**Fishery Data Series No. 96-10**

# Surveys of the Chinook and Coho Salmon Sport Fisheries in the Lower Naknek River, Alaska, 1995

**by**

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**and**

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**May 1996**

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**Weights and measures (metric)**

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

**Weights and measures (English)**

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

Spell out acre and ton.

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| hour (spell out for 24-hour clock) | h |
| minute | min |
| second | s |

Spell out year, month, and week.

**Physics and chemistry**

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

**General**

| | |
|---|---|
| All commonly accepted abbreviations. | e.g., Mr., Mrs., a.m., p.m., etc. |
| All commonly accepted professional titles. | e.g., Dr., Ph.D., R.N., etc. |
| and | & |
| at | @ |
| Compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| Copyright | © |
| Corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| et alii (and other people) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g., |
| 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 |
| number (before a number) | # (e.g., #10) |
| pounds (after a number) | # (e.g., 10#) |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S. state and District of Columbia abbreviations | use two-letter abbreviations (e.g., AK, DC) |

**Mathematics, statistics, fisheries**

| | |
|---|---|
| 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 | C.I. |
| correlation coefficient | R (multiple) |
| correlation coefficient | r (simple) |
| covariance | cov |
| degree (angular or temperature) | ° |
| degrees of freedom | df |
| divided by | ÷ or / (in equations) |
| equals | = |
| expected value | E |
| fork length | FL |
| 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. |
| mideye-to-fork | MEF |
| minute (angular) | ' |
| multiplied by | x |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | $\alpha$ |
| probability of a type II error (acceptance of the null hypothesis when false) | $\beta$ |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| standard length | SL |
| total length | TL |
| variance | Var |

*FISHERY DATA SERIES NO. 96-10*

# SURVEYS OF THE CHINOOK AND COHO SALMON SPORT FISHERIES IN THE LOWER NAKNEK RIVER, ALASKA, 1995

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# ABSTRACT

A roving creel survey was conducted on the sport fishery in the lower Naknek River near King Salmon, Alaska from 1 June through 31 August 1995. Emphasis was on the chinook salmon *Oncorhynchus tshawytscha* and coho salmon *Oncorhynchus kisutch* fisheries. Anglers were counted and interviewed to estimate 27,506 (SE = 1,360) angler-hours of effort during the chinook salmon fishery (1 June to 31 July); the season's catch and harvest of chinook salmon were estimated to be 4,238 (SE = 339) and 3,537 (SE = 293) fish, respectively. The estimated catch per hour for chinook salmon was 0.170 (SE = 0.007). An estimated 48.1% (SE = 3.2%) of the daily trips resulted in a catch of at least one chinook salmon; at least one chinook salmon was harvested during 45.5% (SE = 3.0%) of angler trips. The first chinook salmon harvested among all daily harvests produced 69.3% (SE = 5.3%) of the total harvest during the survey. Age-1.3 and -1.4 chinook salmon composed 32.3% (SE = 2.2%) and 46.0% (SE = 2.4%) of the sport harvest, respectively.

An estimated 14,365 (SE = 709) angler-hours were expended during the coho salmon fishery (22 July to 31 August); catch and harvest were estimated to be 3,190 (SE = 441) and 3,037 (SE = 419) fish, respectively. Catch per hour of coho salmon was 0.186 (SE = 0.016). At least one coho salmon was caught during 43.3% (SE = 2.8%) of angler trips; one or more coho salmon was harvested during about the same percentage of angler trips. The first and second coho salmon among all daily harvests produced 42.2% (SE = 5.1%) and 25.2% (SE = 3.2%), respectively, of the total harvest. Age 2.1 coho salmon composed 84.1% (SE = 2.4%) of the sport harvest.

An estimated 188 (SE = 39) chum salmon *Oncorhynchus keta* and 431 (SE = 85) rainbow trout *Oncorhynchus mykiss* were caught during the study. In all fisheries about 36% to 38% of angler-trips were guided and about 73% of trips were made by nonresident anglers. Nearly all anglers used artificial lures in both fisheries.

A total of 4,960 chinook salmon were observed during aerial surveys of major chinook salmon spawning areas. Other than increased angler success in the chinook salmon fishery, no major changes were detected between the 1995 and 1991 and 1992 lower Naknek River chinook and coho salmon studies.



Key words: Chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, chum salmon, *Oncorhynchus keta,* rainbow trout, *Oncorhynchus mykiss,* sport fishing, sport harvest, sport catch, creel survey, fishery survey, angler success, bag limit, guided anglers, unguided anglers, gear type, terminal tackle, Naknek River, Bristol Bay.


# INTRODUCTION

The Naknek River (Figure 1) supports the largest chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, and rainbow trout *O. mykiss* sport fisheries in Southwestern Alaska. Increasingly crowded and restricted fisheries in more populated regions of Alaska and the northwestern states, ease of access, and regularly scheduled airline service into King Salmon contribute to the popularity of the Naknek River. Sport fishing effort in the Naknek River drainage has grown steadily from 4,675 angler-days in 1977, peaked at over 18,000 angler-days in 1988 and has ranged between 12,000 to nearly 16,000 angler-days since 1989 (Mills 1979-1994, Howe et al. 1995). Effort on the Naknek River currently constitutes about 14% of the total effort in southwest Alaska (Mills 1979-1994). Effort as high as 100,900 angler-hours per year was estimated from onsite creel surveys conducted from 1987-1992 (Coggins 1992).

## CHINOOK SALMON FISHERY

Onsite fishery surveys of the Naknek River conducted sporadically by the Alaska Department of Fish and Game (ADF&G) since 1967 have documented increasing levels of catch and harvest for all species. In some instances, the sport harvest has constituted a significant removal of the total annual chinook salmon return. For example, in 1987 anglers harvested an estimated 11,419 chinook salmon, or nearly 48% of the total annual return (Minard and Brookover 1988) (Table 1). At that time the sport fishery was

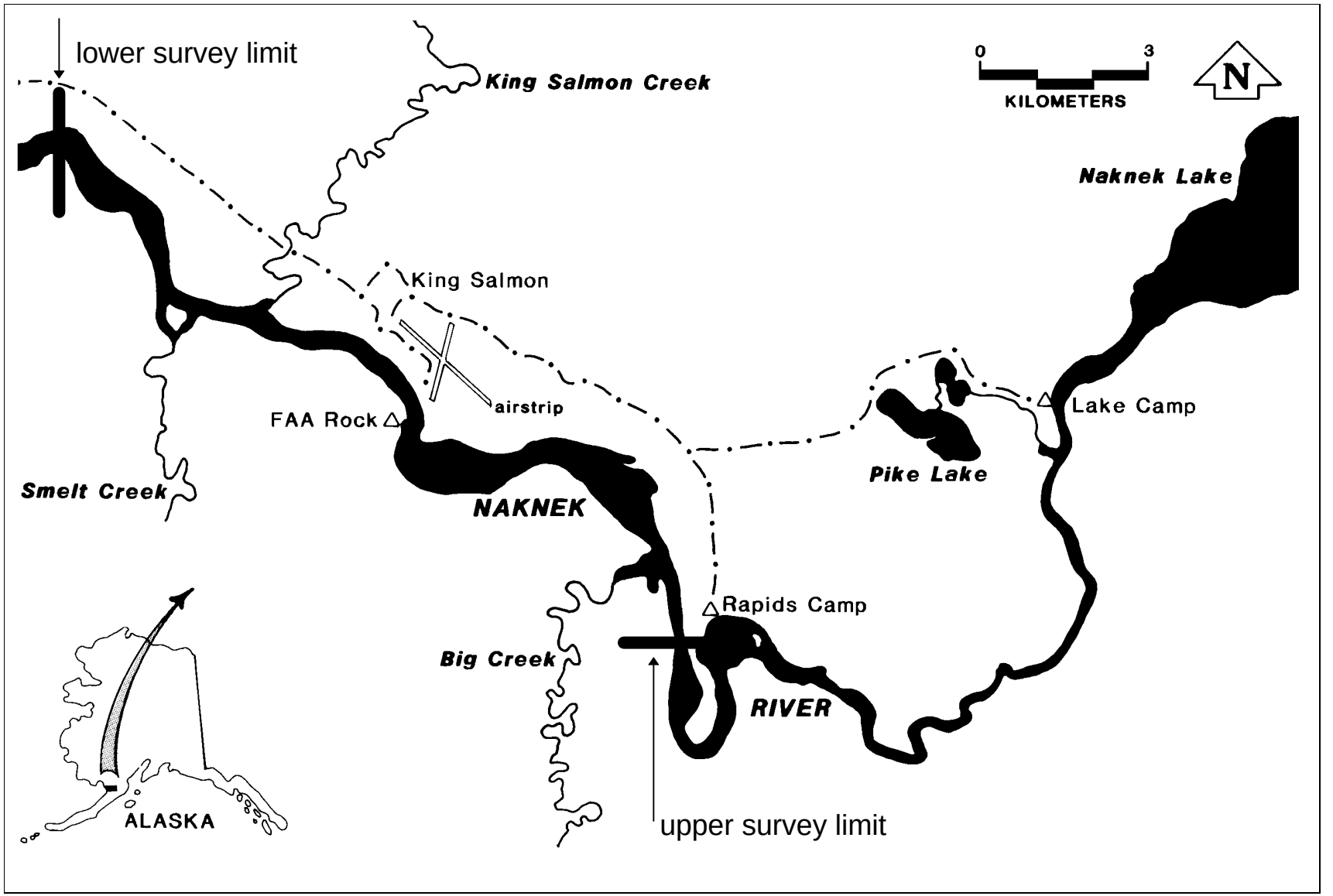



**Figure 1.-Lower Naknek River study area.**

**Table 1.-Harvests of chinook salmon in commercial, subsistence, and sport fisheries of the Naknek River and escapement for the Naknek River, 1970-1995.**

| Year | Harvest | | | | Escapement |
|---|---|---|---|---|---|
| | Commercial[a] | Subsistence | Sport | Total | Index[b] |
| 1970 | 19,037 | 300 | 2,730 | 22,067 | 4,145 |
| 1971 | 10,254 | 200 | 2,417 | 12,871 | 2,885 |
| 1972 | 2,262 | 400 | 1,668 | 4,330 | 2,791 |
| 1973 | 951 | 600 | 1,000 | 2,551 | 2,536 |
| 1974 | 480 | 1,000 | 1,700 | 3,180 | |
| 1975 | 964 | 700 | 427 | 2,091 | 3,452 |
| 1976 | 4,064 | 900 | 800 | 5,764 | 7,131 |
| 1977 | 4,373 | 1,300 | 1,005 | 6,678 | |
| 1978 | 6,930 | 1,200 | 2,406 | 10,536 | |
| 1979 | 10,415 | 1,200 | 2,669 | 14,284 | |
| 1980 | 7,517 | 1,500 | 2,729 | 11,746 | |
| 1981 | 11,048 | 1,000 | 2,581 | 14,629 | 4,271 |
| 1982 | 12,425 | 1,100 | 3,264 | 16,789 | 8,610 |
| 1983 | 8,955 | 1,000 | 3,545 | 13,500 | 7,830 |
| 1984 | 8,972 | 900 | 4,524 | 14,396 | 4,995 |
| 1985 | 5,697 | 1,179 | 5,038 | 11,914 | |
| 1986 | 3,188 | 1,295 | 6,462 | 10,945 | 3,917 |
| 1987 | 5,175 | 1,289 | 11,419 | 17,883 | 4,450 |
| 1988 | 6,538 | 1,057 | 5,380 | 12,975 | 11,730 |
| 1989 | 6,611 | 970 | 3,879 | 11,460 | 2,710 |
| 1990 | 5,068 | 985 | 3,250 | 9,303 | 7,000 |
| 1991 | 3,584 | 1,009 | 3,115 | 7,708 | 4,391 |
| 1992 | 5,724 | 1,039 | 2,633 | 9,396 | 2,691 |
| 1993 | 7,088 | 1,361 | 2,603 | 11,052 | 8,016 |
| 1994 | 6,172 | 1,660 | 3,692 | 11,524 | 9,768 |
| All Year | | | | | |
| Average | 6,540 | 1,006 | 3,237 | 10,783 | 5,438 |
| Percent | 61% | 9% | 30% | | |
| 1990-94 | | | | | |
| 5 Year Avg | 5,527 | 1,211 | 3,059 | 9,797 | 6,373 |
| Percent | 56% | 13% | 31% | | |
| 1995[c] | 5,300 | 1,210 | 3,538 | 10,048 | 4,960 |
| Percent | 53% | 12% | 35% | | |

[a] ADF&G 1994b. Naknek/Kvichak district harvests likely consisting of Naknek, Alagnak, and Kvichak River stocks. The above reported harvests of Naknek River stocks are therefore considered maximums.

[b] ADF&G 1994b. Actual raw count made from fixed-wing or helicopter aerial surveys.

[c] 1995 estimates are preliminary.

the largest component of harvest followed by the commercial (21%) and subsistence (4%) fisheries, which harvested 5,175 and 1,289 chinook salmon, respectively.

Since 1986 the sport fishery for Naknek River chinook salmon has become increasingly restricted as the department has attempted to achieve an annual escapement index of 5,000 fish on the spawning grounds. In 1988 new regulations reduced the daily bag and possession limits, shortened the season, and prohibited the use of bait (ADF&G 1988). In 1990, a weak return of chinook salmon prompted the department to issue an emergency order prohibiting the harvest of large (>71 cm) fish in the sport fishery. From 1992 through 1994, the normal three fish daily bag limit was allowed (ADF&G 1992, 1993, 1994a), but emergency orders closed the mouths and lower reaches of King Salmon Creek and Paul's Creek (Minard and Dunaway 1994 and 1995). In January of 1995 the Board of Fisheries adopted as regulations essentially the same closures effected by the 1992, 1993 and 1994 emergency orders (ADF&G 1995a).

During the period of increasing restrictions, recreational angling effort stabilized or even declined slightly and sport harvests of chinook salmon declined to about 3,000 fish per year (Table 1). Spawning escapements have generally been within biological limits however, and the 1993 and 1994 escapement indices were the strongest consecutive escapements since 1982 and 1983 (Minard and Dunaway 1995).

In early 1995, the Board of Fisheries also modified the Naknek River Sockeye Salmon Management Plan. The changes allow the commercial sockeye salmon fishery to move farther into the lower Naknek River in certain circumstances (ADF&G 1995b). An inriver commercial fishery has the potential to profoundly affect the recreational salmon fisheries as well as the escapement of chinook salmon in the Naknek River.

The chinook and coho salmon fisheries on the Naknek River take place primarily in the lower reach of the river between Smelt Creek and Big Creek (Figure 1). While some fish are available in late May, the bulk of the chinook salmon sport fishery occurs from 1 June to the regulatory closure on 1 August. Current regulations permit sport anglers a daily harvest of three chinook salmon, only one of which may exceed 71 cm (ADF&G 1995a).

## COHO SALMON FISHERY

The Naknek River recreational fishery for coho salmon grew steadily from a harvest of 297 fish in 1977 to a peak harvest of 4,801 fish in 1989 (Mills 1994) (Table 2). Since 1990, the annual sport harvest has ranged from 1,099 to 4,475 coho salmon and averaged 2,254 fish per year (Howe et. al 1995) (Table 2). In addition, an unknown proportion of the average annual commercial harvests (12,159 fish from 1990 to 1994) and average annual subsistence harvests of 1,109 fish (1990-1994) are taken from the Naknek River coho salmon stocks (Table 2). All three harvest groups maintain very strong interests in the Naknek River coho salmon stocks though returns and harvests have declined in recent seasons. No program exists to assess spawning escapement, and there is no way to assess overall exploitation of the Naknek River coho salmon run. Up-to-date information concerning effort, catch, harvest, and angler characteristics in the sport fishery will be valuable to management of this important stock.

Current regulations allow anglers to harvest five coho salmon per day with no size limit (ADF&G 1995a). As with the chinook salmon sport fishery, most effort in the coho

**Table 2.-Harvests of coho salmon in commercial, subsistence, and sport fisheries of the Naknek River, 1971 to 1995.**

| Year | Harvest | | | |
|---|---|---|---|---|
| | Commercial[a] | Subsistence | Sport[c] | Total |
| 1971 | 89 | 100 | | |
| 1972 | 402 | 100 | | |
| 1973 | 255 | 500 | | |
| 1974 | 916 | 200 | | |
| 1975 | 43 | 200 | | |
| 1976 | 1,195 | 600 | | |
| 1977 | 2,883 | 300 | 297 | 3,480 |
| 1978 | 913 | 300 | 646 | 1,859 |
| 1979 | 12,355 | 1,200 | 300 | 13,855 |
| 1980 | 7,802 | 800 | 818 | 9,420 |
| 1981 | 1,229 | 1,100 | 1,156 | 3,485 |
| 1982 | 10,586 | 1,000 | 1,676 | 13,262 |
| 1983 | 7,282 | 900 | 1,385 | 9,567 |
| 1984 | 3,209 | 600 | 2,332 | 6,141 |
| 1985 | 10,474 | 1,103 | 1,281 | 12,858 |
| 1986 | 5,824 | 650 | 1,942 | 8,416 |
| 1987 | 5,274 | 1,106 | 2,292 | 8,672 |
| 1988 | 29,988 | 813 | 4,065 | 34,866 |
| 1989 | 22,668 | 1,927 | 4,801 | 29,396 |
| 1990 | 16,091 | 726 | 2,179 | 18,996 |
| 1991 | 17,527 | 1,056 | 4,475 | 23,058 |
| 1992 | 18,536 | 831 | 1,579 | 20,946 |
| 1993 | 1,798 | 1,572 | 1,099 | 4,469 |
| 1994 | 6,841 | 1,361[b] | 1,940 | 10,142 |
| All Years | | | | |
| Average | 7,674 | 794 | 1,904 | 12,938 |
| Percent | 59% | 6% | 15% | |
| 1990-94 | | | | |
| 5 Year Avg | 12,159 | 1,109 | 2,254 | 15,522 |
| Percent | 78% | 7% | 15% | |
| 1995[c] | 1,000 | 1,100 | 3,037 | 5,137 |
| Percent | 19% | 21% | 59% | |

[a] ADF&G 1994b. Commercial catches are for the Naknek-Kvichak district and therefore include stocks destined for the Kvichak, Alagnak, and Naknek rivers.

[b] Subsistence harvest estimate for 1994 is preliminary.

[c] All 1995 estimates are preliminary.

salmon sport fishery occurs in the lower river. Anglers may anticipate catching coho salmon in the lower Naknek River from late July through September. The coho salmon fishery usually peaks during the first 2 weeks of August and most angling effort occurs during the month of August.

Objectives of the 1995 fisheries survey on the lower Naknek River were:

1. To estimate angling effort (in angler-hours) in the lower Naknek River by temporal component, from 1 June to 31 August 1995;
2. To estimate by temporal component the catch (fish kept plus fish released), harvest (fish kept only), and individual CPUE (catch per hour) of chinook and coho salmon caught in the lower Naknek River sport fishery from 1 June to 31 August;
3. To estimate the distribution of catch and harvest success by angler-day among anglers in the lower Naknek River chinook and coho salmon sport fisheries;
4. To estimate the contributions to the harvests of each fish in anglers' daily bags during the lower Naknek River chinook and coho salmon sport fisheries;
5. To estimate the percentage of angler-trips by terminal tackle type (spin and troll or flies) and angler type (residency status, guided or not) in the lower Naknek River chinook and coho salmon sport fisheries;
6. To estimate the age and sex composition of chinook and coho salmon harvested in the lower Naknek River sport fisheries;
7. To index by aerial survey the spawning escapement of chinook salmon in Paul's, King Salmon, and Big creeks and the main stem of the Naknek River.

# METHODS

## STUDY LOCATION AND DATES

The survey of the lower Naknek River sport fisheries occurred on the Naknek River from 1.5 km upstream of the confluence of Big Creek, downstream to 3 km below the outlet of Smelt Creek (Figure 1). The survey commenced 1 June and ended 31 August 1995. The period from 1 June through 31 July was defined and analyzed as the chinook salmon fishery while the period from 22 June through 31 August defined the coho salmon fishery in the lower Naknek River.

## STUDY DESIGN

A stratified three-stage random sampling design formed the basis for estimating effort (in angler-hours) and catch and harvest rates (fish per angler-hour) in the study area. A roving creel survey was conducted to count and interview anglers as well as to sample the sport harvest. Angler counts were considered instantaneous counts and represented angler effort for the sample in which the count was conducted. Angler interviews were used to estimate catch and harvest rates. Estimates of catch and harvest were the product of the estimated effort and the estimated catch or harvest rates. Sampled days represent the first sampling stage; periods within days represent the second sampling stage; angler counts within periods represent the third sampling stage for the angler effort estimation, and angler interviews represent the third sampling stage for catch and harvest rate estimation.

Information from angler interviews was also used to estimate the distribution of catches and harvests of chinook and coho salmon by angler-day, to estimate the contribution to total harvest of each fish in anglers' daily bags, and to estimate the percentage of angler-trips by tackle type and angler type. The "distribution of catches and harvests by angler-trip" is defined as the proportion of angler-trips that resulted in catches and/or harvests of one or more coho salmon, two or more coho salmon, up to seven or more for catch and up to three for harvest.

The 92-day study period in the lower Naknek River was divided into the following 10 temporal components: component 1 (6/1-6/21), component 2 (6/22-6/30), component 3 (7/1-7/7), component 4 (7/8-7/14), component 5 (7/15-7/21), component 6 (7/22-7/31), component 7 (8/1-8/7), component 8 (8/8-8/14), component 9 (8/15-8/21), component 10 (8/22-8/31). The components were selected to coincide with shifts in angling effort and are similar to those used in previous surveys (Coggins 1992). For components 1-6, the sampling day was 16 hours long and was divided into four 4-hour sampling periods: A 0630-1029, B 1030-1429, C 1430-1829, and D 1830-2229. For components 7 through 10 the sampling day was 12 hours, to account for reduced daylight hours, and was divided into three 4-hour sampling periods: A 0800-1159, B 1200-1559, and C 1600-1959.

Sampling intensity varied by temporal component and was determined to approximate the changes in angler effort observed during previous surveys. During the first temporal component only one technician was deployed. Previous surveys indicated that this period represents the building phase of the fishery, and accordingly, less resources were needed to sample the fishery during the first component. Angling effort in the lower Naknek River typically increases substantially during components 2 through 8, and accordingly, sampling intensity was increased to two technicians. During components 9 and 10 fishing effort declined and sampling intensity was reduced to one technician.

A sampling trip consisted of a 4-hour shift, and a survey technician was responsible for two shifts per sampling day, selected at random from the three or four periods available. During components 1, 9 and 10 when one survey clerk was employed, two types of sampling trips were conducted. During the majority of the sampled days, a single count was conducted within each of the two sampled periods. During the time not spent counting anglers, the single technician conducted angler interviews. Additionally, during 3 of the sampled days within components 1, 9 and 10, the single technician conducted four counts (of the four possible count times) during each sampled period. During these count-only sessions no angler interviews were conducted. The purpose of conducting the count-only samples was to estimate the within-period angler effort variance. Due to the constraint of only one available technician during components 1, 9 and 10, concurrent multiple counts and angler interviews could not be conducted.

Days for conducting the combined single count and angler interview sample sessions were selected at random without replacement (WOR) during seasonal components 1, 9 and 10. Days for conducting the count-only sample sessions were selected at random (WOR) from the days not selected for the combined samples. As noted above, within each sampled day, two sample periods were selected at random (WOR) from the available periods within each day. A count time for the single count and angler interview sample sessions were selected at random from one of four possible 60-minute count times.

During components 2 through 8, two technicians were deployed in the study area. During the majority of days sampled within each temporal component, four (of the possible four) angler counts were conducted within each sampled period. Angler interviews were conducted concurrently by the technician not conducting the angler counts. Accordingly, during these sampled days both technicians were deployed on the river at the same time. Additional days were sampled at random within each temporal component in which only one angler count was conducted within each sampled period. During the time not spent counting anglers, anglers were interviewed. During these additional days only one technician was deployed on the river at a time. This sample design allowed estimates of all sampling-stage components of variance.

Days for conducting the combined four-count and angler interview sample sessions were independently selected at random (WOR) during temporal components 2-8. Days for conducting the remaining single count and angler interview sample sessions were selected at random (WOR) from the days not selected for the combined four-count samples. As noted above, within each sampled day, two sample periods were selected at random (WOR) from the available periods within each day. As before, a single count time was selected at random from one of the four possible 60-minute count times within each period for the samples with only one count.

As noted above, four possible 60-minute count times were available for conducting angler counts within each 4-hour sample period. Angler counts were expected to take 60 minutes to conduct. The counts were scheduled to occur 60 minutes apart (e.g., 0630, 0730, 0830, and 0930 for period A during temporal components 1-6). When counts were expected to take less than 60 minutes to conduct (e.g., few anglers fishing so counts take less time) then the creel technician conducting the count scheduled the count to begin so that it straddled the 60-minute time period.

### Aerial Escapement Surveys

Since 1967 ADF&G has conducted aerial surveys to index the escapement of chinook salmon into key spawning areas of the Naknek River drainage. In 1995, chinook salmon surveys were continued for the twenty-ninth consecutive year.

Counts of live and dead chinook salmon were made from fixed-wing aircraft by an observer wearing Polaroid sunglasses. Surveys were conducted for Paul's, King Salmon, and Big Creek drainages as well as the mainstem Naknek River. Several survey flights were conducted over the course of the summer, starting in late July and continuing through late August. The peak of chinook salmon spawning occurs around early to mid August with Paul's and King Salmon creeks being slightly earlier than the mainstem Naknek River and Big Creek.

## DATA COLLECTION

### Effort, Catch and Harvest

Angler counts were conducted by first randomly selecting the upper or lower boundary as a starting point. Once at the starting point, the creel technician counted all anglers participating in the fishery while driving a boat at a constant rate of speed through the fishery to the far boundary of the study area.

Anglers were interviewed as they left the fishery from the numerous docks located along the river at King Salmon. The majority of anglers access the fishery in this area and the creel technician was able to observe most of the area from the ADF&G dock. Angler interviews consisted of obtaining effort (in

total hours fished), catch and harvest by species, angler type, demographics, and terminal tackle selection information from anglers who had completed fishing for the day (completed-trip interviews).

### Biological Sampling of Harvested Fish

While conducting angler interviews, technicians also collected scale samples for age determination, and weight and length information from fish harvested by anglers. Technicians attempted to measure every fish in the creel of every angler contacted in order to sample a consistent proportion of the harvest. Sport harvested salmon were measured from mid-eye to fork-of-tail to the nearest millimeter; resident species were measured from the tip-of-the snout to the fork-of-tail. Chinook salmon were weighed to the nearest 0.1 kilogram and all other fish were weighed to the nearest 10 grams.

For each salmon or rainbow trout sampled, three or four scales were collected and placed on labeled and numbered adhesive coated cards (scale cards). Scales were removed from the left side of the fish from a point along a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, and two rows of scales above the lateral line (Welander 1940; Scarnecchia 1979). When scales could not be obtained from the preferred area, three scales were taken from as close to the preferred area as possible. However, scales were only taken from the area bounded dorsally by the fourth row of scales above the lateral line, ventrally by the lateral line, and between lines drawn vertically from the posterior insertion of the dorsal fin and the anterior insertion of the anal fin. When no scales were available in the preferred area on the left side of the fish, scales were collected from the preferred area on the right side of the fish.

Completed scale cards were pressed against acetate cards in a heated hydraulic press; resulting scale impressions were displayed on a microfiche projector for age determination. Age determination from collected scales followed Jearld (1983) and Lux (1971). For salmon, the numeral preceding the decimal is the number of freshwater annuli, whereas the numeral following the decimal is the number of marine annuli (European method). Total age from brood year is the sum of the two numerals plus one.

### Aerial Escapement Surveys

For each flight the date, weather conditions and type of aircraft were recorded, and a subjective assessment of survey conditions (Excellent, Good, Fair, or Poor) was made and recorded. The actual number of chinook salmon observed (both live and dead) was recorded. At the end of each flight, the number of chinook salmon observed was tallied by stream. The peak survey count over a series of flights was considered the peak index for that system.

## DATA ANALYSIS

### Effort, Catch and Harvest

Angler counts and completed-trip angler interviews were combined to provide estimates of effort in terms of angler-hours (Objective 1) and angler-trips using methods described in Appendix A1.

Preliminary data analysis indicated that interviews obtained during the first sampling period of the day were biased toward highly successful anglers, which caused over-estimates of catch and harvest when catch and harvest rates were multiplied by effort at the second stage level (sampling periods within a day). Therefore the second sampling stage was dropped (periods within days were ignored) for estimation of catch and harvest rates. Estimates of catch and harvest (Objective 2) were obtained by first combining

catch/harvest and effort data at the first-stage (day) level (Appendix A2).

## Angler Success and Harvest Analysis

In this survey several analyses were used to assess angler success. One indicator of success is catch per unit effort (CPUE) (Objective 2), treated here as catch per hour fished. Appendix A3 describes procedures and equations used to estimate CPUE and associated error terms.

As a second method of characterizing the success of anglers seeking chinook and coho salmon, we estimated the proportion of anglers catching zero fish, one or more fish, two or more fish, etc. (Objective 3). We also estimated the proportion of anglers harvesting zero fish, one or more fish, two or more fish, etc. Procedures detailed in Appendix A4 were used with data from completed trips to estimate these proportions and their standard errors.

In order to assess current harvest practices of anglers, as well as to assess the possible effects of bag limit changes on the fishery, it was useful to estimate the proportion of the total harvest contributed by the first fish in anglers' daily bags, the second fish in anglers' daily bags, etc. (Objective 4). Procedures from Appendix A4 were used with data from completed trips to estimate these proportions and their standard errors.

## Angler Characteristics

Information on angler characteristics (guided vs. unguided, residency status, use of spin tackle vs. flies) (Objective 5) was obtained from anglers personally during interviews. Anglers were never interviewed more than once in a day. Therefore data from all interviews could be used regardless of whether anglers had completed their fishing trip. The proportions of angler-trips[1] in the above categories were estimated as if interview data were collected as a simple random sample of the fishery. That is, the estimated proportion of angler-trips with characteristic k and its variance (Cochran 1977:52) were calculated as

$$\hat{p}_k = \frac{m_k}{m}, \quad (1)$$

$$\hat{Var}(\hat{p}_k) = \frac{\hat{p}_k(1-\hat{p}_k)}{m-1}, \quad (2)$$

where $m_k$ equals the number of angler-trips having characteristic k, and m equals the total number of angler-trips. Standard errors were obtained by taking the square root of the variance estimates.

## Assumptions

The degree to which the above parameter estimates are unbiased depends on the following untested assumptions:

1. Interviewed anglers accurately reported their hours of fishing effort and the number of fish released, by species;
2. Interviewed anglers were representative of the total angler population;
3. No significant fishing effort occurred during the hours not included in the sampling day; and
4. No significant fishing effort occurred in areas not covered by the survey.

Regarding assumption 1, anglers were expected to have a good recollection of the number of fish caught and released by species (at least for the two species of concern). Anglers interviewed onsite had their creel

[1] Since each interview represented information collected from one angler during one trip to the surveyed fishery, the proportions estimated by equation (1) are for angler-trips, not anglers.

inspected by the survey technicians, so the accuracy of the number of fish reported harvested did not depend on the angler's recollection.

### Biological Sampling of Harvested Fish

Estimates of sex and age composition were calculated for chinook and coho salmon harvested in the sport fisheries on the lower Naknek River (Objective 6).

The proportion of harvested chinook or coho salmon that were age u and its variance (Cochran 1977:52) were estimated as:

$$\hat{p}_u = \frac{n_u}{n}, \quad (3)$$

$$\hat{V}[\hat{p}_u] = \left(1 - \frac{n}{\hat{H}}\right)\frac{\hat{p}_u(1-\hat{p})}{n-1}; \quad (4)$$

where $n_u$ is the number of the sampled chinook salmon harvested that are age u, n is the total number of chinook or coho salmon sampled within each survey, and $\hat{H}$ is the estimated total harvest (Appendix A2).

Mean length-at-age of harvested chinook or coho salmon was estimated following standard procedures (Sokal and Rohlf 1981, Boxes 4.2 and 7.1, pages 56 and 139).

### Aerial Escapement Surveys

Escapement indices are considered to be minimum escapement estimates (Objective 7). By following consistent survey procedures among years and conducting these surveys at standard times, escapement indices can be treated as a relative measure of the abundance of salmon on the spawning grounds. The Naknek River drainage is presently managed for a minimal escapement of 5,000 chinook salmon. Raw escapement counts obtained in this survey were treated as the minimal escapement value for management purposes.

# RESULTS

## CHINOOK SALMON FISHERY

### Effort

Most of the lower Naknek River chinook salmon fishery occurs from 1 June through the regulatory closure on 31 July. Effort during 1 June through 21 July is almost exclusively devoted to chinook salmon. During 22 through 31 July coho salmon as well as chinook salmon are pursued. In 1995, the total effort from 1 June through 31 July (temporal components 1 through 6) was estimated to be 27,506 (SE = 1,360) angler-hours (Table 3). After increasing gradually in the first temporal component, effort was relatively stable for the next 3 weeks with the peak of the fishery occurring from 8 July-14 July (temporal component 4) when effort was estimated to be 5,793 (SE = 590) angler-hours. The number of anglers counted during each count in each period made during the survey appears in Appendix B1.

### Catch and Harvest

During temporal components 1 through 6, 1,430 angler interviews were conducted. Anglers caught an estimated 4,238 (SE = 339) chinook salmon during the survey (Table 4). The peak catch of 1,184 (SE = 179) chinook salmon occurred in temporal component 4, though nearly as many fish were caught in the last 9 days of June (temporal component 2). Anglers harvested an estimated 3,537 (SE = 293) chinook salmon (Table 4). As with the estimates of catch, the greatest harvests occurred during temporal components 2 and 4. Anglers harvested 71% to 96% of the chinook salmon they caught throughout the season and overall harvested 83% of the estimated catch (Table 4).

### Angler Success

Estimates of catch per unit effort in angler-hours (CPUE) ranged from 0.092 (SE = 0.017) chinook salmon caught per angler-hour

**Table 3.-Estimated effort (angler-hours), by temporal component and fishery survey, for the sport fishery in the lower Naknek River, 1 June through 31 August 1995.**

| Temporal Component | Days Sampled | Estimated Angler-Hours | SE | 90% Confidence Interval | | RP[a] |
|---|---|---|---|---|---|---|
| | | | | Lower | Upper | |
| 1 (01-21 June) | 12 | 4,732 | 788 | 3,436 | 6,028 | 27.4% |
| 2 (22-30 June) | 7 | 5,403 | 414 | 4,722 | 6,084 | 12.6% |
| 3 (01-07 July) | 5 | 4,561 | 531 | 3,688 | 5,434 | 19.2% |
| 4 (08-14 July) | 5 | 5,793 | 590 | 4,822 | 6,764 | 16.8% |
| 5 (15-21 July) | 5 | 2,926 | 454 | 2,179 | 3,673 | 25.5% |
| 6 (22-31 July) | 7 | 4,091 | 469 | 3,319 | 4,863 | 18.9% |
| 7 (01-07 August) | 5 | 1,817 | 288 | 1,343 | 2,291 | 26.1% |
| 8 (08-14 August) | 5 | 3,191 | 249 | 2,781 | 3,601 | 12.8% |
| 9 (15-21 August) | 5 | 2,726 | 249 | 2,316 | 3,136 | 15.0% |
| 10 (22-31 August) | 7 | 2,540 | 276 | 2,086 | 2,994 | 17.9% |
| Survey Total | 63 | 37,779 | 1,460 | 35,377 | 40,181 | 6.4% |
| Chinook Salmon Survey (1 June- 31 July) | 41 | 27,506 | 1,360 | 25,268 | 29,743 | 8.1% |
| Coho Salmon Survey (22 July - 31 August) | 29 | 14,365 | 709 | 11,072 | 17,658 | 8.1% |

[a] Relative precision of the 90% confidence interval.

**Table 4.- Estimated catch and harvest of chinook salmon by the sport fishery in the lower Naknek River, 1 June through 31 July 1995.**

| Temporal Component and Date | Catch[a] | | | | | Harvest | | | | | Percent of Catch Harvested |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 90% Confidence Interval | | | | | 90% Confidence Interval | | | |
| | Estimate | SE | Lower | Upper | RP[b] | Estimate | SE | Lower | Upper | RP[b] | |
| 1 (01-21 June) | 412 | 150 | 165 | 659 | 60% | 394 | 147 | 152 | 636 | 61% | 96% |
| 2 (22-30 June) | 927 | 131 | 712 | 1,142 | 23% | 840 | 128 | 629 | 1,051 | 25% | 91% |
| 3 (01-07 July) | 506 | 103 | 337 | 675 | 34% | 418 | 81 | 285 | 551 | 32% | 83% |
| 4 (08-14 July) | 1,184 | 179 | 890 | 1,478 | 25% | 955 | 142 | 721 | 1,189 | 25% | 81% |
| 5 (15-21 July) | 525 | 120 | 328 | 722 | 38% | 444 | 101 | 278 | 610 | 37% | 85% |
| 6 (22-31 July) | 684 | 134 | 464 | 904 | 32% | 486 | 106 | 312 | 660 | 36% | 71% |
| Season Total | 4,238 | 339 | 3,694 | 4,810 | 13.1% | 3,537 | 293 | 3,056 | 4,020 | 14% | 83% |

[a] Catch = total fish kept + total fish released.

[b] Relative precision of the 90% confidence interval.

fished in temporal component 1 to a peak of 0.234 (SE = 0.018) in temporal component 4 (Table 5). Overall, the CPUE for the chinook salmon fishery was estimated to be 0.170 (SE = 0.007).

No chinook salmon were caught in 51.9% (SE = 3.2%) of the angler-trips conducted during the survey (Table 6, Figure 2). In 48.1% (SE = 3.2%) of the angler-trips one or more chinook salmon were caught; in 18.7 % (SE = 1.5%) of the trips, two or more were caught, and in only 1.6% (SE = 0.3%) of the angler-trips five or more chinook salmon were caught. No fish were kept in 54.5% (SE = 3.0%) of the angler-trips, one or more fish were kept in 45.5% (SE = 3.0%) of the trips, two or more fish were kept in 15.3% (SE = 1.3%) of the trips, and three fish (the legal limit) were kept in 4.9% (SE = 0.7%) of the trips (Table 7, Figure 2).

The first chinook salmon harvested in all daily creels was estimated to generate 69.3% (SE = 5.3%) of the total harvest during the chinook salmon survey (Table 8, Figure 3). Only 7.3% (SE = 0.9%) of the total harvest resulted from angler-trips that harvested a third chinook salmon.

### Angler Characteristics and Tackle Selection

Of the 1,430 angler interviews conducted during the chinook salmon sport fishery, 38.4% (SE = 1.3%) were guided, 72.3% (SE = 1.2%) were non-Alaskan residents, and 17.2% (SE = 1.0%) were residents of countries other than the United States (Table 9). The majority of anglers were males (87.0%, SE = 0.9%), most anglers fished from boats (98.8%, SE = 0.3%), and most (97.8%, SE = 0.4%) used artificial lures.

### Age, Length at Age, and Sex Composition of the Sport Harvest

Biological data were collected from 519 chinook salmon harvested in the sport fishery from 1 June through 30 July. Females comprised 31.8% (SE = 2.2%) of the harvest while males made up the other 68.2% (SE = 2.2%) (Table 10). The predominant age groups among all fish sampled were age 1.4 (46.0%, SE = 2.4%), and age 1.3 (32.3%, SE = 2.2%). Overall average length was 725 mm (SE = 9) and overall average weight was 7.5 kg (SE = 0.2). The biggest fish sampled during the survey was an age-1.4 male that was 1,085 mm (42.7 in) long, weighed 29.5 kg (65 lb) and was caught 11 July.

### Aerial Escapement Surveys

Aerial surveys of chinook salmon spawning areas in the Naknek River drainage were conducted during the month of August. Paul's and King Salmon creeks were surveyed 5 August; conditions were poor to acceptable, the water levels were above normal, and water clarity was poor in Paul's Creek but acceptable in King Salmon Creek. In both creeks the surveys were judged to be later than desired.

Only 26 chinook salmon were observed in Paul's Creek and 239 chinook salmon were observed in King Salmon Creek (Table 11). On 15 August Big Creek was surveyed under very good conditions; 1,905 chinook salmon were counted (Table 11). The mainstem of the Naknek River was surveyed from the outlet of Big Creek upstream to Naknek Lake on 21 August (Table 11). Survey conditions on the Naknek River were good and a total of 2,790 chinook salmon were counted (Table 11). The total 1995 chinook salmon escapement observed in the Naknek River aerial survey areas was 4,960 fish.

## COHO SALMON FISHERY

### Effort

Effort in the lower Naknek River coho fishery, 22 July through 31 August, was estimated to be 14,365 (SE = 709) angler-hours (Table 3). The greatest effort occurred

**Table 5.-Catch per unit effort for the chinook salmon sport fishery in the lower Naknek River, 1 June through 31 July 1995.**

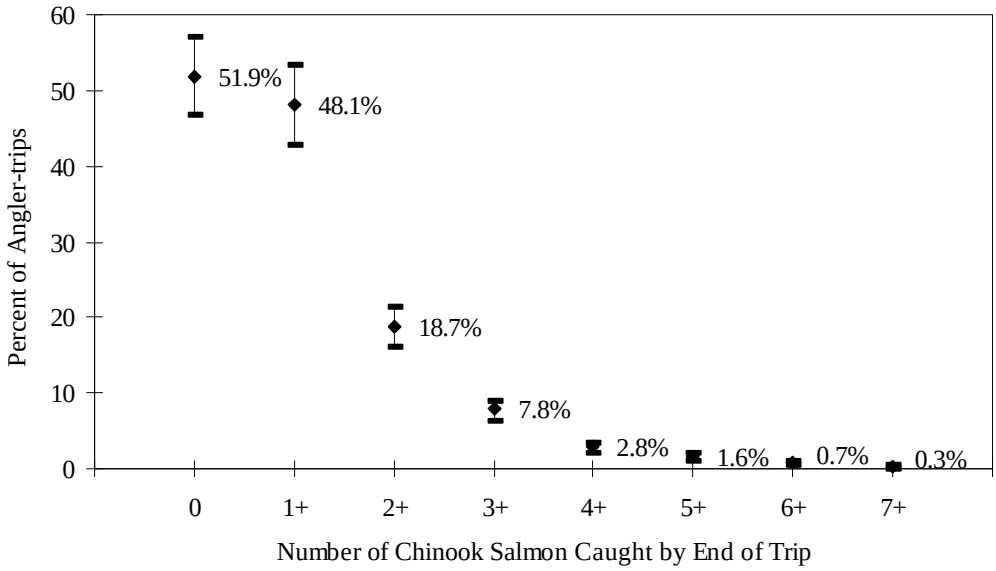
| Temporal Component | CPUE[a] | SE | 90% Confidence Interval | | | RP[b] |
|---|---|---|---|---|---|---|
| | | | Lower | | Upper | |
| 1 (01-21 June) | 0.092 | 0.017 | 0.065 | - | 0.120 | 29.8% |
| 2 (22-30 June) | 0.161 | 0.015 | 0.137 | - | 0.185 | 15.0% |
| 3 (01-07 July) | 0.136 | 0.014 | 0.114 | - | 0.159 | 16.4% |
| 4 (08-14 July) | 0.234 | 0.018 | 0.204 | - | 0.264 | 12.8% |
| 5 (15-21 July) | 0.155 | 0.015 | 0.130 | - | 0.179 | 15.8% |
| 6 (22-31 July) | 0.184 | 0.021 | 0.149 | - | 0.219 | 19.1% |
| All | 0.170 | 0.007 | 0.158 | - | 0.182 | 7.1% |

[a] Number of fish caught per angler-hour of effort.

[b] Relative precision of the 90% confidence interval.

**Table 6.-Estimated percent of angler-trips resulting in catches of zero, one or more, two or more, and up to seven or more chinook salmon in the lower Naknek River, 1 June through 31 July 1995.**

| Catch | Percent of Angler-trips | Standard Error | 90% Confidence Interval | | |
|---|---|---|---|---|---|
| | | | Lower | | Upper |
| 0 | 51.9 | 3.2 | 46.7 | - | 57.2 |
| 1+ | 48.1 | 3.2 | 42.8 | - | 53.3 |
| 2+ | 18.7 | 1.5 | 16.2 | - | 21.3 |
| 3+ | 7.8 | 0.8 | 6.4 | - | 9.1 |
| 4+ | 2.8 | 0.5 | 2.0 | - | 3.5 |
| 5+ | 1.6 | 0.3 | 1.1 | - | 2.2 |
| 6+ | 0.7 | 0.2 | 0.4 | - | 1.1 |
| 7+ | 0.3 | 0.1 | 0.1 | - | 0.6 |



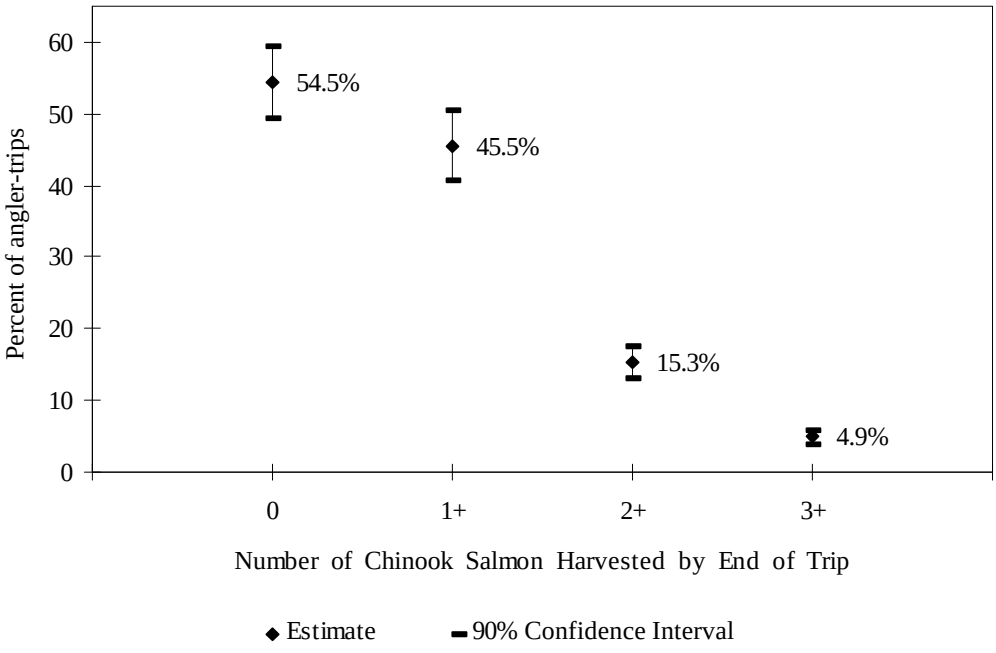




**Figure 2.-Distribution of catch and harvest success in the chinook salmon sport fishery in the lower Naknek River, 1 June through 31 July 1995.**

**Table 7.-Estimated percent of angler-trips resulting in harvests of zero, one or more, two or more, and three or more chinook salmon in the lower Naknek River, 1 June through 31 July 1995.**

| Harvest | Percent of Angler-trips | Standard Error | 90% Confidence Interval Lower | Upper |
|---|---|---|---|---|
| 0 | 54.5 | 3.0 | 49.5 | 59.4 |
| 1+ | 45.5 | 3.0 | 40.6 | 50.5 |
| 2+ | 15.3 | 1.3 | 13.0 | 17.5 |
| 3 | 4.9 | 0.7 | 3.8 | 5.9 |

**Table 8.-Estimated percent of chinook salmon harvest due to the first, second, and third fish in all anglers daily creels, lower Naknek River, 1 June through 31 July 1995.**

| Fish | Percent of Harvest | Standard Error | 90% Confidence Interval Lower | Upper |
|---|---|---|---|---|
| #1 | 69.3 | 5.3 | 60.5 | 78.1 |
| #2 | 23.4 | 2.1 | 20.0 | 26.7 |
| #3 | 7.3 | 0.9 | 5.8 | 8.8 |

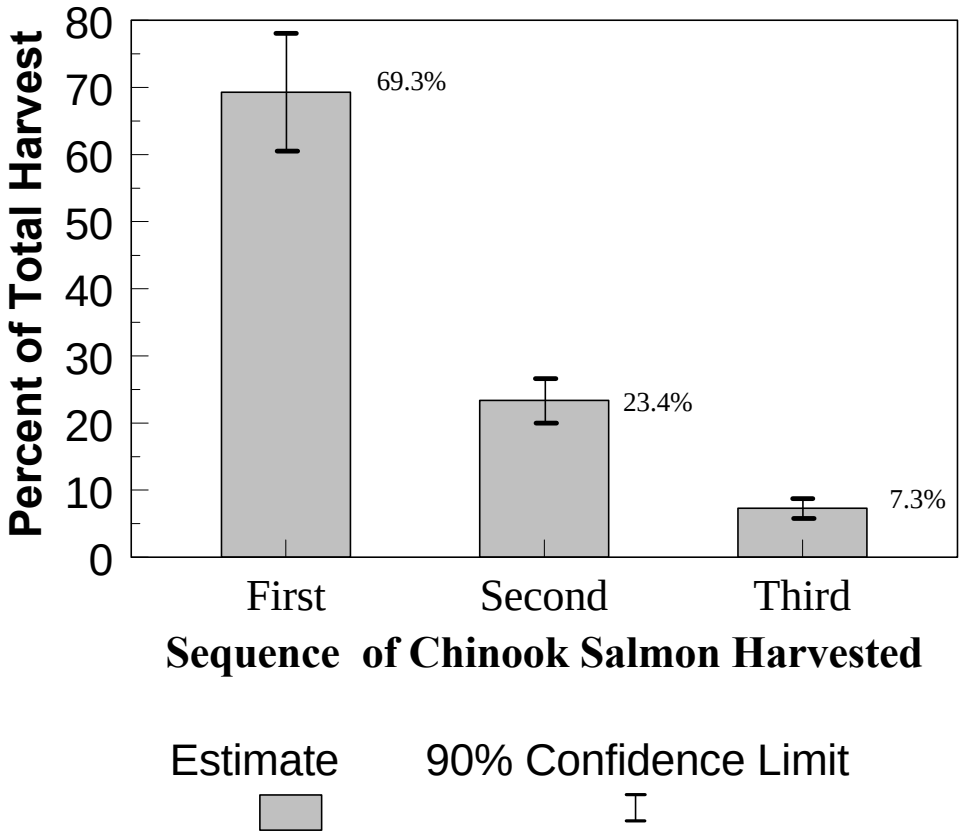



**Figure 3.-Percent of chinook salmon harvest due to the first, second, and third fish in all anglers daily creels, lower Naknek River, 1 June through 31 July 1995.**

during the first 10 days of the fishery, temporal component 6, when both coho and chinook salmon were available. Effort declined the following week, grew again through temporal component 8 and remained relatively stable through the end of the study (Table 3).

## Catch and Harvest

Anglers caught an estimated 3,190 (SE = 441) coho salmon during the survey with the greatest catches occurring in temporal component 8 (1,195, SE = 311) and temporal component 10 (728, SE = 257) (Table 12). An estimated 3,037 (SE = 419) coho salmon or 95% of the catch were harvested (Table 12). Peak harvests occurred during the same periods as peak catch.

## Angler Success

Catch per unit effort ranged from 0.016 (SE = 0.005) coho salmon caught per angler-hour in temporal component 6 to a high of 0.507 (SE = 0.072) during temporal component 8 (Table 13). Overall CPUE for the coho salmon fishery was 0.186 (SE = 0.016) coho salmon caught per angler-hour.

No coho salmon were caught in 56.7% (SE = 2.8%) of angler-trips made during 22 July through 31 August and 43.3 % (SE = 2.8%) resulted in catches of at least one fish (Table 14, Figure 4). Only 2.3% (SE = 0.8%) of angler-trips resulted in catches of six or more

**Table 9.-Number and percent of angler-trips, by angler type and gear type, during the sport fishery for chinook salmon, lower Naknek River, 1 June through 31 July 1995.**

| Characteristic | Angler-trips | Percent | SE (%) |
|---|---|---|---|
| ANGLER TYPE | | | |
| Guided | 549 | 38.4 | 1.3 |
| Unguided | 880 | 61.5 | 1.3 |
| RESIDENCY | | | |
| Alaskan Residents | 396 | 25.8 | 1.1 |
| Local Alaskan Residents[a] | 264 | 18.6 | 1.0 |
| Nonlocal Alaskan Residents[b] | 132 | 9.2 | 0.8 |
| Non-Alaskan Residents | 1,034 | 72.3 | 1.2 |
| U.S. Residents | 788 | 55.1 | 1.3 |
| Non-U.S. Residents | 246 | 17.2 | 1.0 |
| Residency Unknown | 27 | 1.9 | 0.4 |
| SEX | | | |
| Male | 1,244 | 87.0 | 0.9 |
| Female | 186 | 13.0 | 0.9 |
| BOAT/SHORE | | | |
| Fished from boat | 1,411 | 98.8 | 0.3 |
| Fished from shore | 20 | 1.2 | 0.3 |
| TACKLE TYPE | | | |
| Lures (including trolled tackle) | 1,398 | 97.8 | 0.4 |
| Fly | 8 | 0.6 | 0.2 |
| Lures and Fly | 8 | 0.6 | 0.2 |
| Unknown | 14 | 1.0 | 0.3 |
| TOTAL ANGLER-TRIPS | 1,430 | | |

[a] Alaskan residents living in the King Salmon/Naknek area.

[b] All other Alaskan residents.

**Table 10.-Mean lengths (mm) and weights (kg) of chinook salmon, by sex and age group, from samples collected from the lower Naknek River sport harvest, 1 June through 30 July 1995.**

| | Age Group | | | | | |
|---|---|---|---|---|---|---|
| | UNKNOWN | 1.2 | 1.3 | 1.4 | 1.5 | TOTAL |
| **Females** | | | | | | |
| Percent | | | 5.0 | 24.3 | 2.5 | 31.8 |
| SE | | | 1.1 | 2.1 | 0.8 | 2.2 |
| Sample Size | | | 22 | 106 | 11 | 139 |
| Mean Length | 843 | | 819 | 880 | 938 | 870 |
| SE | 15 | | 19 | 7 | 10 | 6 |
| Sample Size | 26 | | 22 | 106 | 11 | 165 |
| Mean Weight | 10.6 | | 8.9 | 11.4 | 14.1 | 11.1 |
| SE | 0.6 | | 0.7 | 0.3 | 0.5 | 0.2 |
| Sample Size | 26 | | 22 | 106 | 11 | 165 |
| **Males** | | | | | | |
| Percent | | 18.8 | 27.2 | 21.7 | 0.5 | 68.2 |
| SE | | 1.9 | 2.1 | 2.0 | 0.3 | 2.2 |
| Sample Size | | 82 | 119 | 95 | 2 | 298 |
| Mean Length | 640 | 493 | 608 | 861 | 993 | 657 |
| SE | 25 | 10 | 14 | 12 | 45 | 10 |
| Sample Size | 58 | 81 | 119 | 95 | 2 | 355 |
| Mean Weight | 5.9 | 2.2 | 4.3 | 10.8 | 15.9 | 5.9 |
| SE | 0.7 | 0.2 | 0.3 | 0.5 | 2.1 | 0.3 |
| Sample Size | 58 | 81 | 118 | 95 | 2 | 354 |
| **All Samples** | | | | | | |
| Percent | | 18.8 | 32.3 | 46.0 | 3.0 | 100.0 |
| SE | | 1.9 | 2.2 | 2.4 | 0.8 | 0.0 |
| Sample Size | | 82 | 141 | 201 | 13 | 437 |
| Mean Length | 703 | 493 | 641 | 871 | 946 | 725 |
| SE | 21 | 10 | 14 | 7 | 11 | 9 |
| Sample Size | 84 | 81 | 141 | 201 | 13 | 520 |
| Mean Weight | 7.3 | 2.2 | 5.0 | 11.1 | 14.4 | 7.5 |
| SE | 0.5 | 0.2 | 0.3 | 0.3 | 0.5 | 0.2 |
| Sample Size | 84 | 81 | 140 | 201 | 13 | 519 |

**Table 11.-Unexpanded aerial escapement counts for chinook salmon in the Naknek River and drainage, 1970-1995.**

| Source[a] | Year | Mainstream Naknek | Paul's Creek | King Salmon Creek | Big Creek | Total |
|---|---|---|---|---|---|---|
| A | 1970 | 3,060 | | 260 | 825 | 4,145 |
| A | 1971 | 1,639 | 52 | 704 | 490 | 2,885 |
| A | 1972 | 351 | 156 | 1,224 | 1,060 | 2,791 |
| A | 1973 | 1,315 | | 115 | 1,106 | 2,536 |
| A | 1974 | | 91 | 495 | 860 | |
| A | 1975 | 2,250 | 144 | 279 | 779 | 3,452 |
| A | 1976 | 5,950 | 31 | 180 | 970 | 7,131 |
| A | 1977 | 4,830 | | 1,860 | | |
| A | 1978 | | | | | |
| A | 1979 | | | | | |
| A | 1980 | 300 | 17 | | 30 | |
| A | 1981 | 2,890 | | 591 | 790 | 4,271 |
| A | 1982 | 5,360 | 340 | 980 | 1,930 | 8,610 |
| A | 1983 | 2,860 | 290 | 460 | 4,220 | 7,830 |
| A | 1984 | 790 | 400 | 385 | 3,420 | 4,995 |
| B | 1985 | 590 | | | | |
| C | 1986 | 2,200 | 73 | 102 | 1,542 | 3,917 |
| C | 1987 | 2,800 | 7 | 290 | 1,353 | 4,450 |
| C | 1988 | 7,380 | 150 | 600 | 3,600 | 11,730 |
| C | 1989 | 1,700 | 50 | 100 | 860 | 2,710 |
| C | 1990 | 4,500 | 150 | 350 | 2,000 | 7,000 |
| C | 1991 | 1,655 | 121 | 275 | 2,340 | 4,391 |
| C | 1992 | 1,550 | 88 | 158 | 895 | 2,691 |
| C | 1993 | 5,520 | 86 | 700 | 1,710 | 8,016 |
| C | 1994 | 5,970 | 203 | 974 | 2,531 | 9,678 |
| | All Year | 2,975 | 136 | 528 | 1,586 | 5,225 |
| | Average Percent | 57% | 3% | 10% | 30% | |
| C | 1995 | 2,790 | 26[b] | 239[b] | 1,905[b] | 4,960 |
| | Percent | 56% | <1% | 5% | 38% | |

[a] Data sources:

A Russell 1985.

B ADF&G 1986.

C ADF&G, Divisions of Commercial and Sport Fish aerial surveys, 1986 through 1995.

[b] Surveys in 1995 may have been affected or delayed by poor weather or visibility.

**Table 12.-Estimated catch and harvest of coho salmon by the sport fishery in the lower Naknek River, 22 July through 31 August 1995.**

| Temporal Component and Date | Catch[a] | | | | | Harvest | | | | | Percent of Catch Harvested |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 90% Confidence Interval | | | | | 90% Confidence Interval | | | |
| | Estimate | SE | Lower | Upper | RP[b] | Estimate | SE | Lower | Upper | RP[b] | |
| 6 (22-31 July) | 66 | 27 | 22 | 110 | 67% | 63 | 27 | 19 | 107 | 70% | 96% |
| 7 (01-07 August) | 633 | 130 | 419 | 847 | 34% | 624 | 125 | 418 | 830 | 33% | 99% |
| 8 (08-14 August) | 1,195 | 311 | 683 | 1,707 | 43% | 1,102 | 271 | 656 | 1,548 | 41% | 92% |
| 9 (15-21 August) | 568 | 120 | 371 | 765 | 35% | 548 | 134 | 328 | 768 | 40% | 97% |
| 10 (22-31 August) | 728 | 257 | 305 | 1,151 | 58% | 700 | 260 | 272 | 1,128 | 61% | 96% |
| Season Total | 3,190 | 441 | 2,466 | 3,916 | 23% | 3,037 | 419 | 2,348 | 3,726 | 23% | 95% |

[a] Catch = total fish kept + total fish released.

[b] Relative precision of the 90% confidence interval.

**Table 13.-Catch per unit effort for the coho salmon sport fishery in the lower Naknek River, 22 July through 31 August 1995.**

| Temporal Component | CPUE[a] | SE | 90% Confidence Interval | | RP[b] |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| 6 (22-31 July) | 0.016 | 0.005 | 0.007 | 0.025 | 54.5% |
| 7 (01-07 August) | 0.292 | 0.037 | 0.232 | 0.352 | 20.6% |
| 8 (08-14 August) | 0.507 | 0.072 | 0.388 | 0.625 | 23.4% |
| 9 (15-21 August) | 0.203 | 0.037 | 0.142 | 0.264 | 30.1% |
| 10 (22-31 August) | 0.297 | 0.045 | 0.224 | 0.370 | 24.7% |
| All | 0.186 | 0.016 | 0.160 | 0.212 | 13.7% |

[a] Number of fish caught per angler-hour of effort.

[b] Relative precision of the 90% confidence interval.

**Table 14.-Estimated percent of angler-trips resulting in catches of zero, one or more, and up to eight or more, coho salmon in the lower Naknek River, 22 July through 31 August 1995.**

| Catch | Percent of Angler-trips | Standard Error | 90% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower | Upper |
| 0 | 56.7 | 2.8 | 52.1 | 61.3 |
| 1+ | 43.3 | 2.8 | 38.7 | 47.9 |
| 2+ | 26.0 | 2.3 | 22.2 | 29.9 |
| 3+ | 16.8 | 1.9 | 13.6 | 19.9 |
| 4+ | 12.5 | 1.7 | 9.7 | 15.2 |
| 5+ | 8.4 | 1.4 | 6.1 | 10.7 |
| 6+ | 2.3 | 0.8 | 1.0 | 3.6 |
| 7+ | 1.7 | 0.7 | 0.6 | 2.8 |
| 8+ | 0.6 | 0.4 | 0 | 1.3 |

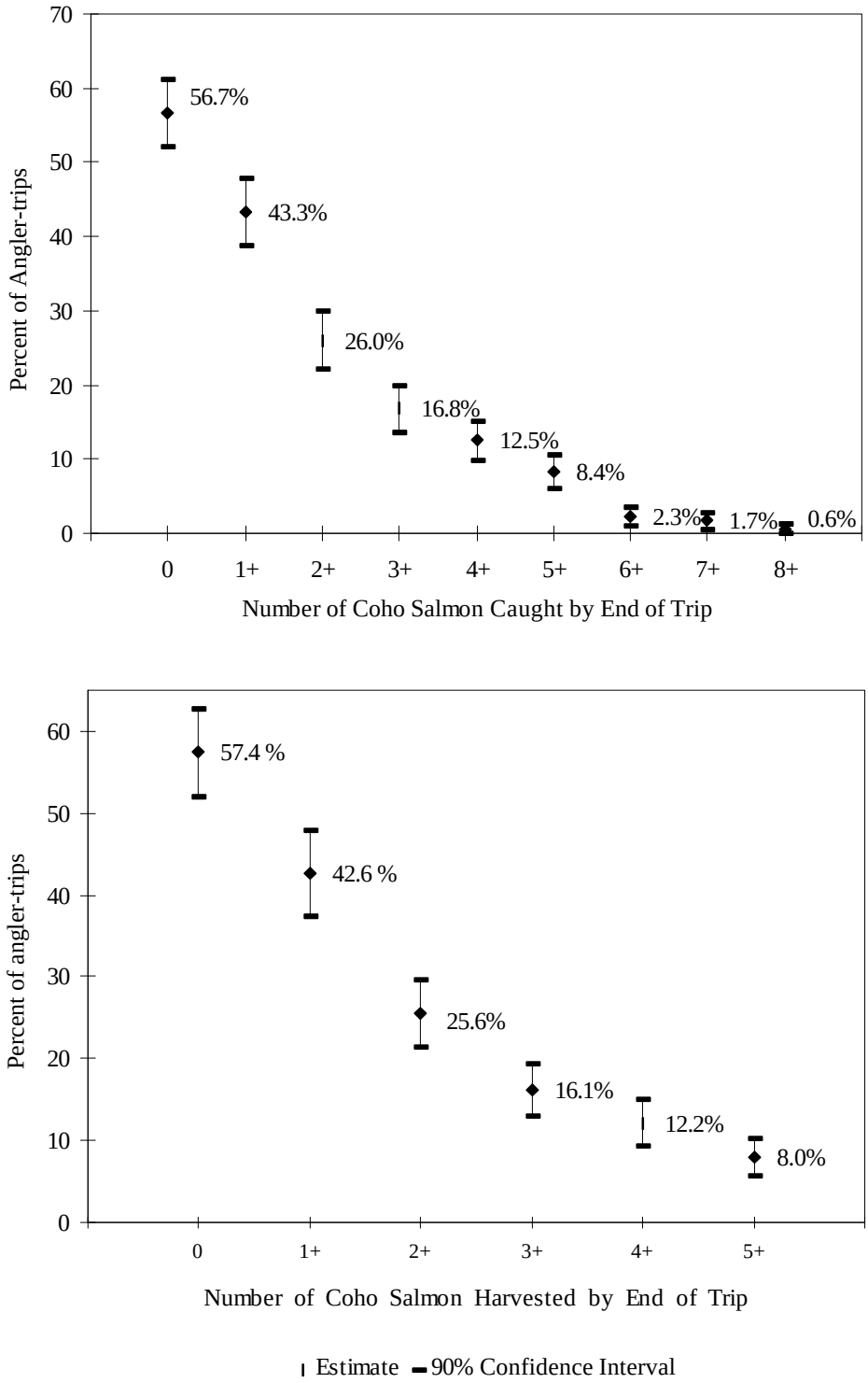



**Figure 4.-Distribution of catch and harvest success in the lower Naknek River coho salmon sport fishery, 22 July through 31 August 1995.**

coho salmon. No coho salmon were harvested in 57.4% (SE = 3.2%) of angler-trips, one or more coho salmon were harvested in 42.6% (SE = 3.2%) of the trips, two or more fish were taken in 25.6% (SE = 2.5%) of the trips and only 8% (SE = 1.4%) of the trips resulted in a harvest of the full five fish bag limit (Table 15, Figure 4).

The first fish harvested among all anglers' daily take made up 42.2% (SE = 5.1%), and the second fish kept constituted another 25.2% (SE = 3.2%) of the total sport harvest of coho salmon in 1995 (Table 16, Figure 5). Significant portions of the total harvest also came from the third fish harvested (15.1%, SE = 2.1%) and fourth fish harvested (10.8%, SE = 1.6%), while the fifth fish harvested contributed 6.8% (SE = 1.1%).

### Angler Characteristics

Among the 597 angler-trip interviews collected during the coho salmon fishery, 64.0% (SE = 2.0%) were guided, 73.2% (SE = 1.8%) were of non-Alaskan residents, and 14.4% (SE = 1.4%) were of residents of countries other than the United States (Table 17). The majority of trips were made by males (86.6%, SE = 1.4%) and nearly all trips were conducted from boats (99.7%, SE = 0.2%). Artificial lures were almost the only tackle used (96.8%, SE = 0.7%) (Table 17).

### Age, Length at Age, and Sex Composition of the Sport Harvest

Of the 282 coho salmon sampled from the sport harvest from 28 July through 30 August, 46.8% (SE = 3.3%) were females and 53.2% (SE = 3.3) were males (Table 18). Most (84.1%, SE = 2.4%) of the fish were age 2.1, age 1.1 (8.2%, SE = 1.8%) and age 3.1 (3.9%, SE = 1.3%). The few remaining fish were ages 2.2, 3.2 and 4.1 (Table 18). The biggest coho salmon sampled was an age-3.2 male that was caught on 5 August. The fish measured 635 mm (25 in) in length, and weighed 6,700 grams (14.7 lb).

### Incidental Species

The Naknek River sustains populations of several other fish species popular with sport anglers. Typically, chum salmon and rainbow trout are caught occasionally, although they are not targeted by sport anglers in the lower river. In the course of collecting interview data for the chinook and coho salmon fisheries, anglers reported their catches of other species, permitting estimates of their catches and harvests. Since the 1995 survey was designed for the chinook and coho salmon fisheries, the estimates of incidentally caught species serve as interesting information, but are not definitive for the fisheries for those species.

During the 1995 survey on the lower Naknek River an estimated 188 (SE = 39) chum salmon were caught and 87 (SE = 20) were harvested (Appendix C1). An estimated 431 (SE = 85) rainbow trout were caught, and 54 (SE = 17) were harvested (Appendix C2). Sample sizes of chum salmon and rainbow trout were too small to estimate age and length compositions.

Data files and computer programs used to produce this report are listed in Appendix D1.

## DISCUSSION

### Chinook Salmon Fishery

Although 1995 angler effort was below the 1986-1992 average, it was similar to 1991 and 1992 estimates (Table 19). The 1995 overall catch and harvest estimates for 1 June through 31 July were much like all estimates generated since 1988 (Table 19). The 1995 CPUE estimate (0.17, SE = 0.007) was slightly, though significantly, higher than the 0.12 (SE = 0.007) estimate of 1991 (Table 20). Comparing the catch distribution estimates, at least one chinook salmon was

**Table 15.-Estimated percent of angler-trips resulting in harvests of zero, one or more, and up to five, coho salmon in the lower Naknek River, 22 July through 31 August 1995.**

| Harvest | Percent of Angler-trips | Standard Error | 90% Confidence Interval Lower | Upper |
|---|---|---|---|---|
| 0 | 57.4 | 3.2 | 52.1 | - 62.7 |
| 1+ | 42.6 | 3.2 | 37.3 | - 47.9 |
| 2+ | 25.6 | 2.5 | 21.5 | - 29.7 |
| 3+ | 16.1 | 2.0 | 12.9 | - 19.4 |
| 4+ | 12.2 | 1.7 | 9.3 | - 15.0 |
| 5 | 8.0 | 1.4 | 5.6 | - 10.3 |

**Table 16.-Estimated percent of coho salmon harvest due to the first, second, third, fourth, and fifth fish in all anglers daily creels, lower Naknek River, 22 July through 31 August 1995.**

| Fish | Percent of Harvest | Standard Error | 90% Confidence Interval Lower | Upper |
|---|---|---|---|---|
| #1 | 42.2 | 5.1 | 33.8 | - 50.5 |
| #2 | 25.2 | 3.2 | 20.0 | - 30.4 |
| #3 | 15.1 | 2.1 | 11.7 | - 18.5 |
| #4 | 10.8 | 1.6 | 8.2 | - 13.3 |
| #5 | 6.8 | 1.1 | 4.9 | - 8.7 |

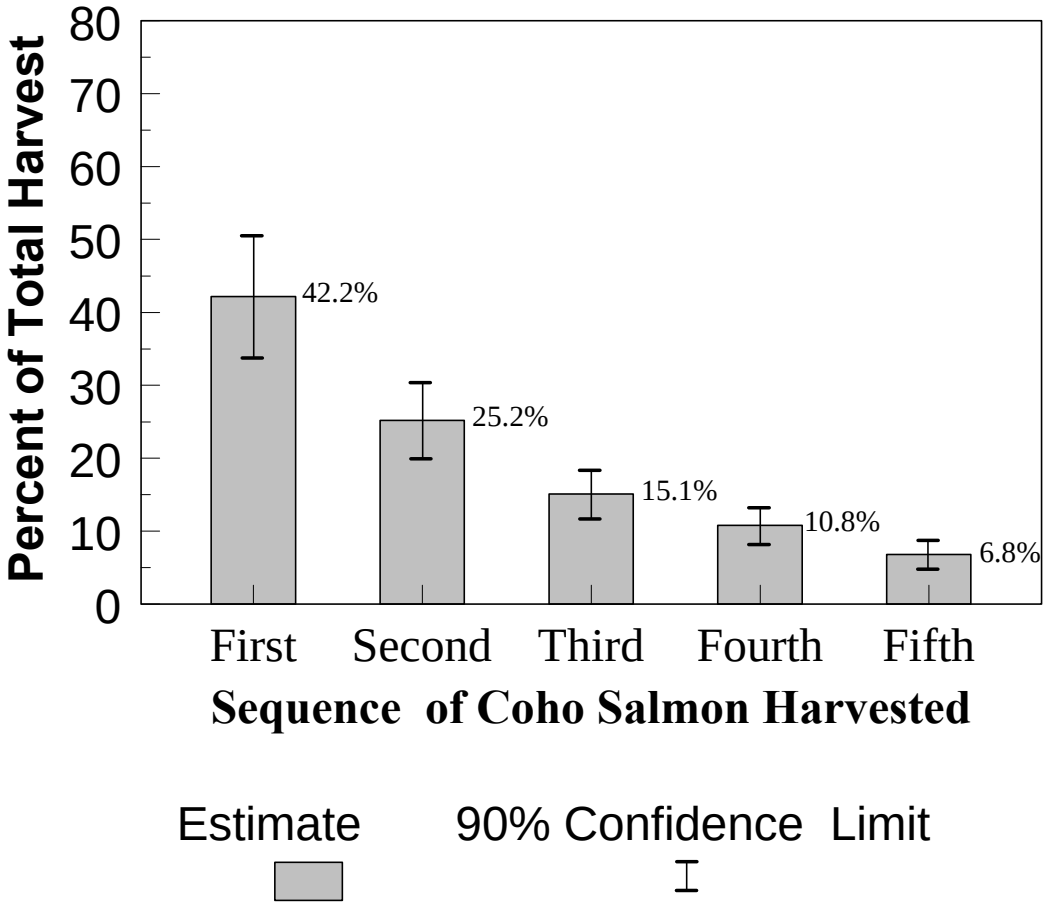



**Figure 5.-Estimated percent of coho salmon harvest due to the first, second, third, fourth, and fifth fish in all anglers daily creels, lower Naknek River coho salmon sport fishery, 22 July through 31 August 1995.**

caught in more angler-trips in 1995 (48%, SE = 3%) than in 1991 (30%, SE = 3) (Table 20). The better catch rates and success estimated in 1995 than in 1991 may be related to the significantly greater percentage of guided anglers participating in the 1995 fishery (38.4% versus 24.3%) (Table 20). The 1995 escapement estimate of 4,960 chinook salmon essentially met the 5,000 fish biological escapement goal for the Naknek River drainage though it is below the levels observed in 1993 and 1994 (Table 11).

## COHO SALMON FISHERY

Effort in the coho salmon fishery of the lower Naknek River has declined since 1988, although catch and harvest of coho salmon has remained stable (Table 21). Most other characteristics of the fishery and characteristics of anglers in this fishery have shown no changes since 1991 (Table 22).

Unfortunately, still lacking are escapement estimates for Naknek River drainage coho salmon. The continuing demand on Naknek River coho salmon, including commercial, subsistence as well as sport fisheries, and the critical dependence of each return upon a

**Table 17.-Number and percent of angler-trips, by angler type and gear type, during the lower Naknek River coho salmon sport fishery, 22 July through 31 August 1995.**

| Characteristic | Angler-trips | Percent | SE (%) |
|---|---|---|---|
| ANGLER TYPE | | | |
| Guided | 382 | 64.0 | 2.0 |
| Unguided | 215 | 36.0 | 2.0 |
| RESIDENCY | | | |
| Alaskan Residents | 160 | 26.8 | 1.8 |
| Local Alaskan Residents[a] | 118 | 19.8 | 1.7 |
| Nonlocal Alaskan Residents[b] | 42 | 7.0 | 0.3 |
| Non-Alaskan Residents | 437 | 73.2 | 1.8 |
| U.S. Residents | 351 | 58.8 | 2.0 |
| Non-U.S. Residents | 86 | 14.4 | 1.4 |
| SEX | | | |
| Male | 517 | 86.6 | 1.4 |
| Female | 80 | 13.4 | 1.4 |
| BOAT/SHORE | | | |
| Fished from boat | 595 | 99.7 | 0.2 |
| Fished from shore | 2 | 0.3 | 0.2 |
| TACKLE TYPE | | | |
| Lures (including trolled tackle) | 578 | 96.8 | 0.7 |
| Fly | 5 | 0.8 | 0.4 |
| Lures and Fly | 3 | 0.5 | 0.3 |
| Unknown | 11 | 1.8 | 0.5 |
| TOTAL ANGLER-TRIPS | 597 | | |

[a] Alaskan residents living in the King Salmon/Naknek area.

[b] All other Alaskan residents.

**Table 18.-Mean lengths (mm) and weights (g) of coho salmon, by sex and age group, from samples collected from the lower Naknek River sport harvest, 28 July through 30 August 1995.**

| | Age Group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | UNKNOWN | 1.1 | 2.1 | 2.2 | 3.1 | 3.2 | 4.1 | TOTAL |
| **FEMALES** | | | | | | | | |
| Percent | | 3.9 | 39.5 | 1.7 | 1.3 | | 0.4 | 46.8 |
| SE | | 1.3 | 3.2 | 0.9 | 0.7 | | 0.4 | 3.3 |
| Sample Size | | 9 | 92 | 4 | 3 | | 1 | 109 |
| Mean Length | 576 | 587 | 583 | 581 | 588 | | 534 | 582 |
| SE | 7 | 19 | 4 | 21 | 36 | | | 3 |
| Sample Size | 24 | 9 | 92 | 4 | 3 | | 1 | 133 |
| Mean Weight | 3,240 | 3,344 | 3,408 | 3,125 | 3,367 | | 2,500 | 3,357 |
| SE | 128.82 | 222.59 | 69.70 | 353.85 | 560.01 | | | 57.63 |
| Sample Size | 24 | 9 | 92 | 4 | 3 | | 1 | 133 |
| **MALES** | | | | | | | | |
| Percent | | 4.3 | 44.6 | 0.4 | 2.6 | 1.3 | | 53.2 |
| SE | | 1.3 | 3.3 | 0.4 | 1.0 | 0.7 | | 3.3 |
| Sample Size | | 10 | 104 | 1 | 6 | 3 | | 124 |
| Mean Length | 603 | 614 | 598 | 625 | 596 | 622 | | 600 |
| SE | 9 | 18 | 4 | | 14 | 9 | | 3 |
| Sample Size | 25 | 9 | 104 | 1 | 6 | 3 | | 148 |
| Mean Weight | 3,852 | 4,025 | 3,817 | 4,000 | 3,717 | 5,067 | | 3,859 |
| SE | 169.67 | 283.85 | 77.76 | | 242.10 | 829.32 | | 67.39 |
| Sample Size | 25 | 10 | 104 | 1 | 6 | 3 | | 149 |
| **ALL SAMPLES** | | | | | | | | |
| Percent | | 8.2 | 84.1 | 2.1 | 3.9 | 1.3 | 0.4 | 100.0 |
| SE | | 1.8 | 2.4 | 1.0 | 1.3 | 0.7 | 0.4 | 0.0 |
| Sample Size | | 19 | 196 | 5 | 9 | 3 | 1 | 233 |
| Mean Length | 590 | 601 | 591 | 590 | 593 | 622 | 534 | 592 |
| SE | 6 | 13 | 3 | 18 | 14 | 9 | | 2 |
| Sample Size | 49 | 18 | 196 | 5 | 9 | 3 | 1 | 281 |
| Mean Weight | 3,552 | 3,703 | 3,625 | 3,300 | 3,600 | 5,067 | 2,500 | 3,622 |
| SE | 114.85 | 195.06 | 54.53 | 325.19 | 232.29 | 829.32 | | 47.16 |
| Sample Size | 49 | 19 | 196 | 5 | 9 | 3 | 1 | 282 |

**Table 19.-Historical estimates of effort, catch, and harvest from creel surveys conducted on the lower Naknek River chinook salmon sport fishery.**

| Temporal Component | | 1986[a] | 1987[b] | 1988[c] | 1989[d] | 1990[e] | 1991[f] | 1992[g] | 1986-92 Average | 1995 | Cumulative Est. Average 1986-92 | Cumulative Est. Average 1995 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Effort (Angler-Hours) | | | | | | | | | | | | |
| 1 | 6/1-6/21 | 3,996 | 4,193 | 9,734 | 7,655 | 7,623 | 2,940 | 3,379 | 5,646 | 4,732 | 5,646 | 4,732 |
| 2 | 6/22-6/30 | 10,350 | 8,401 | 17,241 | 16,949 | 11,480 | 6,456 | 6,678 | 11,079 | 5,403 | 16,725 | 10,135 |
| 3 | 7/1-7/7 | 9,781 | 11,195 | 11,110 | 11,613 | 7,392 | 7,190 | 6,233 | 9,216 | 4,561 | 25,941 | 14,696 |
| 4 | 7/8-7/14 | 9,597 | 10,416 | 9,366 | 7,665 | 5,076 | 4,010 | 5,284 | 7,345 | 5,793 | 33,286 | 20,489 |
| 5 | 7/15-7/21 | 2,604 | 6,334 | 8,671 | 6,006 | 4,294 | 3,791 | 3,298 | 5,000 | 2,926 | 38,286 | 23,415 |
| 6 | 7/22-7/31 | 3,906 | 5,902 | 10,396 | 5,745 | 3,787 | 4,427 | 3,556 | 5,388 | 4,091 | 43,674 | 27,506 |
| | Total | 40,234 | 46,441 | 66,518 | 55,633 | 39,652 | 28,814 | 28,428 | 43,674 | 27,506 | | |
| Catch Estimates | | | | | | | | | | | | |
| 1 | 6/1-6/21 | 741 | 309 | 248 | 413 | 655 | 93 | 312 | 396 | 412 | 396 | 412 |
| 2 | 6/22-6/30 | 877 | 2,682 | 1,081 | 1,037 | 1,373 | 517 | 781 | 1,193 | 927 | 1,588 | 1,339 |
| 3 | 7/1-7/7 | 2,339 | 3,432 | 961 | 908 | 901 | 1,246 | 549 | 1,477 | 506 | 3,065 | 1,845 |
| 4 | 7/8-7/14 | 2,377 | 2,546 | 724 | 830 | 484 | 506 | 685 | 1,165 | 1,184 | 4,230 | 3,029 |
| 5 | 7/15-7/21 | 549 | 1,859 | 1,014 | 609 | 493 | 520 | 520 | 795 | 525 | 5,024 | 3,554 |
| 6 | 7/22-7/31 | 860 | 1,621 | 1,314 | 444 | 359 | 735 | 515 | 835 | 684 | 5,860 | 4,238 |
| | Total | 7,743 | 12,449 | 5,342 | 4,241 | 4,265 | 3,617 | 3,362 | 5,860 | 4,238 | | |
| Harvest Estimates | | | | | | | | | | | | |
| 1 | 6/1-6/21 | 670 | 309 | 248 | 413 | 650 | 93 | 294 | 382 | 394 | 382 | 394 |
| 2 | 6/22-6/30 | 816 | 2,414 | 947 | 976 | 1,284 | 503 | 751 | 1,099 | 840 | 1,481 | 1,234 |
| 3 | 7/1-7/7 | 1,976 | 2,636 | 724 | 802 | 864 | 1,153 | 501 | 1,237 | 418 | 2,718 | 1,652 |
| 4 | 7/8-7/14 | 2,118 | 2,495 | 642 | 798 | 138 | 488 | 562 | 1,034 | 955 | 3,752 | 2,607 |
| 5 | 7/15-7/21 | 443 | 1,615 | 758 | 602 | 180 | 431 | 416 | 635 | 444 | 4,387 | 3,051 |
| 6 | 7/22-7/31 | 845 | 1,178 | 1,229 | 433 | 134 | 477 | 425 | 674 | 486 | 5,062 | 3,537 |
| | Total | 6,868 | 10,647 | 4,548 | 4,024 | 3,250 | 3,145 | 2,949 | 5,062 | 3,537 | | |

Note: This table was produced by partitioning and reanalyzing portions of the original data that correspond to the temporal components used in 1991, 1992 and 1995. The reanalysis was done only for the portions of each survey that occurred between 1 June and 31 July: estimates presented here may differ from those in the original reports.

[a] Minard (1987)

[b] Minard and Brookover (1988)

[c] Minard (1989). Note: addition producing June and July total effort estimate (Table 1, page 10 in Minard 1989) is incorrect and should be 75,260 angler-hours.

[d] Dunaway (1990).

[e] Dunaway and Bingham (1991).

[f] Coggins (1992).

[g] Coggins and Bingham (1993).

**Table 20.-Comparison of angler success distributions, angler characteristics, and gear selection observed during surveys of the recreational chinook salmon fishery in the lower Naknek River.**

| Survey Year | 1991[a] | | 1992[b] | | 1995 | |
|---|---|---|---|---|---|---|
| Survey Dates | 6/1 to 7/31 | | 6/8 to 7/31 | | 6/1 to 7/31 | |
| Total Interviews | 1,490 | | 2,030 | | 1,430 | |
| Completed-trip interviews | 914 | | 2,030 | | 1,430 | |
| Estimated Effort (angler-hours) | 28,814 | SE=1,749 | 28,428 | SE=1,457 | 27,506 | SE=1,360 |
| Catch Rate (fish/hour) | 0.12 | SE=0.007 | no estimate | | 0.17 | 0.007 |
| Estimated Harvest | 3,115 | SE=343.3 | 2,949 | SE=233 | 3,537 | SE = 293 |
| Catch Distribution[c] number of fish | Percent of Angler-trips | SE(%) | Percent of Angler-trips | SE(%) | Percent of Angler-trips | SE(%) |
| 0 | 70 | 4 | not | | 52 | 3 |
| 1+ | 30 | 3 | estimated | | 48 | 3 |
| 2+ | 4 | 1 | | | 19 | 2 |
| 3+ | 1 | <1 | | | 8 | 1 |
| 4+ | <1 | <1 | | | 3 | 1 |
| 5+ | <1 | <1 | | | 2 | <1 |
| Harvest Distribution | | | | | | |
| 0 | 71 | 4 | not | | 55 | 3 |
| 1+ | 29 | 3 | estimated | | 46 | 3 |
| 2+ | 3 | <1 | | | 15 | 1 |
| 3+ | <1 | <1 | | | 5 | 1 |
| ANGLER TYPES | | | | | | |
| Guided | 24.3 | 1.4 | 41.7 | 1.1 | 38.4 | 1.3 |
| Unguided (all) | 75.7 | 1.4 | 58.3 | 1.1 | 61.5 | 1.3 |
| Alaskan Residents | 34.1 | 1.6 | 28.9 | 1.0 | 25.8 | 1.1 |
| Non Alaskan | 65.9 | 1.6 | 71.1 | 1.0 | 72.3 | 1.2 |
| not recorded | | | | | 1.9 | 0.4 |
| TACKLE TYPE | | | | | | |
| Lures | 99.7 | 0.2 | 97.8 | 0.3 | 97.8 | 0.4 |
| Fly | 0.3 | 0.2 | 2.2 | 0.3 | 0.6 | 0.2 |
| Lures and Fly | | | | | 0.6 | 0.2 |
| unknown | | | | | 1.0 | 0.3 |

[a] Coggins 1992.

[b] Coggins and Bingham 1993. The creel survey was conducted mainly to recover tagged fish in an inriver abundance study of chinook salmon; analysis of other interview data was limited.

[c] For the purposes of this comparison, the percent of angler-trips and SE are shown only for the catch and harvest distribution of the angler-trips for which up to five or more fish were caught or harvested.

**Table 21.-Historical estimates of effort, catch, and harvest from creel surveys conducted on the lower Naknek River coho salmon sport fishery.**

| Temporal Component | | 1988[a] | 1989[b] | 1991[c] | 1988-1991 Average Estimate | 1995 Estimate | Cumulative Estimate Average 1988-1991 | Cumulative Estimate 1995 |
|---|---|---|---|---|---|---|---|---|
| Fishing Effort (Angler-hours) | | | | | | | | |
| 6 | 7/22-7/31 | 10,396 | 5,745 | 4,427 | 6,856 | 4,091 | 6,586 | 4,091 |
| 7 | 8/1-8/7 | 3,571 | 3,683 | 2,587 | 3,280 | 1,817 | 9,866 | 5,908 |
| 8 | 8/8-8/14 | 4,172 | 3,311 | 2,794 | 3,426 | 3,191 | 13,292 | 9,099 |
| 9 | 8/15-8/21 | 2,739 | 3,395 | 3,782 | 3,305 | 2,726 | 16,597 | 11,825 |
| 10 | 8/22-8/31 | 2,532 | 2,171 | 3,561 | 2,755 | 2,540 | 19,352 | 14,365 |
| | TOTAL | 23,410 | 18,305 | 17,151 | 19,622 | 14,365 | | |
| Catch Estimates | | | | | | | | |
| 6 | 7/22-7/31 | 70 | 259 | 170 | 166 | 66 | 166 | 66 |
| 7 | 8/1-8/7 | 534 | 825 | 1,347 | 902 | 633 | 1,068 | 699 |
| 8 | 8/8-8/14 | 1,938 | 1,413 | 824 | 1,392 | 1,195 | 2,460 | 1,894 |
| 9 | 8/15-8/21 | 693 | 1,039 | 1,690 | 1,141 | 568 | 3,600 | 2,462 |
| 10 | 8/22-8/31 | 618 | 662 | 789 | 690 | 728 | 4,290 | 3,190 |
| TOTAL | | 3,853 | 4,198 | 4,820 | 4,290 | 3,190 | | |
| Harvest Estimates | | | | | | | | |
| 6 | 7/22-7/31 | 70 | 253 | 170 | 164 | 63 | 164 | 63 |
| 7 | 8/1-8/7 | 460 | 809 | 1,245 | 838 | 624 | 1,002 | 687 |
| 8 | 8/8-8/14 | 1,847 | 1,112 | 667 | 1,209 | 1,012 | 2,211 | 1,699 |
| 9 | 8/15-8/21 | 680 | 961 | | 1,091 | 548 | 3,301 | 2,247 |
| 10 | 8/22-8/31 | 589 | 653 | 754 | 665 | 700 | 3,967 | 2,947 |
| TOTAL | | 3,646 | 3,788 | 4,467 | 3,967 | 3,037 | | |

Note: This table was produced by partitioning and reanalyzing portions of the original data that correspond to the temporal components used in 1991 and 1995. The reanalysis was done only for the portions of each survey that occurred between 22 July and 15 September: estimates presented here may differ from those in the original reports (estimates for 1 through 15 September of 1988 and 1989 not presented here).

[a] Minard (1989). Note: addition producing June and July total effort estimate (Table 1, page 10 in Minard 1989) is incorrect and should be 75,260 angler-hours.

[b] Dunaway (1990).

[c] Coggins (1992). The 1991 estimates for the time period 8/22-8/31 are actually for the time period 8/22-9/1.

**Table 22.-Comparison of angler success distributions, angler characteristics, and gear selection observed during surveys of the recreational coho salmon fishery in the lower Naknek River.**

| Survey Year | 1991[a] | | 1995 | |
|---|---|---|---|---|
| Survey Dates | 7/22 to 9/1 | | 7/22 to 8/31 | |
| Total Interviews | 1,145 | | 597 | |
| Completed-trip interviews | 666 | | 597 | |
| Estimated Effort (angler-hours) | 17,151 | SE = 716 | 14,365 | SE=709 |
| Catch Rate (fish/hour) | 0.22 | SE=0.01 | 0.19 | SE=0.02 |
| Estimated Harvest | 3,447 | SE=524.7 | 3,037 | SE=419 |
| Catch Distribution[b] | Percent of Angler-trips | SE(%) | Percent of Angler-trips | SE(%) |
| number of fish | | | | |
| 0 | 60 | 4 | 57 | 3 |
| 1+ | 40 | 2 | 43 | 3 |
| 2+ | 25 | 2 | 26 | 2 |
| 3+ | 14 | 2 | 17 | 2 |
| 4+ | 10 | 2 | 13 | 2 |
| 5+ | 5 | 1 | 8 | 1 |
| Harvest Distribution | | | | |
| 0 | 61 | 4 | 58 | 3 |
| 1+ | 39 | 3 | 43 | 3 |
| 2+ | 24 | 3 | 26 | 3 |
| 3+ | 14 | 2 | 16 | 2 |
| 4+ | 9 | 2 | 12 | 2 |
| 5 | 4 | 1 | 8 | 1 |
| ANGLER TYPES | | | | |
| Guided | 21.8 | 1.6 | 36 | 2 |
| Unguided (all) | 78.2 | 1.6 | 64 | 2 |
| Alaskan Residents | 26.3 | 1.7 | 26.8 | 1.8 |
| Non-Alaskan Residents | 73.7 | 1.7 | 73.2 | 1.8 |
| TACKLE TYPE | | | | |
| Lures | 98.9 | 0.4 | 96.8 | 0.7 |
| Fly | 1.1 | 0.4 | 0.8 | 0.4 |
| Lures and Fly | | | 0.8 | 0.3 |
| unknown | | | 1.8 | 0.5 |

[a] Coggins 1992.

[b] For the purposes of this comparison, the percent of angler-trips and SE are shown only for the catch and harvest distribution of the angler-trips for which up to five or more fish were caught or harvested.

single parent year should be a source of concern for the department. Development of an escapement data base for Naknek River coho salmon could be an important step toward improving the monitoring and management of this stock.

## ACKNOWLEDGMENTS

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# APPENDIX A. STATISTICAL METHODS

**Appendix A1.-Equations used to estimate angler effort (in hours and angler-trips) on the lower Naknek River, 1995.**

Hours of angler effort, number of angler-trips, their associated variances, and standard errors were estimated using the following procedures.

## Hours of Angler Effort

Within each sampling period (second-stage sampling unit j) within each sampled day (first-stage sampling unit i) within each stratum (stratum h), total angler effort (in hours) and its variance were estimated as:

$$\hat{E}_{hij} = \bar{x}_{hij} T_{hij} \tag{A1.1}$$

$$\hat{V}\left[\hat{E}_{hij}\right] = \hat{V}\left[\bar{x}_{hij}\right] T_{hij}^2 \tag{A1.2}$$

where $\bar{x}_{hij}$ is the average number of anglers counted fishing, $T_{hij}$ is the number of hours in each sampling period (4), and $\hat{V}\left[\bar{x}_{hij}\right]$ is the estimated variance of $\bar{x}_{hij}$, obtained approximately by using the successive difference formula appropriate for systematic samples (adapted from Wolter 1985, equation 7.2.4, page 251):

$$\hat{V}\left[\bar{x}_{hij}\right] \approx \frac{\sum_{k=2}^{r_{hij}} \left(x_{hijk} - x_{hij(k-1)}\right)^2}{2\, r_{hij}(r_{hij} - 1)} \tag{A1.3}$$

where $x_{hijk}$ is number of anglers during angler count k and $r_{hij}$ is the number of angler counts per period.

Angler effort within each sampled day for each stratum was estimated by expanding over periods within each day:

$$\hat{E}_{hi} = Q_{hi} \bar{E}_{hi} \tag{A1.4}$$

where:

$$\bar{E}_{hi} = \frac{\sum_{j=1}^{q_{hi}} \hat{E}_{hij}}{q_{hi}}, \tag{A1.5}$$

$Q_{hi}$ is the number of periods in each sampled day (equal to four through 31 July and three thereafter), and $q_{hi}$ is the number of periods sampled.

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Estimates of angler effort within each stratum were calculated by expanding over days:

$$\hat{E}_h = D_h \overline{E}_h \tag{A1.6}$$

where:

$$\overline{E}_h = \frac{\sum_{i=1}^{d_h} \hat{E}_{hi}}{d_h}, \tag{A1.7}$$

$D_h$ is the number of days within each stratum (temporal component), and $d_h$ is the number of days sampled.

The variance of angler effort by stratum was estimated as:

$$\hat{V}\left[\hat{E}_h\right] = \left(1 - f_{1h}\right)\frac{D_h^2}{d_h}\frac{\sum_{i=1}^{d_h}\left(\hat{E}_{hi} - \overline{E}_h\right)^2}{d_h - 1} + f_{1h}\frac{D_h^2}{d_h^2}\sum_{i=1}^{d_h}\left[\left(1 - f_{2hi}\right)\frac{Q_{hi}^2}{q_{hi}}\frac{\sum_{j=1}^{q_{hi}}\left(\hat{E}_{hij} - \overline{E}_{hi}\right)^2}{q_{hi} - 1}\right] + f_{1h}\frac{D_h^2}{d_h^2}\sum_{i=1}^{d_h}\left[f_{2hi}\frac{Q_{hi}^2}{q_{hi}}\frac{\sum_{j=1}^{q_{hi}}\hat{V}\left[\hat{E}_{hij}\right]}{q'_{hi}}\right] \tag{A1.8}$$

where $f_{1h}$ is the first-stage sampling fraction ($d_h/D_h$), $f_{2hi}$ is the second-stage sampling fraction for first-stage unit i ($q_{hi}/Q_{hi}$), and $q'_{hi}$ is the number of second-stage units in first-stage unit i in which the variance of the effort could be estimated (number of periods in which $r_{hij} > 1$).

The total angler effort (across all strata) and its variance were estimated as:

$$\hat{E} = \sum_{h=1}^{L} \hat{E}_h \tag{A1.9}$$

$$\hat{V}\left[\hat{E}\right] = \sum_{h=1}^{L} \hat{V}\left[\hat{E}_h\right] \tag{A1.10}$$

where L is the number of strata.

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## Number of Angler-Trips

The number of angler-trips per stratum was estimated in order to provide a weighting factor for distributions of angler catch and harvest (Appendix A4). The number of angler-trips during day i of stratum h was estimated as the ratio of the estimated angler effort in angler-hours divided by the average hours per completed angler-trip:

$$\hat{M}_{hi} \approx \frac{\hat{E}_{hi}}{\bar{e}_{hi}} \tag{A1.11}$$

where $\bar{e}_{hi}$ is the mean of angler effort over all completed-trip anglers during day i:

$$\bar{e}_{hi} = \frac{\sum_{j=1}^{q_{hi}} \sum_{l=1}^{m_{hij}} e_{hijl}}{m_{hi}}, \tag{A1.12}$$

where $e_{hijl}$ is the hours of effort expended by each completed-trip angler interviewed and $m_{hi}$ is the number of completed-trip anglers interviewed during all sampled periods of day i, stratum h.

The variance of $\hat{M}_{hi}$ was estimated as:

$$\hat{V}\left[\hat{M}_{hi}\right] = \hat{V}\left[1/\bar{e}_{hi}\right]\hat{E}_{hi}^2 + \hat{V}\left[\hat{E}_{hi}\right]\left(1/\bar{e}_{hi}\right)^2 - \hat{V}\left[\hat{E}_{hi}\right]\hat{V}\left[1/\bar{e}_{hi}\right] \tag{A1.13}$$

where:

$$\hat{V}\left[1/\bar{e}_{hi}\right] \approx \hat{V}\left[\bar{e}_{hi}\right]\left(1/\bar{e}_{hi}^4\right) \tag{A1.14}$$

where:

$$\hat{V}\left[\bar{e}_{hi}\right] = \frac{\sum_{j=1}^{q_{hi}} \sum_{l=1}^{m_{hij}} \left(e_{hijl} - \bar{e}_{hi}\right)^2}{m_{hi}\left(m_{hi} - 1\right)} \tag{A1.15}$$

and where:

$$\hat{V}\left[\hat{E}_{hi}\right] = \left(1 - f_{2hi}\right)\frac{Q_{hi}^2}{q_{hi}}\frac{\sum_{j=1}^{q_{hi}}\left(\hat{E}_{hij} - \bar{E}_{hi}\right)}{q_{hi} - 1} + f_{2hi}\frac{Q_{hi}^2}{q_{hi}}\frac{\sum_{j=1}^{q_{hi}}\hat{V}\left[\hat{E}_{hij}\right]}{q_{hi}}. \tag{A1.16}$$

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For days in which only one angler count was conducted per period, the second and third terms of (A1.13) could not be calculated directly because $\hat{V}\left[\hat{E}_{hij}\right]$, and therefore $\hat{V}\left[\hat{E}_{hi}\right]$, could not be estimated (equations 2 and 16). For these periods, values for $\hat{V}\left[\hat{E}_{hij}\right]$ were imputed by assuming that relative variability was constant within temporal components:

$$\hat{V}'\left[\hat{E}_{hij}\right] = \left[\overline{CV}_h \ \hat{E}_{hij}\right]^2, \tag{A1.17}$$

where $\overline{CV}_h$ is the pooled coefficient of variation for temporal component h expressed as a proportion:

$$\overline{CV}_h = \frac{\sum_{i=1}^{d_h}\sum_{j=1}^{q_{hi}}\sqrt{\hat{V}\left[\hat{E}_{hij}\right]}}{\sum_{i=1}^{d_h}\sum_{j=1}^{q_{hi}}\hat{E}_{hij}}, \tag{A1.18}$$

where both $\hat{E}_{hij}$ and $\hat{V}\left[\hat{E}_{hij}\right]$ were summed over only those periods where more than one angler count was conducted.

Estimates of angler effort within each stratum were calculated by expanding over days:

$$\hat{M}_h = D_h\overline{M}_h \tag{A1.19}$$

where:

$$\overline{M}_h = \frac{\sum_{i=1}^{d_h}\hat{M}_{hi}}{d_h}. \tag{A1.20}$$

Finally, its variance was estimated as:

$$\hat{V}\left[\hat{M}_h\right] = \left(1 - f_{1h}\right)\frac{D_h^2}{d_h}\frac{\sum_{i=1}^{d_h}\left(\hat{M}_{hi} - \overline{M}_h\right)^2}{d_h - 1} + f_{1h}\frac{D_h^2}{d_h}\sum_{i=1}^{d_h}\left[\frac{\hat{V}\left[\hat{M}_{hi}\right]}{d'_{hi}}\right]. \tag{A1.21}$$

where $d'_h$ is the number of days in stratum h in which $\hat{V}\left[\hat{M}_{hi}\right]$ could be estimated.

**Appendix A2.-Equations used to estimate harvest and catch, by species, on the lower Naknek River, 1995.**

Harvest and catch, their associated variances, and standard errors were estimated using the following procedures. The following estimates of CPUE (and their variances) were not used to describe individual angler catch rates (Objective 2). Appendix A3 describes methods used to estimate such catch rates.

Within first-stage unit i of stratum h, estimates of mean harvest per unit effort were calculated using a jackknife procedure (Efron 1982) to reduce bias. Data from completed-trip interviews only were used. First, the mean harvest of angler-trips was divided by the mean length of trip to estimate the sample ratio of HPUE:

$$\overline{HPUE}_{hi} = \frac{\bar{H}_{hi}}{\bar{e}_{hi}} = \frac{\sum_{j=1}^{q_{hi}} \sum_{l=1}^{m_{hij}} H_{hijl} \Big/ m_{hi}}{\sum_{j=1}^{q_{hi}} \sum_{l=1}^{m_{hij}} e_{hijl} \Big/ m_{hi}} = \frac{\sum_{j=1}^{q_{hi}} \sum_{l=1}^{m_{hij}} H_{hijl}}{\sum_{j=1}^{q_{hi}} \sum_{l=1}^{m_{hij}} e_{hijl}} \qquad \text{(A2.1)}$$

where $H_{hijl}$ is the harvest by species during an angler trip l, $e_{hijl}$ is the effort expended (in hours) during angler-trip l, and $m_{hi}$ is the number of completed-trip interviews during day i. Since the above estimate of mean HPUE has an inherent bias of order $1/m_{hi}$ (Cochran 1977), the jackknifed estimate of mean HPUE was calculated (Efron 1982):

$$\overline{HPUE}^{*}_{hi} = \frac{\sum_{m=1}^{m_{hi}} HPUE^{*}_{him}}{m_{hi}}; \qquad \text{(A2.2)}$$

where:

$$HPUE^{*}_{him} = \frac{\sum_{\substack{l=1 \\ l \neq m}}^{m_{hi}} H_{hil}}{\sum_{\substack{l=1 \\ l \neq m}}^{m_{hi}} e_{hil}}. \qquad \text{(A2.3)}$$

The jackknifed estimate was used to reduce the inherent bias to order $1/m_{hi}^2$ through the adjustment:

$$\overline{HPUE}^{**}_{hi} = m_{hi}\left[\overline{HPUE}_{hi} - \overline{HPUE}^{*}_{hi}\right] + \overline{HPUE}^{*}_{hi}. \qquad \text{(A2.4)}$$

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The variance of $\overline{\text{HPUE}}^{**}_{hij}$ is the variance of $\overline{\text{HPUE}}^{*}_{hij}$:

$$\hat{V}\left[\overline{\text{HPUE}}^{**}_{hi}\right] = \hat{V}\left[\overline{\text{HPUE}}^{*}_{hi}\right] = \frac{m_{hi}-1}{m_{hi}} \sum_{m=1}^{m_{hi}} \left[\text{HPUE}^{*}_{him} - \overline{\text{HPUE}}^{*}_{hi}\right]^2 \quad \text{(A2.5)}$$

Mean catch per unit effort (CPUE) was estimated using equations (A2.1)-(A2.5), after first substituting catch $C_{hijl}$ for harvest $H_{hijl}$.

Total harvest, by species, during each sampling period of each sampled day of each stratum was estimated as the product of estimated effort and bias-corrected HPUE:

$$\hat{H}_{hi} = \hat{E}_{hi}\overline{\text{HPUE}}^{**}_{hi} \quad \text{(A2.6)}$$

and its variance followed Goodman (1960):

$$\hat{V}\left[\hat{H}_{hi}\right] = \hat{V}\left(\overline{\text{HPUE}}^{**}_{hi}\right)\hat{E}^2_{hi} + \hat{V}\left(\hat{E}_{hi}\right)\overline{\text{HPUE}}^{**2}_{hi} - \hat{V}\left(\overline{\text{HPUE}}^{**}_{hi}\right)\hat{V}\left(\hat{E}_{hi}\right). \quad \text{(A2.7)}$$

For days in which only one angler count was conducted per period, the second and third terms of (A2.7) could not be calculated directly because $\hat{V}\left[\hat{E}_{hij}\right]$, and therefore $\hat{V}\left[\hat{E}_{hi}\right]$, could not be estimated (Appendix A1). For these periods, values for $\hat{V}\left[\hat{E}_{hij}\right]$ were imputed by assuming that relative variability was constant within temporal components (Appendix A1).

The total number of fish harvested during stratum h was estimated by expanding over days:

$$\hat{H}_h = D_h\overline{H}_h \quad \text{(A2.8)}$$

where:

$$\overline{H}_h = \frac{\sum_{i=1}^{d_h}\hat{H}_{hi}}{d_h}. \quad \text{(A2.9)}$$

Its variance was estimated as:

$$\hat{V}\left[\hat{H}_h\right] = (1-f_{1h})\frac{D_h^2}{d_h}\frac{\sum_{i=1}^{d_h}\left(\hat{H}_{hi}-\overline{H}_h\right)^2}{d_h-1} + f_{1h}\frac{D_h^2}{d_h}\sum_{i=1}^{d_h}\left[\frac{\hat{V}\left[\hat{H}_{hi}\right]}{d'_{hi}}\right]. \quad \text{(A2.10)}$$

where $d'_h$ is the number of days in stratum h in which $\hat{V}\left[\hat{H}_{hi}\right]$ could be estimated.

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Total harvest during the fishery, by species, and its variance were estimated by summing over strata:

$$\hat{H} = \sum_{h=1}^{L} \hat{H}_h \qquad \text{(A2.11)}$$

$$\hat{V}\left[\hat{H}\right] = \sum_{h=1}^{L} \hat{V}\left[\hat{H}_h\right]. \qquad \text{(A2.12)}$$

Catch statistics were estimated similarly, after substituting $\overline{\text{CPUE}}^{**}_{hij}$ for $\overline{\text{HPUE}}^{**}_{hij}$ in equations (A2.6) through (A2.12).

**Appendix A3.-Equations used to estimate catch per unit effort as an index of angler success on the lower Naknek River, 1995.**

Catch per unit effort (CPUE) of anglers participating in the 1995 lower Naknek River chinook and coho salmon fishery, indicative of the abundance of each species as they passed through the fishery, was estimated as follows. First, CPUE was calculated for each interviewed angler:

$$\mathrm{CPUE}_{hijl} = \frac{C_{hijl}}{e_{hijl}} \tag{A3.1}$$

where $C_{hijl}$ is the catch of interviewed angler l, during sampled period j of sampled day i of stratum h, and $e_{hijl}$ is defined in Appendix A1.

The mean CPUE for each stratum was then calculated over all anglers interviewed during each stratum:

$$\overline{\mathrm{CPUE}}_h = \frac{\sum_{i=1}^{d_h} \sum_{j=1}^{q_{hi}} \sum_{l=1}^{m_{hij}} \mathrm{CPUE}_{hijl}}{m_h} \tag{A3.2}$$

where $m_h$ is the number of anglers interviewed within a stratum:

$$m_h = \sum_{i=1}^{d_h} \sum_{j=1}^{q_{hi}} m_{hij} . \tag{A3.3}$$

The variance of CPUE by stratum was estimated as:

$$\hat{V}\left[\overline{\mathrm{CPUE}}_h\right] = \frac{\sum_{i=1}^{d_h} \sum_{j=1}^{q_{hi}} \sum_{l=1}^{m_{hij}} \left(\mathrm{CPUE}_{hijl} - \overline{\mathrm{CPUE}}_h\right)^2}{m_h\left(m_h - 1\right)} . \tag{A3.4}$$

**Appendix A4.-Equations used to estimate, by species, the distributions of angler catch and harvest, and the contributions to harvest of each successive fish in the angler s creel, for the lower Naknek River 1995.**

## Distributions of Angler Catches and Harvests

The distribution of angler catches is defined as the proportions $p_g$ of angler-trips in which g or more fish were caught, from g = 1 to the maximum number of fish caught by any one angler ($g_{max}$). Additionally, $p_0$ is defined as the proportion of angler-trips with a catch of zero fish (by species). These proportions and their variances were calculated, by stratum, from completed-trip interviews only as:

$$\hat{p}_{gh} = \frac{\sum_{i=1}^{d_h} \sum_{j=1}^{q_{hi}} y_{ghij}}{m_h} \tag{A4.1}$$

$$\hat{V}\left[\hat{p}_{gh}\right] = \frac{\hat{p}_{gh}\left(1-\hat{p}_{gh}\right)}{m_h - 1}, \tag{A4.2}$$

where $y_{ghij}$ is the number of interviewed completed-trip anglers in each sample period whose catch puts them into category g (for example $y_{ghij}$ for the estimate of $p_{3h}$ would be the number of anglers interviewed that caught three or more fish during period j of day i of stratum h), and $m_h$ is the total number of completed-trip interviews within each stratum, calculated as:

$$m_h = \sum_{i=1}^{d_h} \sum_{j=1}^{q_{hi}} m_{hij}, \tag{A4.3}$$

where $m_{hij}$ equals the number of completed-trip interviews within each sample.

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The distributions of angler catches for the entire season (across all temporal components) were estimated by taking the weighted average of within-stratum estimates, with the weights being the estimated proportion of all angler-trips which occurred in each stratum. The proportions of angler-trips yielding a catch of g or more fish, and their variances, were estimated as:

$$\hat{p}_g = \sum_{h=1}^{L} \hat{W}_h \hat{p}_{gh} \tag{A4.4}$$

$$\hat{V}\left[\hat{p}_g\right] \approx \sum_{h=1}^{L}\left[\hat{W}_{Mh}^2 \hat{V}\left(\hat{p}_{gh}\right) + \hat{p}_{gh}^2 \hat{V}\left(\hat{W}_{Mh}\right) - \hat{V}\left(\hat{W}_{Mh}\right)\hat{V}\left(\hat{p}_{gh}\right)\right], \tag{A4.5}$$

where the stratum weights and their variances were estimated as:

$$\hat{W}_{Mh} = \frac{\hat{M}_h}{\sum_{h=1}^{L} \hat{M}_h}, \tag{A4.6}$$

$$\hat{V}\left[\hat{W}_{Mh}\right] \approx \hat{W}_{Mh}^2 \left[\frac{\hat{V}\left(\hat{M}_h\right)}{\hat{M}_h^2} + \frac{\hat{V}\left(\hat{M}\right)}{\hat{M}^2} - \frac{\hat{V}\left(\hat{M}_h\right)}{\hat{M}_h \hat{M}}\right], \tag{A4.7}$$

where $\hat{M}_h$ and $\hat{V}\left(\hat{M}_h\right)$ are the estimated number of angler-trips during stratum h and its variance, defined in Appendix A1, and where

$$\hat{M} = \sum_{h=1}^{L} \hat{M}_h \text{, and} \tag{A4.8}$$

$$\hat{V}\left[\hat{M}\right] = \sum_{h=1}^{L} \hat{V}\left[\hat{M}_h\right]. \tag{A4.9}$$

The distribution of angler harvests was calculated in the same manner as that of angler catches.

$$\hat{q}_{gh} = \hat{p}_{gh} - \hat{p}_{(g+1)h} = \frac{\sum_{i=1}^{d_h} \sum_{j=1}^{q_{hi}} y_{ghij}}{m_h} \tag{A4.10}$$

is the estimated proportion of anglers harvesting exactly g fish, $g_{max}$ is the largest observed number of fish in any angler's daily bag, and $y_{ghij}$ is the number of anglers harvesting exactly g fish during period j of day i of stratum h.

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## Contributions to Total Harvest by Each Fish in Anglers Daily Bags

The contributions to total harvest by each fish in anglers' daily bags were calculated by using the harvest distribution estimates. Harvest contribution estimates by stratum (proportion of the harvest that is due to the $g^{th}$ fish is each angler's daily bag during temporal component h) were calculated as follows:

$$\hat{s}_{gh} = \frac{\sum_{g'=g}^{g\,max} \hat{q}_{g'h}}{\sum_{g'=1}^{g\,max} g' \cdot q_{g'h}} \tag{A4.11}$$

where the variance of $\hat{s}_{gh}$ is calculated approximately (Delta method) by:

$$\begin{aligned}\hat{V}\left[\hat{s}_{gh}\right] \approx{}& \frac{1}{\overline{H}_h'^4}\sum_{g'=1}^{g-1}\left\{\left(g'\sum_{g''=g'}^{g\,max}\hat{q}_{g''h}\right)^2 V\left[\hat{q}_{g'h}\right]\right\} + \frac{1}{\overline{H}_h'^4}\sum_{g'=g}^{g\,max}\left\{\left(\overline{H}_h' - g'\sum_{g''=g'}^{g\,max}\hat{q}_{g''h}\right)^2 V\left[\hat{q}_{g'h}\right]\right\} \\ &+ \frac{2}{\overline{H}_h'^4}\sum_{g'=1}^{g-1}\sum_{g''=g'+1}^{g\,max}\left\{\left(g'\sum_{g'''=g'}^{g\,max}\hat{q}_{g'''h}\right)\left(g''\sum_{g'''=g''}^{g\,max}\hat{q}_{g'''h}\right)\mathrm{cov}\left[\hat{q}_{g'h}\hat{q}_{g''h}\right]\right\} \\ &+ \frac{2}{\overline{H}_h'^4}\sum_{g'=g}^{g\,max}\sum_{g''=g'+1}^{g\,max}\left\{\left(\overline{H}_h' - g'\sum_{g'''=g'}^{g\,max}\hat{q}_{g'''h}\right)\left(\overline{H}_h' - g''\sum_{g'''=g''}^{g\,max}\hat{q}_{g'''h}\right)\mathrm{cov}\left[\hat{q}_{g'h}\hat{q}_{g''h}\right]\right\}\end{aligned} \tag{A4.12}$$

where:

$$\overline{H}_h' = \sum_{g=1}^{g\,max} g \cdot \hat{q}_{gh}\,, \tag{A4.13}$$

$$\hat{V}\left[\hat{q}_{gh}\right] = \frac{\hat{q}_{gh}(1-\hat{q}_{gh})}{m_h},\ \text{and} \tag{A4.14}$$

$$\mathrm{cov}\left[\hat{q}_{g'h}\hat{q}_{g''h}\right] = \frac{-\hat{q}_{g'h}\hat{q}_{g''h}}{m_h}. \tag{A4.15}$$

-continued-

The contributions to harvest for the entire season (across all temporal components) were estimated by taking the weighted average of within-stratum estimates:

$$\hat{s}_g = \sum_{h=1}^{L} \hat{W}_{Hh} \hat{s}_{gh} \tag{A4.16}$$

$$\hat{V}\left[\hat{s}_g\right] \approx \sum_{h=1}^{L} \left[ \hat{W}_{Hh}^2 \hat{V}\left(\hat{s}_{gh}\right) + \hat{s}_{gh}^2 \hat{V}\left(\hat{W}_{Hh}\right) - \hat{V}\left(\hat{W}_{Hh}\right)\hat{V}\left(\hat{s}_{gh}\right) \right], \tag{A4.17}$$

where the weights were estimated proportions of total harvest by stratum:

$$\hat{W}_{Hh} = \frac{\hat{H}_h}{\sum_{h=1}^{L} \hat{H}_h}, \tag{A4.18}$$

$$\hat{V}\left[\hat{W}_{Hh}\right] \approx \hat{W}_{Hh}^2 \left[ \frac{\hat{V}\left(\hat{H}_h\right)}{\hat{H}_h^2} + \frac{\hat{V}\left(\hat{H}\right)}{\hat{H}^2} - \frac{\hat{V}\left(\hat{H}_h\right)}{\hat{H}_h \hat{H}} \right], \tag{A4.19}$$

where $\hat{H}_h$, $\hat{H}$, $\hat{V}\left(\hat{H}_h\right)$, and $\hat{V}\left(\hat{H}\right)$ are harvest statistics defined in Appendix A2.

# APPENDIX B. ANGLER COUNT DATA

**Appendix B1.-Angler counts by period during the survey on the lower Naknek River, 1 June through 31 August 1995.**

| Date | TC[a] | Period | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A, 0630-1029 | | | | B, 1030-1429 | | | | C, 1430-1829 | | | | D, 1830-2230 | | | |
| 6/1/95 | 1 | | | | | | | | | | | | | | | | |
| 6/2/95 | | 5 | | | | 4 | | | | | | | | | | | |
| 6/3/95 | | 4 | 10 | 14 | 21 | | | | | | | | | 38 | 52 | 48 | 35 |
| 6/4/95 | | | | | | | | | | | | | | | | | |
| 6/5/95 | | | | | | | | | | | | | | | | | |
| 6/6/95 | | | | | | | | | | | | | | | | | |
| 6/7/95 | | 0 | | | | 2 | | | | | | | | | | | |
| 6/8/95 | | | | | | 5 | | | | 1 | | | | | | | |
| 6/9/95 | | 0 | | | | | | | | 11 | | | | | | | |
| 6/10/95 | | | | | | 17 | | | | 15 | | | | | | | |
| 6/11/95 | | | | | | | | | | | | | | | | | |
| 6/12/95 | | | | | | | | | | | | | | | | | |
| 6/13/95 | | | | | | 9 | | | | 0 | | | | | | | |
| 6/14/95 | | | | | | | | | | | | | | | | | |
| 6/15/95 | | 1 | 1 | 1 | 3 | | | | | | | | | 17 | 21 | 24 | 20 |
| 6/16/95 | | | | | | 28 | | | | 11 | | | | | | | |
| 6/17/95 | | | | | | | | | | | | | | | | | |
| 6/18/95 | | 8 | | | | 33 | | | | | | | | | | | |
| 6/19/95 | | | | | | | | | | 40 | 47 | 38 | 20 | 14 | 20 | 17 | 14 |
| 6/20/95 | | | | | | | | | | | | | | | | | |
| 6/21/95 | | | | | | 22 | | | | 37 | | | | | | | |
| 6/22/95 | 2 | 10 | 20 | 42 | 52 | 41 | 26 | 15 | 21 | | | | | | | | |
| 6/23/95 | | | | | | 30 | | | | | | | | 35 | | | |
| 6/24/95 | | | | | | 81 | 78 | 35 | 38 | 50 | 76 | 58 | 51 | | | | |
| 6/25/95 | | | | | | | | | | | | | | | | | |
| 6/26/95 | | | | | | | | | | | | | | | | | |
| 6/27/95 | | | | | | 46 | | | | | | | | 33 | | | |
| 6/28/95 | | 19 | | | | | | | | 44 | | | | | | | |
| 6/29/95 | | 15 | 40 | 78 | 89 | | | | | | | | | 40 | 30 | 26 | 9 |
| 6/30/95 | | | | | | | | | | 40 | | | | 23 | | | |
| 7/1/95 | 3 | | | | | | | | | | | | | | | | |
| 7/2/95 | | 8 | 8 | 50 | 95 | | | | | | | | | 62 | 39 | 37 | 26 |
| 7/3/95 | | 41 | | | | 59 | | | | | | | | | | | |
| 7/4/95 | | | | | | | | | | 79 | | | | 19 | | | |
| 7/5/95 | | 19 | 24 | 42 | 41 | | | | | | | | | 25 | 23 | 25 | 22 |
| 7/6/95 | | | | | | | | | | | | | | | | | |
| 7/7/95 | | 17 | 46 | 51 | 71 | | | | | | | | | 18 | 19 | 32 | 37 |
| 7/8/95 | 4 | | | | | | | | | | | | | | | | |
| 7/9/95 | | | | | | 92 | 85 | 48 | 79 | 70 | 61 | 65 | 31 | | | | |
| 7/10/95 | | | | | | 84 | | | | | | | | 35 | | | |
| 7/11/95 | | | | | | | | | | | | | | | | | |
| 7/12/95 | | | | | | 74 | 47 | 53 | 74 | | | | | 35 | 42 | 31 | 17 |
| 7/13/95 | | | | | | | | | | 92 | 62 | 51 | 49 | 43 | 27 | 43 | 22 |
| 7/14/95 | | 25 | | | | | | | | 50 | | | | | | | |

-continued-

**Appendix B1.-Page 2 of 2.**

| Date | TC[a] | Period A, 0630-1029 | | | | B, 1030-1429 | | | | C, 1430-1829 | | | | D, 1830-2230 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/15/95 | 5 | | | | | | | | | | | | | | | | |
| 7/16/95 | | 24 | | | | | | | | | | | | 61 | | | |
| 7/17/95 | | 9 | 14 | 10 | 4 | | | | | | | | | | | | |
| 7/18/95 | | 16 | 26 | 12 | 24 | 29 | 41 | 43 | 35 | | | | | 23 | 26 | 27 | 17 |
| 7/19/95 | | | | | | 28 | 35 | 35 | 39 | 49 | 34 | 28 | 13 | | | | |
| 7/20/95 | | | | | | | | | | | | | | | | | |
| 7/21/95 | | | | | | 14 | | | | | | | | 8 | | | |
| 7/22/95 | 6 | | | | | | | | | 45 | 35 | 26 | 31 | 23 | 21 | 27 | 8 |
| 7/23/95 | | | | | | | | | | 51 | 59 | 40 | 32 | 35 | 33 | 30 | 16 |
| 7/24/95 | | 46 | | | | 16 | | | | | | | | | | | |
| 7/25/95 | | | | | | | | | | | | | | | | | |
| 7/26/95 | | 21 | | | | | | | | 26 | | | | | | | |
| 7/27/95 | | | | | | | | | | | | | | | | | |
| 7/28/95 | | 32 | | | | | | | | 29 | | | | | | | |
| 7/29/95 | | 1 | | | | | | | | | | | | 8 | | | |
| 7/30/95 | | | | | | 41 | 41 | 25 | 37 | | | | | 26 | 4 | M[b] | M[b] |
| 7/31/95 | | | | | | | | | | | | | | | | | |

| Date | TC[a] | Period A, 0800-1159 | | | | B, 1200-1559 | | | | C, 1600-1959 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/1/95 | 7 | 11 | 21 | 18 | 21 | | | | | 16 | 2 | 5 | 9 |
| 8/2/95 | | | | | | 1 | | | | 22 | | | |
| 8/3/95 | | | | | | | | | | | | | |
| 8/4/95 | | | | | | 19 | 17 | 24 | 20 | 16 | 15 | 6 | 8 |
| 8/5/95 | | 22 | 37 | 26 | 18 | | | | | 37 | 27 | 30 | 12 |
| 8/6/95 | | 37 | | | | 47 | | | | | | | |
| 8/7/95 | | | | | | | | | | | | | |
| 8/8/95 | 8 | | | | | | | | | | | | |
| 8/9/95 | | | | | | | | | | | | | |
| 8/10/95 | | 30 | 39 | 51 | 40 | 33 | 42 | 49 | M[b] | | | | |
| 8/11/95 | | 37 | | | | 20 | | | | | | | |
| 8/12/95 | | 47 | 46 | 48 | 41 | 16 | 54 | M[b] | M[b] | | | | |
| 8/13/95 | | 53 | | | | | | | | 20 | | | |
| 8/14/95 | | 42 | 45 | 59 | 33 | 27 | 19 | 67 | 60 | | | | |
| 8/15/95 | 9 | 44 | 49 | 54 | 37 | | | | | 29 | 49 | 24 | 49 |
| 8/16/95 | | | | | | 37 | | | | 28 | | | |
| 8/17/95 | | | | | | 35 | | | | 33 | | | |
| 8/18/95 | | | | | | | | | | | | | |
| 8/19/95 | | | | | | | | | | | | | |
| 8/20/95 | | 50 | 60 | 57 | 42 | | | | | 30 | 31 | 9 | 13 |
| 8/21/95 | | | | | | 18 | 24 | 25 | 27 | 17 | 16 | 6 | 6 |
| 8/22/95 | 10 | 20 | 19 | 34 | 31 | 27 | 21 | 11 | 13 | 18 | 15 | 10 | 11 |
| 8/23/95 | | 28 | 32 | 34 | 37 | | | | | | | | |
| 8/24/95 | | 40 | | | | | | | | 11 | | | |
| 8/25/95 | | 24 | | | | M[b] | M[b] | M[b] | M[b] | | | | |
| 8/26/95 | | | | | | | | | | | | | |
| 8/27/95 | | 4 | 9 | 9 | 8 | | | | | 13 | 17 | 2 | 4 |
| 8/28/95 | | | | | | | | | | | | | |
| 8/29/95 | | 16 | | | | 6 | | | | | | | |
| 8/30/95 | | | | | | | | | | 24 | | | |
| 8/31/95 | | 31 | | | | | | | | | | | |

[a] Temporal component.

[b] Count missed.

# APPENDIX C. CATCH AND HARVEST OF INCIDENTAL SPECIES

**Appendix C1.-Estimated catch and harvest of chum salmon by the sport fishery in the lower Naknek River, 1 June through 31 August 1995.**

| Temporal Component and Date | Catch[a] | | | | | Harvest | | | | | Percent of Catch Harvested |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 90% Confidence Interval | | | | | 90% Confidence Interval | | | |
| | Estimate | SE | Lower | Upper | RP[b] | Estimate | SE | Lower | Upper | RP[b] | |
| 1 (01-21 June) | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | | |
| 2 (22-30 June) | 61 | 26 | 18 | 104 | 70% | 26 | 11 | 8 | 44 | 70% | 43% |
| 3 (01-07 July) | 23 | 10 | 7 | 39 | 72% | 11 | 5 | 3 | 19 | 75% | 48% |
| 4 (08-14 July) | 29 | 15 | 4 | 54 | 85% | 12 | 8 | 0 | 25 | 110% | 41% |
| 5 (15-21 July) | 0 | 0 | 0 | 0 | | 0 | 0 | | | | |
| 6 (22-31 July) | 11 | 6 | 1 | 21 | 90% | 11 | 6 | 1 | 21 | 90% | 100% |
| 7 (01-07 August) | 47 | 17 | 19 | 75 | 60% | 26 | 12 | 6 | 46 | 76% | 55% |
| 8 (08-14 August) | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | | |
| 9 (15-21 August) | 10 | 10 | 0 | 27 | 165% | 0 | 0 | 0 | 0 | | 0% |
| 10 (22-31 August) | 6 | 6 | 0 | 16 | 165% | 0 | 0 | 0 | 0 | | 0% |
| Season Total | 188 | 39 | 124 | 252 | 34% | 87 | 20 | 54 | 120 | 38% | 46% |

[a] Catch = total fish kept + total fish released.

[b] Relative precision of the 90% confidence interval.

**Appendix C2.-Estimated catch and harvest of rainbow trout by the sport fishery in the lower Naknek River, 1 June through 31 August 1995.**

| Temporal Component and Date | Catch[a] | | | | | Harvest | | | | | Percent of Catch Harvested |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 90% Confidence Interval | | | | | 90% Confidence Interval | | | |
| | Estimate | SE | Lower | Upper | RP[b] | Estimate | SE | Lower | Upper | RP[b] | |
| 1 (01-21 June) | 210 | 63 | 106 | 314 | 49% | 31 | 14 | 8 | 54 | 74% | 15% |
| 2 (22-30 June) | 16 | 11 | 0 | 34 | 113% | 2 | 2 | 0 | 5 | 165% | 13% |
| 3 (01-07 July) | 54 | 30 | 5 | 103 | 91% | 4 | 3 | 0 | 9 | 123% | 7% |
| 4 (08-14 July) | 18 | 8 | 5 | 31 | 73% | 7 | 5 | 0 | 15 | 118% | 39% |
| 5 (15-21 July) | 48 | 37 | 0 | 109 | 127% | 0 | 0 | 0 | 0 | | 0% |
| 6 (22-31 July) | 62 | 21 | 27 | 97 | 56% | 10 | 8 | 0 | 23 | 132% | 16% |
| 7 (01-07 August) | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | | |
| 8 (08-14 August) | 18 | 19 | 0 | 49 | 174% | 0 | 0 | 0 | 0 | | 0% |
| 9 (15-21 August) | 5 | 5 | 0 | 13 | 165% | 0 | 0 | 0 | 0 | | 0% |
| 10 (22-31 August) | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | | |
| Season Total | 431 | 85 | 291 | 571 | 32% | 54 | 17 | 26 | 82 | 52% | 13% |

[a] Catch = total fish kept + total fish released.

[b] Relative precision of the 90% confidence interval.

# APPENDIX D. LIST OF DATA FILES AND PROGRAMS USED

**Appendix D1.-Data files and computer programs used to produce this report.**

Data Files

Angler count data:

| | |
|---|---|
| R007ACA5.DTA | Angler counts 6/1/95 to 6/21/95 |
| R007ACB5.DTA | Angler counts 6/22/95 to 6/30/95 |
| R007ACC5.DTA | Angler counts 7/1/95 to 7/7/95 |
| R007ACD5.DTA | Angler counts 7/8/95 to 7/14/95 |
| R007ACE5.DTA | Angler counts 7/15/95 to 7/21/95 |
| R007ACF5.DTA | Angler counts 7/22/95 to 7/31/95 |
| R007ACG5.DTA | Angler counts 8/1/95 to 8/7/95 |
| R007ACH5.DTA | Angler counts 8/8/95 to 8/14/95 |
| R007ACI5.DTA | Angler counts 8/15/95 to 8/21/95 |
| R007ACJ5.DTA | Angler counts 8/22/95 to 8/31/95 |
| R007ACX5.DTA | Merged angler counts (above) used for analysis 6/1/95 to 8/31/95. |

Angler interview data:

| | |
|---|---|
| R007AIA5.DTA | Angler interviews 6/1/95 to 6/21/95 |
| R007AIB5.DTA | Angler interviews 6/22/95 to 6/30/95 |
| R007AIC5.DTA | Angler interviews 7/1/95 to 7/7/95 |
| R007AID5.DTA | Angler interviews 7/8/95 to 7/14/95 |
| R007AIE5.DTA | Angler interviews 7/15/95 to 7/21/95 |
| R007AIF5.DTA | Angler interviews 7/22/95 to 7/31/95 |
| R007AIG5.DTA | Angler interviews 8/1/95 to 8/7/95 |
| R007AIH5.DTA | Angler interviews 8/8/95 to 8/14/95 |
| R007AII5.DTA | Angler interviews 8/15/95 to 8/21/95 |
| R007AIJ5.DTA | Angler interviews 8/22/95 to 8/31/95 |
| R007AIX5.DTA | Merged angler interviews (above) used for analysis of whole season 6/1/95 to 8/31/95. |
| R007AIK5.DTA | Merged angler interviews (above) used for analysis of chinook salmon fishery 6/1/95 through 7/31/95. |
| R007AIS5.DTA | Merged angler interviews (above) used for analysis of coho salmon fishery 7/22/95 through 8/31/95. |

Biological data:

| | |
|---|---|
| R007ABA5.DTA | Naknek River sport harvested coho salmon. |
| R007ABB5.DTA | Naknek River sport harvested chinook salmon. |

Analysis Programs

| | |
|---|---|
| CC91 | A series of programs which sort raw data files and produce frequency reports and assist data editing. The programs also summarize some of the raw data. |
| BBXPEXE | A series of programs that use data files in standard Age, Weight, Length format to produce tables of mean lengths and weights by sex and age group. |
| DOINT90 | A set of Dbase® programs that reformats standard angler interview data files into a single row of data for each interview. |