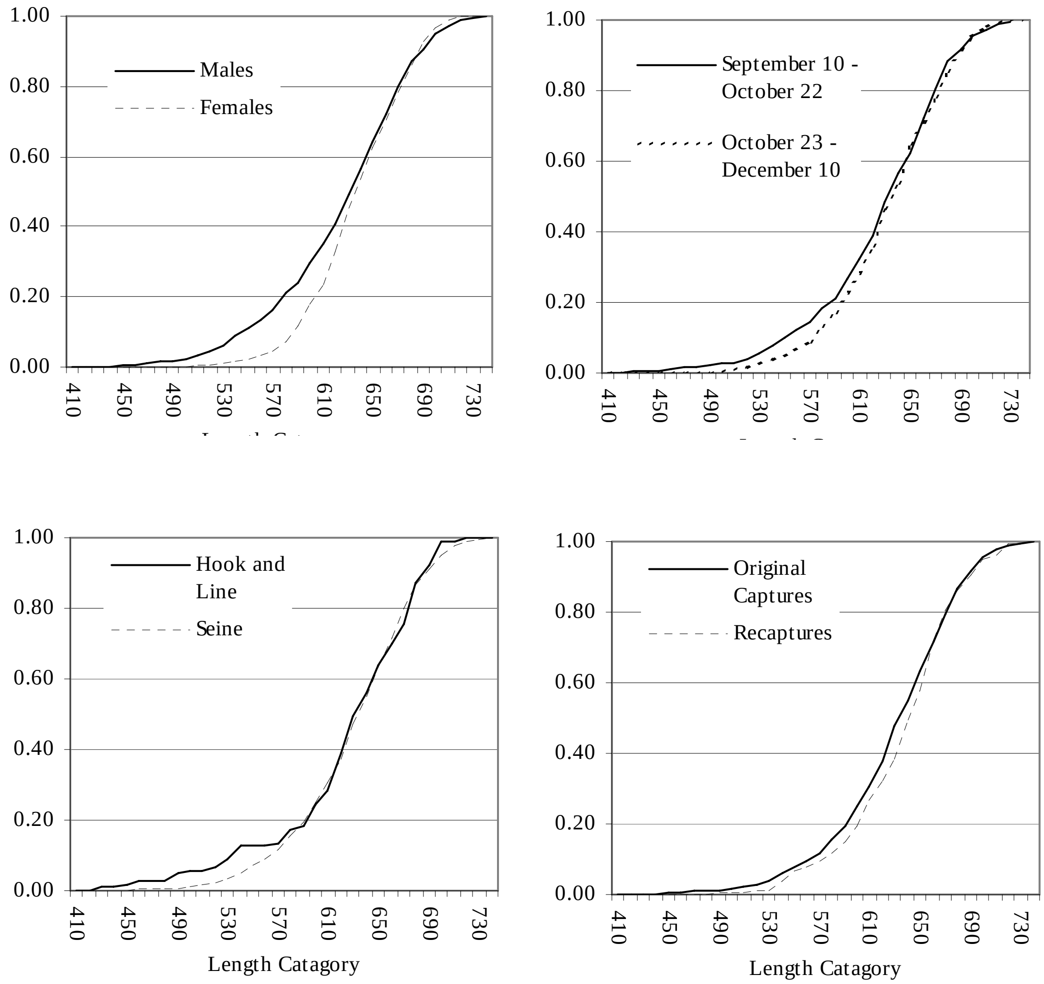


**Figure 3.**–Cumulative length frequency distributions to test for differences in lengths of captured coho by sex, time, gear, and capture or recapture, 2004.

**Table 8.**–Jolly Seber estimates of abundance (N), survival (ϕ), and recruitment (B) of adult coho salmon in Nakwasina River, 2004.

| Week(s) | Dates | $\hat{N}$ | $SE(\hat{N})$ | $\hat{\phi}$ | $SE(\hat{\phi})$ | $\hat{B}$ | $SE(\hat{B})$ |
|---|---|---|---|---|---|---|---|
| 1-3 | 9/10–10/2 | 1,477 | 335 | 1.000 | 0.000 | 0 | 0 |
| 4 | 10/3–10/9 | 1,453 | 335 | 0.584 | 0.122 | 0 | 0 |
| 5 | 10/10–10/16 | 825 | 246 | 1.000 | 0.000 | 1,152 | 430 |
| 6 | 10/17–10/23 | 1,929 | 413 | 1.000 | 0.000 | 35 | 511 |
| 7 | 10/24-10/30 | 1,913 | 336 | 0.4179 | 0.080 | 714 | 208 |
| 8 | 10/31-11/6 | 1,497 | 234 | 1.000 | 0.000 | 0 | 0 |
| 9 | 11/7-11/13 | 1,462 | 234 | 0.3553 | 0.157 | 0 | 0 |
| 10 | 11/14-11/20 | 502 | 223 | 0.997 | 0.786 | 87 | 153 |
| 11 | 11/21-11/27 | 563 | 421 | 0.999 | 0.000 | 43 | 205 |
| 12 | 11/28-12/4 | 595 | 400 | 0.023 | 0.015 | 0 | 0 |
| 13 | 12/5-12/11 | 13 | 4 | 0.000 | 0.000 | 0 | 0 |

## VISUAL COUNTS

Visual counts were conducted on Nakwasina River on two occasions in 2004 (Table 13). The peak count (399) occurred November 8 and represented 10.3% of the estimated total escapement.

# DISCUSSION

## SMOLT ABUNDANCE AND ADULT HARVEST

The smolt-to-adult survival rate of 9.9% in 2004 is low, but comparable to some other systems in the region (Table 14) and similar to the 2000–2004 average of 9.6% (Table 1). Because of the low average smolt-to-adult survival rate in Nakwasina River in 2000–2002 (8.7%), extra care was taken in spring 2003 to insure smolt were given an adequate opportunity to recover and smolt naturally. However, survival remained relatively low in 2003–2004, indicating that Nakwasina River coho smolt-to-adult survival rate may tend toward the lower end of the range observed in Southeast Alaska systems.

Condition 1 of an unbiased estimate of smolt abundance required that there was no recruitment to the population between years. Because almost all wild coho salmon return to their natal streams and sampling only occurred in the river, there was probably no appreciable recruitment to the stock between marking and recovery. The presence of stray coho salmon reared at Medvejie hatchery is possible but unlikely given the geographical distance between the two sites. Additionally, no coho salmon from Medvejie hatchery have been recovered in Salmon Lake, which is much closer to the hatchery release area.

Vincent-Lang (1993) has shown that coho salmon smolts marked as in this project and handled competently suffer no detectable mortality from the experience, so we believe condition 2 was satisfied. Also, there is no reason to believe that capture rates for adults was influenced by the code on a tag imbedded deep within its cartilage. For these reasons, the differences in recovery rates were most likely due to natural differences in survival rates.

It is unlikely that smolt regenerated the clipped adipose fin that identified the fish as containing a tag, so it is likely that condition 3 was satisfied. In conjunction with tag retention and overnight mortality tests, adipose fin clips on smolt were examined. All smolt examined appeared to have good fin clips. Also, all adult coho examined had well defined or a complete absence of an adipose fin.

**Table 9.**–Summary of goodness-of-fit tests for homogeneous capture/survival probabilities by tag group for adult coho salmon in Nakwasina River, 2004. Overall chi-squares are the sum of the individual test statistics.

| | Component 1[a] | | | Component 2[b] | | |
|---|---|---|---|---|---|---|
| Period | $\chi^2$ τατσ | df | P-value | $\chi^2$ τατσ | df | P-value |
| 2 | 0.40 | 1 | 0.53 | 0.00 | 0 | 0.00 |
| 3 | 1.30 | 1 | 0.25 | 0.11 | 1 | 0.73 |
| 4 | 3.47 | 1 | 0.06[c] | 1.96 | 1 | 0.16 |
| 5 | 0.35 | 1 | 0.85 | 3.95 | 1 | 0.05[d] |
| 6 | 0.61 | 1 | 0.43 | 0.11 | 1 | 0.74 |
| 7 | 0.6 | 1 | 0.81 | 0.02 | 1 | 0.90 |
| 8 | 0.15 | 1 | 0.70 | 0.14 | 1 | 0.71 |
| 9 | 0.16 | 1 | 0.69 | 0.00 | 0 | 0.00 |
| 10 | 0.0 | 0 | 0.00 | 0.00 | 0 | 0.00 |
| Overall | 6.175 | 8 | 0.62 | 6.301 | 6 | 0.39 |

[a] Test for short-term mortality per Robson (1969).
[b] Test for heterogenous survival probabilities per Pollock et al. (1990).
[c] Fisher's Exact Test P-value = 0.08.
[d] Fisher's Exact Test P-value=0.21.

Although the assumption that complete mixing occurred cannot be tested, coho salmon most likely mixed within or across stocks during their extended time (14 months) at sea. In Nakwasina River catches, the fraction of adult coho salmon with marks (missing an adipose fin) did not vary significantly over time ($\chi^2$ = 1.18, P = 0.556; Table 15).

Smolt-to-adult survival rates for smolt tagged in the main stem of Nakwasina River and those tagged in Bridge Creek were not significantly different. However, it appears that survival was lower for smaller smolt (those ≤65 mm) than larger smolt tagged in Nakwasina River. Neither condition S2 nor condition S3 can be satisfied when unequal survival is detected.

To evaluate if condition S1 was satisfied, the assumption that the probability of capture for Nakwasina River smolt was independent of size was tested. The ratio of the catchability coefficients (estimated A) for large to small smolt was estimated using the methods described in Tydingco (2005b). For smolt tagged in 2003, the estimated ratio was 3.368 (SE = 2.021; 95%

**Table 10.–**Results of $\chi 2$ tests for differences in tagged rate between river sections for adult coho salmon in Nakwasina River, 2004.

| Location | Untagged | Tagged | Total | p |
|---|---|---|---|---|
| Upstream 1 | 197 | 49 | 246 | 0.199 |
| Middle 2 | 402 | 66 | 468 | 0.141 |
| Lower 3 | 443 | 41 | 484 | 0.084 |
| Tide water | 32 | 0 | 32 | |
| Total | 1,074 | 156 | 1,230 | |

CIMCMC: 1.165, 8.835), which provides evidence that smolt from the two size groups had significantly different capture probabilities. It was not possible to compare the probability of tagging Bridge Creek smolt with that of Nakwasina River smolt. Further, there are no expectations that capture probabilities were similar because tagging occurred in geographically separate areas. However, smolt capture occurred throughout the emigration, within most of the available smolt habitat, and was accomplished with minnow traps that captured a wide range of smolt sizes. Smolt tagging occurred just prior to and during the smolt migration. Because approximately equal effort occurred throughout the emigration, later migrating smolt may have had a higher probability of capture. Similarly, recovery effort was expended throughout most of the run of returning adults, but not in exact proportion to fish abundance, and a small number of fish probably returned earlier or later than the tag recovery sampling.

Because none of the conditions S1–S3 were satisfied, the Chapman modification to the Petersen estimator (Seber 1982) could not be used to calculate an unbiased estimate of smolt abundance. It was necessary to employ equations (1-3) to adjust for the differential catchability detected between large and small smolt during tagging. Adjusting for differential catachability will result in an unbiased estimate of abundance subject to the other conditions 1-5 also being satisfied.

The smolt estimate of 55,424 may be biased low, despite the adjustments for differential catchability between large and small smolt tagged in Nakwasina River. Unfortunately, attempts to assess the bias are, at best, speculative because no data are available to measure differences in probability of tagging between the Nakwasina River and Bridge Creek rearing areas. However, if the probabilities of a smolt being tagged were approximately the same for both Nakwasina River and Bridge Creek, then approximately 20–25% of the smolt in the Nakwasina system were in Bridge Creek when tagging was conducted, and the projected true smolt abundance is 1.05 to 1.10 times the estimated value. If Bridge Creek smolt were tagged at a higher rate than Nakwasina River smolt, the potential bias is not so severe. If Bridge Creek smolt were tagged at a lower rate than Nakwasina River smolt, the potential bias is greater than projected.

## ADULT ESCAPEMENT IN 2004

There were no indications to suggest problems with the abundance estimate; tag loss was low (<1%), sampling rates were high, assumptions of the JS experiment were met, and the JS model fit the data. Diagnostic testing for handling mortality and/or heterogeneity in probability of capture or survival indicated some potential for these problems, but detailed inspection of these diagnostics led to the conclusion that the potential for bias resulting from these types of problems was very low. Additionally, marking did not appear to affect the behavior or movement of fish, as marked fish were observed spawning with or near unmarked fish throughout the study.

A higher rate of recapture was observed for males than females. This may have been due to error in determining the sex of fish early in the run.

**Table 11.–**Results of Kolmogorov-Smirnov tests for differences between cumulative length frequencies for adult coho salmon in Nakwasina River, 2004.

| | Males vs. | Females | Sept. 10-Oct. 22 vs. | Oct. 23 - Dec 10 | Hook and line vs. | Seine | Original capture vs. | Recapture |
|---|---|---|---|---|---|---|---|---|
| Number of lengths compared | 643 | 431 | 535 | 539 | 103 | 971 | 1024 | 156 |
| $D_i$ | 0.142 | | 0.055 | | 0.079 | | 0.939 | |
| P-value | <0.000 | | 0.386 | | 0.592 | | 0.174 | |

Because the secondary maturation characteristics had not fully developed earlier in the run, it is possible that some fish were misidentified as females. When recaptured, fish previously identified as females may have been identified as males. This would lead to an indication that a higher proportion of males were recaptured. Similar tests from previous years have yielded inconsistent results, with no difference detected between male and female recapture rates in 2000 and 2002, a significantly higher apparent recapture rate for females in 2001, and a significantly higher rate for males in 2003 (Brookover et al. 2003; Tydingco 2003; 2005a,b). The lack of pattern across years suggests that apparent differences are more likely the result of misclassification than in behavioral differences between males and females that affect probability of recapture.

The fact that the JS estimations were constrained to yield admissible values does not necessarily indicate that violation of some of the assumptions occurred and that the estimation model is inappropriate (Schwarz et al. 1993). However, assumptions that all fish have the same survival rate and that all fish have the same probability of capture during each event are not likely to be satisfied in a field experiment such as this one, so potential for bias in the abundance estimate needs to be considered. Differences were found between the fractions of fish carrying marks in upriver and downriver locations (Table 10), indicating that marked and unmarked fish did not mix completely between sampling events. Lack of complete mixing between events can only be mitigated by application of uniform sampling effort across the study area during each event, ensuring similar probabilities of capture for all fish in the experiment during each sampling event. While it is unlikely that equal capture probabilities can be uniformly achieved, field efforts to sample proportional to our perception of fish abundance across the study area are intended to minimize the potential for bias in abundance estimation due to violating this assumption. It is not expected that the survival rate is uniform across all fish in the experiment between sampling events. "Older" fish are expected to have a lower survival rate between events, particularly later in this experiment. While Seber (1982), as cited by Sykes and Botsford (1986), suggests that JS estimates should be relatively unbiased if mark status and mortality are not correlated, Schwarz et al. (1993) demonstrated with simulation that declines in survival of 20% between successive sampling periods after new fish enter the study area can result in over-estimates of abundance on the order of one standard error of the point estimate. However, if "older" fish are also more susceptible to capture due to declining condition, a negative

**Table 12.–**Differences in coho salmon sex composition between capture type, gear, and location in Nakwasina River, 2004.

| Capture | Females | Males | % Males | $\chi 2$ | p-value |
|---|---|---|---|---|---|
| Captured | 431 | 643 | 59.87% | 11.27 | 0.0008 |
| Recapture | 35 | 103 | 74.64% | | |
| **Gear type** | | | | | |
| Hook and line | 50 | 53 | 51.46% | 3.36 | 0.067 |
| Seine/tangle net | 381 | 590 | 60.76% | | |
| **Location** | | | | | |
| 1 | 65 | 132 | 67.01% | 5.33[a] | 0.070 |
| 2 | 159 | 243 | 60.45% | | |
| 3 | 189 | 254 | 57.34% | | |
| Tide water | 18 | 14 | 43.75% | | |

[a] Location 1 vs. 2 vs. 3.

**Table 13.–**Nakwasina River stream survey counts including number of coho salmon counted, date, survey conditions, and percentage of total escapement estimate represented by daily count.

| Date | Count | Conditions | % of total escapement |
|---|---|---|---|
| 10/8/2004 | 148 | Visibility poor, tide high, water normal | 3.8% |
| 11/8/2004 | 399 | Visibility poor, tide high, water low | 10.3% |

**Table 14.–**Smolt to adult survival rate for coho indicator streams around Southeast Alaska.

| | Return Year | | | | | |
|---|---|---|---|---|---|---|
| Stream | 2000 | 2001 | 2002 | 2003 | 2004 | Average |
| Auke Creek | 18.5 | 28.3 | 26.8 | 25 | 20.7 | 23.9 |
| Berners River | 12.1 | 11.9 | 19 | 19.1 | 17.7 | 16.0 |
| Taku River | 6.3 | 8.8 | 11.1 | 8.9 | 8.6 | 8.7 |
| Ford Arm | 12.8 | 8.2 | 14.7 | 17 | 11.9 | 12.9 |
| Hugh Smith Lake | 6.6 | 13.5 | 14.5 | 13.7 | 10.4 | 11.7 |
| Unuk River | 3.8 | 11.4 | 9.3 | | | 8.2 |
| Nakwasina River | 6.8 | 9.5 | 9.8 | 11.9 | 9.9 | 9.6 |

bias can result which may nearly cancel the positive bias resulting from the survival heterogeneity. While it is expected that fish in this experiment tended to experience lower survival later in their tenure in the study area, it is not likely as well correlated or severe as that simulated by Schwarz et al. (1993). If the escapement estimate is biased due to differential mortality, it is biased high and the magnitude of the bias is within one standard error of the estimate.

Although some fish do temporarily emigrate and re-immigrate after being tagged, no data exists to indicate a problem due to fish from other systems temporarily entering the system, being tagged, and then permanently emigrating. Some fish may temporarily emigrate from the study area due to stress associated with handling and tagging and later re-immigrate into the study area. In 2001, a Floy™ tagged fish with fresh herring in its belly was returned by a fisherman that captured the fish in Nakwasina River. This indicates that some fish do temporarily emigrate and re-immigrate after being tagged. The temporary lack of closure is not likely a significant source of bias. Of 138 first recaptures of marked fish in 2003, 42% occurred during the sampling event immediately after the tagging event and 68% occurred during either the first or second event immediately after tagging.

**Table 15.**–Proportion of recovered Nakwasina River adult coho salmon observed with and without adipose fin clips, 2004.

| Date | No. clip | Clip observed | Tagged proportion |
|---|---|---|---|
| 10-Sep | 3 | | 0.00 |
| 16-Sep | 6 | | 0.00 |
| 17-Sep | 6 | 3 | 0.33 |
| 30-Sep | 12 | 6 | 0.33 |
| 1-Oct | 7 | 8 | 0.53 |
| 4-Oct | 63 | 27 | 0.30 |
| 5-Oct | 21 | 11 | 0.34 |
| 11-Oct | 7 | 6 | 0.46 |
| 12-Oct | 101 | 36 | 0.26 |
| 19-Oct | 4 | 3 | 0.43 |
| 20-Oct | 83 | 28 | 0.25 |
| 21-Oct | 63 | 16 | 0.20 |
| 22-Oct | 11 | 4 | 0.27 |
| 27-Oct | 34 | 15 | 0.31 |
| 28-Oct | 51 | 26 | 0.34 |
| 5-Nov | 36 | 16 | 0.31 |
| 6-Nov | 40 | 18 | 0.31 |
| 9-Nov | 67 | 20 | 0.23 |
| 10-Nov | 43 | 19 | 0.31 |
| 11-Nov | 43 | 19 | 0.31 |
| 18-Nov | 27 | 12 | 0.31 |
| 23-Nov | 25 | 9 | 0.26 |
| 29-Nov | 12 | 2 | 0.14 |
| 7-Dec | | 2 | 1.00 |
| 8-Dec | 2 | 1 | 0.33 |
| Grand total | 767 | 307 | 0.286 |
| Sept. 10–Oct. 5 | 118 | 55 | |
| Oct.11–Oct. 28. | 354 | 134 | |
| Nov. 5–Dec. 8 | 295 | 118 | |
| | $\chi^2$ = | 1.18 | |
| | P = | 0.556 | |

In 2004, 32 fish were tagged at tidewater. Of these, 4 were recovered. This recovery rate is similar to sections 2 and 3 (Table 16). These recovery rates indicate that problems associated with tagging mortality near the saltwater/freshwater interface (Vincent-Lang 1993) were not present at detectable levels during this study.

## VISUAL COUNTS

Nakwasina River is similar to other clearwater streams in the area, and the relationship between the peak observer count and the total escapement is similar to that found in Steep Creek near Juneau, Alaska (Jones III and McPherson 1997; McPherson et al. 1996). The ability to count spawning salmon depends on many factors, including the observer, weather, water clarity,

**Table 16.**–Numbers of coho salmon recaptured in Nakwasina River by location of original tagging and location of recapture, 2004.

| | Original tag location | | | |
|---|---|---|---|---|
| Location of recapture | 1 Upstream | 2 Middle section | 3 Lower section | Tide water |
| Upstream 1 | 7 | 17 | 23 | 2 |
| Middle section 2 | 5 | 27 | 34 | |
| Lower section 3 | 1 | 16 | 22 | 2 |
| Totals | 13 | 60 | 79 | 4 |
| Total number of fish tagged | 197 | 402 | 443 | 32 |
| Proportion recovered | 0.066 | 0.149 | 0.178 | 0.125 |

canopy cover, pool-to-riffle ratio, the density of fish, the amount of undercut banks, and the ecology, behavior, size, and color of salmon (Jones III 1995).

### HARVEST SAMPLING

To assess the adequacy of sampling rates in the purse seine and gillnet fisheries, troll harvests within Southeast Alaska where Nakwasina River coho salmon recovery occurred were examined (Table 17). The sampling rate for troll fisheries in the Northwest Quadrant ranged from 9% (District 154) to 21% (District 113). Not all fisheries were sampled, so it is likely that Nakwasina River coho salmon harvest was underestimated in some fisheries.

**Table 17.–**Numbers of coho salmon harvested and sampled for CWT recovery for districts in which Nakwasina River coho salmon were recovered in 2004.

| District | Gear type | Fish harvested | Fish sampled | Proportion sampled |
|---|---|---|---|---|
| 113 | Purse | 913 | 98 | 0.107 |
| 109 | Troll | 113,411 | 24,050 | 0.212 |
| 113 | Troll | 752,855 | 159,569 | 0.212 |
| 114 | Troll | 181,491 | 37,106 | 0.204 |
| 116 | Troll | 93,588 | 14,581 | 0.156 |
| 154 | Troll | 48,850 | 6,008 | 0.123 |
| 183 | Troll | 6,911 | 653 | 0.094 |
| | | 1,198,019 | 242,065 | 0.202 |

## RECOMMENDATIONS

In future tagging events, extra care should be taken to ensure that any potential effects of tagging are minimized. Recommendations for future tagging include: 1) releasing smolt in side tributaries with extensive available rearing habitat as opposed to mainstem areas with higher velocities; 2) minimizing transport distances by centralizing the tagging and holding site; 3) returning tagged smolt to locations near their capture site; 4) tagging and sampling all fish within 48 hours of capture to ensure fish are not held for periods greater than 72 hours, including overnight mortality testing; and 5) estimating the true contribution and survival of Bridge Creek smolt in the Nakwasina adult escapement. This may be done by installing a weir on Bridge Creek through the smolting migration and either counting each fish that smolts through the weir or conducting a mark recapture experiment to estimate the number of smolt in Bridge Creek prior to the smolting migration.

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# APPENDICES

**Appendix A1.–**Simulated values modeled from observed data used to estimate catchability of coho smolt from the Nakwasina River in 2003.

observed 52 = $H_1$ ~binomial($H_1$'/9925, 9925);

observed 22 = $H_2$ ~binomial($H_2$'/2533, 2533);

observed 24 = $H_{BC}$ ~binomial($H_{BC}$'/3304, 3304);

observed 180 = $R_1$ ~binomial($R_1$'/(9925-$H_1$'), 9925-$H_1$');

observed 77 = $R_2$ ~binomial($R_2$'/(2533-$H_2$'), 2533-$H_2$');

observed 44 = $R_{BC}$ ~binomial($R_{BC}$'/(3304-$H_{BC}$'), 3304-$H_{BC}$');

$T_i' = H_i' + R_i'$ for $i$ = 1,2, and $BC$;

observed 6 = $R_3$ ~binomial($R_3$'/307, 307);

observed 333 = 333*$\hat{\phi}_1$~binomial($\hat{\phi}_1$',333);

observed 77 = 87*$\hat{\phi}_2$ ~binomial($\hat{\phi}_2$',87); and

observed 840 = 851* $\hat{p}$ ~binomial( $\hat{p}$ ,851).

At the end of the iterations, the following statistics were calculated:

$$\overline{N}' = \frac{\sum_{b=1}^{100000} \hat{N}'_{(b)}}{100000} \qquad (4a)$$

$$\text{var}(\hat{N}) = \frac{\sum_{b=1}^{100000} (\hat{N}'_{(b)} - \overline{N}')^2}{100000-1} \qquad (4b)$$

Similar formulas were used to calculate $\overline{A'}$ and var( $\hat{A}$ ).

**Appendix A2.–**Brood year, age classes and lengths of coho salmon by year sampled in the Nakwasina River, 2001–2004.

| | | | Brood year and age class | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample year** | | | 2002 1.0 | 2001 1.1 | 2000 2.1 | 2001 1.0 | 2000 2.0 | 2000 1.1 | 1999 2.1 | 2000 1.0 | 1999 1.1 | 1998 2.1 | 1999 1.0 | 1998 2.0 | 1998 1.1 | 1997 2.1 | **Total aged** |
| **2004** | Females | Sample size | | 332 | 4 | | | | | | | | | | | | 336 |
| | | % age comp | | 98.8 | 1.2 | | | | | | | | | | | | |
| | | SE of % | | 0.6 | 0.6 | | | | | | | | | | | | |
| | | Average length | | 640 | 615 | | | | | | | | | | | | |
| | | SE | | 2 | 27 | | | | | | | | | | | | |
| | Males | Sample size | 20 | 488 | 7 | | | | | | | | | | | | 515 |
| | | % age comp | 3.9 | 94.8 | 1.4 | | | | | | | | | | | | |
| | | SE of % | 0.9 | 1.0 | 0.5 | | | | | | | | | | | | |
| | | Average length | 327 | 626 | 636 | | | | | | | | | | | | |
| | | SE | 5 | 3 | 25 | | | | | | | | | | | | |
| | All Fish | Sample size | 20 | 820 | 11 | | | | | | | | | | | | 851 |
| | | % age comp | 2.4 | 96.4 | 1.3 | | | | | | | | | | | | |
| | | SE of % | 0.5 | 0.6 | 0.4 | | | | | | | | | | | | |
| | | Average length | 327 | 632 | 629 | | | | | | | | | | | | |
| | | SE | 5 | 2 | 18 | | | | | | | | | | | | |
| **2003** | Females | Sample size | | | | | | 276 | 6 | | | | | | | | 282 |
| | | % age comp | | | | | | 97.9 | 2.1 | | | | | | | | |
| | | SE of % | | | | | | 0.9 | 0.9 | | | | | | | | |
| | | Average length | | | | | | 635 | 640 | | | | | | | | |
| | | SE | | | | | | 2 | 18 | | | | | | | | |
| | Males | Sample size | | | | 16 | 5 | 405 | 7 | | | | | | | | 433 |
| | | % age comp | | | | 3.7 | 1.2 | 93.5 | 1.6 | | | | | | | | |
| | | SE of % | | | | 0.9 | 0.5 | 1.2 | 0.6 | | | | | | | | |
| | | Average length | | | | 319 | 319 | 614 | 654 | | | | | | | | |
| | | SE | | | | 8 | 14 | 3 | 13 | | | | | | | | |
| | All Fish | Sample size | | | | 16 | 5 | 681 | 13 | | | | | | | | 715 |
| | | % age comp | | | | 2.2 | 0.7 | 95.2 | 1.8 | | | | | | | | |
| | | SE of % | | | | 0.6 | 0.3 | 0.8 | 0.5 | | | | | | | | |
| | | Average length | | | | 319 | 319 | 622 | 648 | | | | | | | | |
| | | SE | | | | 8 | 14 | 2 | 10 | | | | | | | | |

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**Appendix A2.–**Page 2 of 2.

| Sample year | | | 2002 1.0 | 2001 1.1 | 2000 2.1 | 2001 1.0 | 2000 2.0 | 2000 1.1 | 1999 2.1 | 2000 1.0 | 1999 1.1 | 1998 2.1 | 1999 1.0 | 1998 2.0 | 1998 1.1 | 1997 2.1 | Total aged |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Brood year and age class | | | | | | | | | | | | | | |
| 2002 | Females | Sample size | | | | | | | | | 243 | 13 | | | | | 256 |
| | | % age comp | | | | | | | | | 94.9 | 5.1 | | | | | |
| | | SE of % | | | | | | | | | 1.4 | 1.4 | | | | | |
| | | Average length | | | | | | | | | 626 | 647 | | | | | |
| | | SE | | | | | | | | | 3 | 11 | | | | | |
| | Males | Sample size | | | | | | | | 2 | 409 | 12 | | | | | 423 |
| | | % age comp | | | | | | | | 0.5 | 96.7 | 2.8 | | | | | |
| | | SE of % | | | | | | | | 0.3 | 0.9 | 0.8 | | | | | |
| | | Average length | | | | | | | | 313 | 608 | 641 | | | | | |
| | | SE | | | | | | | | 3 | 3 | 18 | | | | | |
| | All Fish | Sample size | | | | | | | | 2 | 652 | 25 | | | | | 679 |
| | | % age comp | | | | | | | | 0.3 | 96.0 | 3.7 | | | | | |
| | | SE of % | | | | | | | | 0.2 | 0.7 | 0.7 | | | | | |
| | | Average length | | | | | | | | 313 | 615 | 644 | | | | | |
| | | SE | | | | | | | | 3 | 2 | 10 | | | | | |
| 2001 | Females | Sample size | | | | | | | | | | | | | 263 | 5 | 268 |
| | | % age comp | | | | | | | | | | | | | 98.1 | 1.9 | |
| | | SE of % | | | | | | | | | | | | | 0.8 | 0.8 | |
| | | Average length | | | | | | | | | | | | | 630 | 658 | |
| | | SE | | | | | | | | | | | | | 2 | 18 | |
| | Males | Sample size | | | | | | | | | | | 4 | 2 | 433 | 14 | 453 |
| | | % age comp | | | | | | | | | | | 0.9 | 0.4 | 95.6 | 3.1 | |
| | | SE of % | | | | | | | | | | | 0.4 | 0.3 | 1.0 | 0.8 | |
| | | Average length | | | | | | | | | | | 283 | 353 | 621 | 597 | |
| | | SE | | | | | | | | | | | 6. | 28 | 3 | 18 | |
| | All Fish | Sample size | | | | | | | | | | | 4 | 2 | 696 | 19 | 721 |
| | | % age comp | | | | | | | | | | | 0.6 | 0.3 | 96.5 | 2.6 | |
| | | SE of % | | | | | | | | | | | 0.3 | 0.2 | 0.7 | 0.6 | |
| | | Average length | | | | | | | | | | | 283 | 353 | 624 | 613 | |
| | | SE | | | | | | | | | | | 6 | 28 | 2 | 16 | |

**Appendix A3.–**Recoveries of coded wire tags originating from Nakwasina River coho salmon during 2004**.**

| Head | Tag Code | Gear Class | Date (CWT) | Stat Week | Quadrant | District | Sub-District | Length | Survey Site | Sample |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Random Recoveries | | | | | |
| 260069 | 40817 | TROLL | 8/15/2004 | 34 | NW | 113 | 45 | 511 | SITKA | 4031147 |
| 263472 | 40817 | TROLL | 7/4/2004 | 28 | NW | 113 | 31 | 552 | SITKA | 4030798 |
| 267085 | 40817 | TROLL | 9/6/2004 | 37 | NW | 114 | 21 | 557 | PELICAN | 4010106 |
| 266854 | 40817 | TROLL | 9/11/2004 | 37 | NW | 113 | 71 | 567 | PELICAN | 4010116 |
| 266161 | 40817 | TROLL | 7/9/2004 | 28 | NW | 113 | 91 | 588 | PELICAN | 4010015 |
| 538086 | 40817 | TROLL | 7/6/2004 | 28 | NW | | | 590 | EXCURSION INLET | 4100018 |
| 263854 | 40817 | TROLL | 7/25/2004 | 31 | NW | 113 | 31 | 590 | SITKA | 4031003 |
| 265140 | 40817 | TROLL | 7/24/2004 | 30 | | | | 591 | PORT ALEXANDER | 4080053 |
| 261324 | 40817 | TROLL | 9/19/2004 | 39 | NW | 113 | 45 | 597 | SITKA | 4031304 |
| 261259 | 40817 | TROLL | 9/11/2004 | 37 | NW | 113 | 45 | 601 | SITKA | 4031277 |
| 264274 | 40817 | TROLL | 9/8/2004 | 37 | NW | 113 | 11 | 606 | PORT ALEXANDER | 4080177 |
| 261053 | 40817 | TROLL | 8/28/2004 | 35 | NW | 113 | 45 | 609 | SITKA | 4031227 |
| 266316 | 40817 | TROLL | 7/30/2004 | 31 | NW | 116 | 11 | 612 | PELICAN | 4010042 |
| 266776 | 40817 | TROLL | 8/26/2004 | 35 | NW | 113 | 91 | 613 | PELICAN | 4019999 |
| 260746 | 40817 | TROLL | 8/17/2004 | 34 | NW | 154 | | 617 | SITKA | 4031195 |
| 260314 | 40817 | TROLL | 8/26/2004 | 35 | NW | 154 | | 620 | SITKA | 4031223 |
| 267070 | 40817 | TROLL | 9/3/2004 | 36 | NW | 114 | 21 | 620 | PELICAN | 4010104 |
| 262272 | 40817 | PURSE | 7/27/2004 | 31 | NW | 113 | | 625 | SITKA | 4031015 |
| 263849 | 40817 | TROLL | 7/25/2004 | 31 | NW | 113 | 31 | 625 | SITKA | 4031003 |
| 262840 | 40817 | TROLL | 8/8/2004 | 33 | NW | 113 | 41 | 631 | SITKA | 4031105 |
| 266364 | 40817 | TROLL | 8/10/2004 | 33 | NW | 116 | 11 | 632 | PELICAN | 4010052 |
| 266742 | 40817 | TROLL | 8/24/2004 | 35 | NW | 113 | 71 | 632 | PELICAN | 4010075 |
| 262866 | 40817 | TROLL | 8/9/2004 | 33 | NW | 113 | 45 | 634 | SITKA | 4031118 |
| 261271 | 40817 | TROLL | 9/11/2004 | 37 | NW | 113 | 91 | 637 | SITKA | 4031278 |
| 519390 | 40817 | TROLL | 8/19/2004 | 34 | NW | 114 | 21 | 640 | ELFIN COVE | 4020163 |
| 530928 | 40817 | TROLL | 7/18/2004 | 30 | NW | 183 | 10 | 641 | YAKUTAT | 4140045 |
| 260011 | 40817 | TROLL | 8/9/2004 | 33 | NW | 113 | | 642 | SITKA | 4031115 |
| 260331 | 40817 | TROLL | 8/26/2004 | 35 | NW | | | 645 | SITKA | 4031226 |
| 265458 | 40817 | TROLL | 8/25/2004 | 35 | NW | 113 | 11 | 648 | PORT ALEXANDER | 4080138 |
| 274385 | 40817 | TROLL | 8/30/2004 | 36 | NW | 154 | | 650 | HOONAH | 4110316 |
| 261301 | 40817 | TROLL | 9/18/2004 | 38 | NW | 113 | 81 | 651 | SITKA | 4031299 |
| 538327 | 40817 | TROLL | 8/13/2004 | 33 | NW | | | 654 | EXCURSION INLET | 4100083 |
| 261072 | 40817 | TROLL | 8/28/2004 | 35 | NW | 113 | 45 | 654 | SITKA | 4031229 |
| 261281 | 40817 | TROLL | 9/11/2004 | 37 | NW | 113 | 91 | 655 | SITKA | 4031278 |
| 260111 | 40817 | TROLL | 8/14/2004 | 33 | NW | 113 | 31 | 662 | SITKA | 4031131 |
| 260320 | 40817 | TROLL | 8/27/2004 | 35 | NW | 154 | | 668 | SITKA | 4031225 |
| 274609 | 40817 | TROLL | 9/4/2004 | 36 | NW | | | 670 | HOONAH | 4110354 |
| 261394 | 40817 | TROLL | 9/20/2004 | 39 | NW | 154 | | 670 | SITKA | 4031310 |
| 274896 | 40817 | TROLL | 9/25/2004 | 39 | NW | 114 | | 671 | HOONAH | 4110397 |
| 260340 | 40817 | TROLL | 8/26/2004 | 35 | NW | | | 672 | SITKA | 4031226 |
| 260525 | 40817 | TROLL | 9/2/2004 | 36 | NW | 113 | 45 | 673 | SITKA | 4031250 |
| 265485 | 40817 | TROLL | 8/26/2004 | 35 | NE | 109 | 10 | 681 | PORT ALEXANDER | 4080141 |
| 262137 | 40817 | TROLL | 10/1/2004 | 40 | NW | 113 | 41 | 714 | SITKA | 4031325 |
| 266864 | 40817 | TROLL | 9/13/2004 | 38 | NW | 113 | 91 | 738 | PELICAN | 4010118 |
| 519432 | 40817 | TROLL | 8/31/2004 | 36 | NW | | | 835 | ELFIN COVE | 4020198 |
| 288534 | 40817 | TROLL | 7/27/2004 | 31 | NW | | | | JUNEAU | 4040504 |
| 260589 | 40817 | TROLL | 9/20/2004 | 39 | NW | 113 | 45 | 681 | SITKA | 4031317 |
| 273845 | 40818 | TROLL | 8/2/2004 | 32 | NW | 116 | 11 | 580 | HOONAH | 4110197 |
| 262375 | 40818 | TROLL | 8/2/2004 | 32 | NW | 113 | 31 | 600 | SITKA | 4031058 |
| 262673 | 40818 | TROLL | 7/31/2004 | 31 | NW | 113 | 41 | 622 | SITKA | 4031038 |

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**Appendix A3.–**Page 2 of 3**.**

| Head | Tag code | Gear class | Date (CWT) | Stat week | Quadrant | District | Sub-district | Length | Survey site | Sample |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Random recoveries | | | | | |
| 267097 | 40818 | TROLL | 9/7/2004 | 37 | NW | | | 623 | PELICAN | 4010107 |
| 261369 | 40818 | TROLL | 9/20/2004 | 39 | NW | 113 | 45 | 633 | SITKA | 4031309 |
| 266887 | 40818 | TROLL | 9/16/2004 | 38 | NW | 113 | 91 | 643 | PELICAN | 4010123 |
| 266795 | 40818 | TROLL | 8/28/2004 | 35 | NW | 113 | 91 | 646 | PELICAN | 4010082 |
| 261251 | 40818 | TROLL | 9/11/2004 | 37 | NW | 113 | 45 | 659 | SITKA | 4031276 |
| 274611 | 40818 | TROLL | 9/4/2004 | 36 | NW | | | 665 | HOONAH | 4110354 |
| 273769 | 40818 | TROLL | 7/26/2004 | 31 | NW | | | 675 | HOONAH | 4110188 |
| 263818 | 40818 | TROLL | 7/22/2004 | 30 | NW | 113 | 45 | 682 | SITKA | 4030980 |
| 260106 | 40818 | TROLL | 8/14/2004 | 33 | NW | 113 | 41 | 682 | SITKA | 4031128 |
| 261399 | 40818 | TROLL | 9/20/2004 | 39 | NW | 154 | | 683 | SITKA | 4031310 |
| 267076 | 40818 | TROLL | 9/3/2004 | 36 | NW | 114 | 21 | 685 | PELICAN | 4010105 |
| 261265 | 40818 | TROLL | 9/11/2004 | 37 | NW | 113 | 45 | 697 | SITKA | 4031277 |
| 260311 | 40818 | TROLL | 8/26/2004 | 35 | NW | 113 | 45 | 704 | SITKA | 4031222 |
| 266891 | 40818 | TROLL | 9/16/2004 | 38 | NW | 113 | 91 | 715 | PELICAN | 4010123 |
| 519404 | 40818 | TROLL | 8/25/2004 | 35 | NW | 114 | 21 | 720 | ELFIN COVE | 4020176 |
| 266879 | 40818 | TROLL | 9/15/2004 | 38 | NW | 113 | | 725 | PELICAN | 4010121 |
| 260584 | 40818 | TROLL | 9/20/2004 | 39 | NW | 113 | 91 | 740 | SITKA | 4031315 |
| 262869 | 40819 | TROLL | 8/9/2004 | 33 | NW | 113 | 45 | 495 | SITKA | 4031118 |
| 249159 | 40819 | TROLL | 7/5/2004 | 28 | NW | 113 | 31 | 593 | SITKA | 4030835 |
| 262306 | 40819 | TROLL | 7/30/2004 | 31 | NW | 113 | 41 | 602 | SITKA | 4031030 |
| 261016 | 40819 | TROLL | 8/25/2004 | 35 | NW | 113 | 45 | 611 | SITKA | 4031213 |
| 262890 | 40819 | TROLL | 8/13/2004 | 33 | NW | 113 | 45 | 613 | SITKA | 4031125 |
| 261382 | 40819 | TROLL | 9/20/2004 | 39 | NW | 154 | | 619 | SITKA | 4031310 |
| 260862 | 40819 | TROLL | 8/21/2004 | 34 | NW | 113 | 41 | 631 | SITKA | 4031200 |
| 266865 | 40819 | TROLL | 9/13/2004 | 38 | NW | 113 | 91 | 631 | PELICAN | 4010118 |
| 260357 | 40819 | TROLL | 9/1/2004 | 36 | NW | 113 | 45 | 632 | SITKA | 4031242 |
| 266992 | 40819 | TROLL | 9/1/2004 | 36 | NW | 116 | 14 | 650 | PELICAN | 4010095 |
| 274560 | 40819 | TROLL | 9/4/2004 | 36 | NW | | | 650 | HOONAH | 4110345 |
| 260353 | 40819 | TROLL | 8/26/2004 | 35 | NW | | | 665 | SITKA | 4031226 |
| 260795 | 40819 | TROLL | 8/23/2004 | 35 | NW | 113 | 81 | 677 | SITKA | 4031205 |
| 262669 | 40819 | TROLL | 7/31/2004 | 31 | NW | 113 | 31 | 683 | SITKA | 4031037 |
| 262676 | 40819 | TROLL | 7/31/2004 | 31 | NW | 113 | 41 | 683 | SITKA | 4031038 |
| 260040 | 40819 | TROLL | 8/11/2004 | 33 | NE | 109 | | 683 | SITKA | 4031207 |
| 262831 | 40819 | TROLL | 8/8/2004 | 33 | NW | 113 | 31 | 701 | SITKA | 4031096 |
| 261228 | 40819 | TROLL | 9/8/2004 | 37 | NW | 113 | 45 | 710 | SITKA | 4031268 |
| 538231 | 40819 | TROLL | 7/19/2004 | 30 | NW | | | 715 | EXCURSION INLET | 4100039 |
| 256884 | 40817 | SPORT | 8/27/2004 | 35 | NW | 113 | 45 | 573 | SITKA | 4035426 |
| 256900 | 40817 | SPORT | 9/4/2004 | 36 | NW | 113 | 61 | 649 | SITKA | 4035472 |
| 288455 | 40817 | SPORT | 8/15/2004 | 34 | NW | 113 | 91 | 650 | ELFIN COVE | 4025050 |
| 256980 | 40817 | SPORT | 9/13/2004 | 38 | NW | 113 | 31 | 658 | SITKA | 4035486 |
| 259648 | 40817 | SPORT | 7/21/2004 | 30 | NW | 113 | 45 | 673 | SITKA | 4035291 |
| 256940 | 40818 | SPORT | 8/3/2004 | 32 | NW | 113 | 41 | 598 | SITKA | 4035353 |
| 288473 | 40818 | SPORT | 8/30/2004 | 36 | NW | 113 | 91 | 690 | ELFIN COVE | 4025057 |
| 259666 | 40819 | SPORT | 8/3/2004 | 32 | NW | 113 | 41 | 560 | SITKA | 4035342 |
| 288477 | 40819 | SPORT | 8/30/2004 | 36 | NW | 113 | 91 | 625 | ELFIN COVE | 4025057 |
| 256859 | 40819 | SPORT | 8/13/2004 | 33 | NW | 113 | 41 | 679 | SITKA | 4035382 |
| 259677 | 40819 | SPORT | 8/17/2004 | 34 | NW | 113 | 41 | 680 | SITKA | 4035390 |
| 256833 | 40819 | SPORT | 7/16/2004 | 29 | NW | 113 | 45 | 682 | SITKA | 4035263 |

-continued-

**Appendix A3.–**Page 3 of 3.

| Head | Tag code | Gear class | Date (CWT) | Stat week | Quadrant | District | Sub-district | Length | Survey site | Sample |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Select recoveries | | | | | |
| 274195 | 40817 | TROLL | | | | | | 655 | HOONAH | 4110291 |
| 901712 | 40817 | TROLL | 8/18/2004 | 34 | NW | 154 | | | SITKA | 4039975 |
| 901271 | 40817 | TROLL | 9/1/2004 | 36 | NW | | | | SITKA | 4039983 |
| 901264 | 40817 | TROLL | 9/2/2004 | 36 | NW | 113 | 71 | | SITKA | 4039984 |
| 901783 | 40817 | TROLL | 9/16/2004 | 38 | NW | 113 | 91 | | SITKA | 4039970 |
| 901806 | 40817 | TROLL | 9/16/2004 | 38 | NW | 113 | 91 | | SITKA | 4039970 |
| 288220 | 40817 | SPORT | 8/23/2004 | 35 | NW | 113 | 31 | | SITKA | 4035430 |
| 900800 | 40819 | TROLL | 8/1/2004 | 32 | NW | 113 | | | SITKA | 4039990 |
| 901710 | 40819 | TROLL | 8/18/2004 | 34 | NW | 154 | | | SITKA | 4039975 |

**Appendix A4.–**Capture and recovery data from the Nakwasina River coho salmon mark-recapture study, 2004, by area and date.

| Week # | Location | Original captures | Recaptures | Total captures | Proportion (Floy) tagged |
|---|---|---|---|---|---|
| 37 | 2 | 2 | 0 | 2 | 0.00 |
| | 3 | 1 | 0 | 1 | 0.00 |
| 38 | 2 | 6 | 0 | 6 | 0.00 |
| | 3 | 6 | 0 | 6 | 0.00 |
| | Tide water | 3 | 0 | 3 | 0.00 |
| 40 | 2 | 7 | 0 | 7 | 0.00 |
| | 3 | 8 | 0 | 8 | 0.00 |
| | Tide water | 18 | 0 | 18 | 0.00 |
| 41 | 2 | 25 | 1 | 26 | 0.04 |
| | 3 | 97 | 0 | 97 | 0.00 |
| 42 | 1 | 1 | 0 | 1 | 0.00 |
| | 2 | 80 | 11 | 91 | 0.12 |
| | 3 | 58 | 3 | 61 | 0.05 |
| | Tide water | 11 | 0 | 11 | 0.00 |
| 43 | 2 | 92 | 8 | 100 | 0.08 |
| | 3 | 120 | 12 | 132 | 0.09 |
| 44 | 1 | 77 | 14 | 91 | 0.15 |
| | 2 | 35 | 9 | 44 | 0.20 |
| | 3 | 14 | 3 | 17 | 0.18 |
| 45 | 2 | 52 | 6 | 58 | 0.10 |
| | 3 | 58 | 4 | 62 | 0.06 |
| 46 | 1 | 87 | 25 | 112 | 0.22 |
| | 2 | 62 | 15 | 77 | 0.19 |
| | 3 | 62 | 9 | 71 | 0.13 |
| 47 | 2 | 26 | 10 | 36 | 0.28 |
| | 3 | 13 | 3 | 16 | 0.19 |
| 48 | 1 | 30 | 8 | 38 | 0.21 |
| | 3 | 4 | 6 | 10 | 0.60 |
| 49 | 2 | 13 | 6 | 19 | 0.32 |
| | 3 | 1 | 0 | 1 | 0.00 |
| 50 | 1 | 2 | 2 | 4 | 0.50 |
| | 2 | 2 | 0 | 2 | 0.00 |
| | 3 | 1 | 1 | 2 | 0.50 |
| Grand total | | 1,074 | 156 | 1,230 | 0.13 |

**Appendix A5.–**Data files used to estimate parameters of the Nakwasina River coho population, 2003 and 2004.

| Data file[a] | Description |
|---|---|
| 2004_Adult_CWT_Recoveries.xls | Recovery information from 2004 coded wire tag recoveries in Southeast Alaska. |
| Nakwasina_River_2004_M-R_and_CWT.xls | Mark, recapture, and coded wire tag recovery information from fish captured in Nakwasina River in 2004. |
| 2004AdultAWL.xls | Age and length information including summary statistics of adult coho captured in Nakwasina River in 2004. |
| 2003_smolt_AWL_data.xls | 2003 smolt raw data including summaries of analyzed data. |

[a] Data files were archived at and are available from the Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1565.