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Annual Report

2003 Skagit River
Wild 0+ Chinook Production Evaluation

Funded by Seattle City Light

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Acknowledgements

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We appreciate the contributions of a number of individuals who provided logistical support: Sherman and Pat Courier, adjacent property owners, for providing drinking water and utility access at the site, and over-winter trap storage; and Burlington Northern continued to allow us to anchor the trap barges to their railroad bridge.

The success of this project relies on the hard work of a number of dedicated permanent and temporary WDFW personnel. Scientific Technicians Mat Gillum, Jim Repoz, Dean Toba and Scott McGrath worked long hours operating and maintaining the traps, and enumerating and sampling catches. Unit biologists Mike Ackley and Pete Topping provided valuable logistical support during trap installation and removal, and Mark Hino developed the computer database which helped analyze much of the trap data contained in this report.

Executive Summary

Skagit River chinook returns (spring and summer/fall combined) have steadily declined over the last fifty years. In 1999, Puget Sound chinook salmon were listed as threatened under the Endangered Species Act. To address this poor stock status, resource managers formed the multi-agency Skagit River Chinook work group in 1995. A major goal of this work group is to determine the factors which limit chinook production. In addition to assessing habitat and adult returns, monitoring juvenile production was initiated as it directly measures freshwater survival. Evaluating the biological attributes of outmigration timing and size contributes to our understanding of chinook freshwater life history. This information is useful for flow management, habitat protection and restoration, and designing hatchery programs to minimize adverse interactions.

In 1990, WDFW initiated downstream migrant trapping in the Skagit River system at Burlington. Although this project was originally directed at assessing coho smolt production (April through June), we identified and enumerated all fish captured. In 1991, through a fisheries settlement agreement with state, federal and tribal agencies, Seattle City Light (operators of several dams on the Skagit River) created the Skagit Non-Flow Plan Coordinating Committee (NCC). Beginning in 1997, this program provided funding to expand our downstream migrant trapping project in the Skagit River to also estimate chinook production (January through July). This report documents our investigations in Spring 2003, the fourteenth year that we have measured downstream migrants from the Skagit River.

We operated two trap types – a floating inclined-plane screen trap (scoop trap) and a screw trap – from January 15 through July 30. The traps were fished every night and every third day unless flows and associated debris loads were excessive. To calibrate trap efficiency, we marked and released five chinook groups (four wild and one hatchery) above the trap. Recovery rates for the four wild groups released in February through April were lower (1.7%) than the single hatchery group released on May 8 (3.6%). Combined, these groups' average is nearly identical to the long-term trap efficiency rate of 2.0%. This is the mean capture rate of 25 zero-age chinook calibration groups that we released upstream of the mainstem traps from 1998 through 2003.

Over the season we captured 51,316 and 34,498 chinook in the scoop and screw traps, respectively. The months of January, February, March, and April accounted for 84% of the season total migration, with about 50% of the chinook outmigrants passing the mainstem traps by March 15. Expanding catches for the intervals not fished estimates an additional 15,463 and 10,058 wild 0+ chinook would have been captured in the scoop and screw traps, respectively. Combining these projected catches with the actual catches estimates 111,335 wild 0+ chinook would have been caught in the two traps had we fished continuously from January 15 through July 30. Expansion of the projected season catch in both traps by the average trap efficiency rate yields a system production estimate of approximately 5.5-million zero-age wild chinook. Average survival-to-migration is estimated at 10.8%. This estimate is based on a potential deposition of 51.1 million eggs (9,295 females and an average fecundity of 5,500 eggs/female) for the 2002 brood.

Over the previous thirteen seasons, flow during egg incubation has explained most of the inter-annual variation in our estimates of egg-to-migrant survival rates. The production in 2003 is somewhat lower than predicted by this relationship, which may indicate other factors at work. One explanation

for this lower-than-predicted survival may be the effects of the high spawning population in 2002. This return, estimated at 20,656 adults, is the highest from which we have estimated production in this system. Continued monitoring of juvenile production including broods with even higher spawning populations and additional flow analyses will further define the constraints to chinook production from the Skagit River.

In addition to wild chinook, we caught a total of 3,644 ad-marked and coded-wire tagged hatchery 0+ chinook in the mainstem traps. We estimate that, had the trap fished continuously, we would have caught an additional 357 fish. The projected total catch of 4,001 hatchery chinook includes 118 fall 0+ chinook (released at Baker River), 1,883 summer 0+ chinook (released at Countyline Ponds) and 2,000 spring 0+ chinook (released at Skagit Hatchery). Application of the average trap efficiency to the projected season catch yields a combined estimate of 197,000 zero-age hatchery chinook. Relating this estimate to the 486,500 hatchery chinook released estimates in-river survival above Mt. Vernon at 40%.

Introduction

Skagit River chinook returns (spring and summer/fall combined) have steadily declined over the last fifty years (PSSSRG 1992, 1997). In 1994, the Joint Chinook Technical Committee of the Pacific Salmon Commission designated the status of these stocks as "Not Rebuilding." To address this poor stock status, resource managers formed the Skagit River Chinook work group in 1995. Composed of state, tribal, and federal fish biologists, this group recommends and coordinates restoration and monitoring programs. A major goal of this work group is to determine the limiting factors for chinook. Necessary data for this purpose include an indicator-stock tagging program, habitat inventory, annual adult escapement estimation, and wild juvenile chinook assessment. The juvenile production evaluation is a vital link in this process because it provides a direct measure of freshwater survival.

Seattle City Light (operators of several dams on the Skagit River), through a 1991 fisheries settlement agreement with WDFW, the Skagit tribes (Skagit System Cooperative or SSC) and federal agencies – National Marine Fisheries Service (NMFS), US Fish & Wildlife Service (USFWS), US Forest Service (USFS) and National Park Service (NPS) – created the Skagit Non-Flow Plan Coordinating Committee (NCC). The NCC is responsible for funding several non-flow fisheries programs including the "Chinook Research Program." Beginning in 1997, this program provided funding to conduct chinook studies. This report documents our 2003 downstream migrant trapping project in the Skagit River which, with funding from the NCC, we expanded to continue estimating wild 0+ chinook production.

Understanding the major sources of inter-annual variation in run size is critical to improving harvest and habitat management. Quantifying anadromous salmonid populations as seaward migrants near saltwater entry is the most direct assessment of stock performance in freshwater because the variation resulting from marine survival and harvest are precluded. Relating smolt production to adult spawners over a number of broods empirically determines the watershed's natural production potential (provided escapement and environmental conditions are sufficient), its stock/recruit function if escapements are less than that required to achieve maximum production, and enables identification of the major density-independent source(s) of inter-annual variation in freshwater survival. To accomplish these and other fish management objectives, the WDFW implemented a long-term research program directed at measuring wild salmon production in terms of smolts and adults in selected watersheds, beginning in 1976 (Seiler *et al.*1981). In 1981, this program, which was directed primarily at coho salmon, was expanded to include additional large watersheds (Seiler *et al.*1984).

In 1990, we initiated downstream migrant trapping in the Skagit River system to quantify wild coho smolt production to, among other objectives, resolve a discrepancy in escapement estimates (Conrad *et al.* 1997). This program, which in 2003 was in its fourteenth year, involves trapping and marking wild coho smolts emigrating from a lower river tributary, Mannser Creek (R.M. 35), and sampling a portion of the entire population via floating traps in the lower mainstem (R.M. 17, Burlington Northern railroad bridge).

In past years we evaluated returns of coho adults coded-wire tagged as smolts at the downstream-migrant trap in Baker Lake. The upstream migrant trap below the dam provided a reliable accounting of all salmon returning to this system. Applying the marine survival estimated from the tag-based

estimates of harvest and escapement to respective estimates of total system wild coho smolt production yielded estimates of adult recruits, escapement, and harvest for the entire Skagit River system (Seiler *et al.*1995). Technical support for this program was eliminated in 2000 and 2001, suspending this portion of the Skagit coho production and survival evaluation. This work resumed in 2002.

Although our trapping in the mainstem was originally directed at coho smolts, we identify and enumerate all fish captured. For the first seven years of this study (1990-1996), season total 0+ chinook catches in the one scoop trap varied six-fold, from 1,700 to 10,500 chinook. (As of 1993, we have simultaneously operated both a scoop and a screw trap.) In addition to abundance, these catch totals are influenced by fishing effort (the time fished on each date and for the season), migration timing relative to the interval we trapped, and instantaneous trap efficiency. Many such variables as discharge, water velocity, turbidity, debris, channel configuration, trap placement, and fish size combine to affect both instantaneous and season average trap efficiency.

Preliminary expansion of these 0+ chinook catches, based on the season average recapture rates of wild coho and several other assumptions held consistent between years, has yielded annual chinook production estimates that range from 0.5 to 6.5 million. The accuracy and precision of these estimates is presently incalculable because the assumptions remain unverified. We believe, however, that these estimates reflect the abundance of wild 0+ chinook production from these broods, at least in a relative sense. We base this contention upon the significant negative correlation between the freshwater survival estimates and the severity of flow during the period that the eggs were incubating in the gravel. The survival rates in this relationship are the ratio of total 0+ chinook emigrants estimated past the traps to the potential egg deposition. System total egg deposition is simply the product of the estimated total adult chinook escapement, an assumed sex ratio, and a fecundity of 5,500 eggs/female (Pete Castle pers. comm.). This relationship indicates that overall egg-to-migrant survival for Skagit River chinook has varied over ten-fold within just the first seven broods, almost entirely as a function of flow during egg incubation.

In 1997, we began trapping in mid-February and continued into September. This first season of extended trapping produced our first insight into the migration timing of wild chinook. Over the season, we estimated a total of 2.4 million 0+ chinook, of which about one third emigrated before April.

Measuring the biological attributes of outmigration timing and size contributes to our understanding of juvenile chinook freshwater life history. This information is useful for flow management (dams and other flow controls), habitat protection, and designing hatchery programs to minimize hatchery/wild interactions.

We estimate coho smolt production from the Skagit River with the mark and recapture strategy that we developed and have used successfully in a number of large watersheds throughout the state over many years. This method involves the following components:

1. Trapping all the wild coho smolts emigrating from a selected tributary;
2. Identifying each of these smolts with an external mark; and
3. Capturing a portion of the smolt population migrating through the lower mainstem and examining each fish for the mark.

This design produces relatively precise and (we believe) unbiased production estimates, because a temporally- representative portion of the coho population is marked via 100% trapping at an upstream tributary. Therefore, trapping in the mainstem does not have to be continuous or even representative with respect to timing (Seber 1982). We explicitly developed this design to avoid the requirement of estimating gear efficiency.

Because of the early life history characteristics of chinook in freshwater, estimating their smolt production with the same statistical precision we achieve for coho smolts is not possible. Chinook originate in discrete portions of the mainstem, and subsequently rear for variable intervals in various reaches. Therefore, the methodology we use with coho, capturing and identifying a representative portion of the entire population, is not feasible for chinook. Each component likely has different survival patterns that result from the complex interactions of a number of factors: their parent's spawning timing and distribution; genetically-programmed juvenile rearing strategies; and the flow and habitat conditions each brood and sub-population within it encounters. In a system as wide as the lower Skagit River, the migration pathways selected may also vary between sub-populations, which would affect capture rates. The susceptibility of migrants to capture also varies as a function of flow and environmental conditions in effect at the trap and upstream of it.

Sources of Variation Affecting Wild 0+ Chinook Estimates

Given the foregoing problems, estimating wild juvenile 0+ chinook production from the trapping data we have collected in the lower Skagit River involves a number of assumptions. Accuracy of the production estimates is a direct function of the veracity of these assumptions. Each assumption deals with the uncertainty resulting from the following five major sources of variation we have identified.

1. **Trap efficiency**. Expanding catches to estimate wild 0+ chinook production requires estimates of instantaneous gear efficiency, ideally as a function of some measurable variable such as flow.

2. **Day vs. night trap efficiency**. Trap efficiency may be influenced by light. For example, it may be lower during the daylight than at night.

   We have operated the traps primarily at night because catch rates, especially for coho and to a lesser extent chinook, are higher at night than during the daylight. Estimating instantaneous trap efficiency during the daylight hours, however, is probably not possible because it would require that a sufficient and known number of marked wild chinook to pass the traps within a single daylight period. The traps fish only the top 4 ft of the water column, and the depth at our site is 20-30 ft, depending on discharge. If, as a function of increasing light intensity, juvenile chinook migrate at greater depth and/or their ability to avoid the trap increases, then trap efficiency during daylight hours would be lower. The behavior of juvenile chinook and the biases imposed by releasing marked fish immediately upstream of the traps precludes estimating instantaneous efficiency within such a limited time interval as a single daylight period. Catches during daylight hours appear to be positively affected by increasing turbidity. If true, this positive correlation between daytime catch and turbidity results from either increased migration rate and/or an increase in trap efficiency because avoidance is reduced.

3. **Day vs. night migration**. Efficiency-based estimates rely on trapping either continuously or randomly throughout the time strata that migration is estimated. We developed our experimental design for estimating coho production to avoid the requirement of continuous

trapping in the mainstem. Therefore, trapping in the early years was conducted almost entirely at night.

4. **Migration interval**. Skagit River 0+ chinook emigrate over a longer season than coho smolts. Chinook begin their downstream migration in January or earlier, and continue through the summer. In the first four years, we operated the traps only over the coho smolt migration period, early-April through mid-June. Beginning in 1994, and continuing through 1996, we extended trapping as late as mid-July. In 1997, we began trapping in mid-February and continued into September. To better define the early portion of the migration period, in 1998, we began trapping in mid-January and extended trapping into September. In 1999 and 2000 we assessed late migration by operating the traps intermittently during October.

5. **Incidence of hatchery-produced fish**. Prior to 1994, releases of hatchery-produced 0+ chinook in the Skagit River were unmarked. Consequently, our estimates of wild chinook production for the first four years rely on an assumption for the number of hatchery-produced fingerlings we caught. Estimating wild and hatchery components of the migration relies on assumptions of how many hatchery fish survived to pass the trap during the interval trapped. Beginning with the 1993 brood, (released in 1994) all hatchery-produced zero-age chinook released into the Skagit River have been marked with an adipose fin-clip (ad-mark) and coded-wire tagged.

Study Plan for 2003

The study plan for the 2003 trapping season was directed at continuing to improve the estimates of Skagit River chinook production through achieving a better understanding of the sources of variation. In addition to continuing our analysis of the chinook and coho trapping data collected over the previous twelve years, the 2003 work plan included the following six operational elements.

1. **Trapping season**. A critical uncertainty in estimating Skagit River wild 0+ chinook production is their emigration timing. In 2003 we began trapping in mid-January and continued through July. Migration was in progress at a low level when trapping began and was essentially over in mid-July.

2. **Nightly trap operation**. We fished the scoop and screw traps nightly throughout the season, unless high flows, debris or damaged gear prevented trap operation.

3. **Daytime trap operation**. Daytime trapping occurred every third day. We enumerated catches shortly after dawn and around dusk to enable us to separate day and night catches.

4. **Wild coho marking**. In 1999 and 2000, we assessed differences in recapture rates of wild coho trapped and marked in the upper river with those marked in the lower watershed by using different marks. Coho smolts marked and released by the NPS and the WDFW Habitat Program were identified with a left ventral fin-clip (LV-mark), as in past years. Smolts captured at Mannser Creek in the lower river were right ventral fin-clipped (RV-marked) by our trapping personnel. During the two-year evaluation we discovered significant differences in recapture rates between the two mark groups. Smolts released high in the river were recovered at lower rates than those released from Mannser Creek in the lower watershed. Inclusion of the upper-river marked smolts in the coho production calculations biased the estimate high. Therefore, we discontinued marking fish in the upper watershed in Spring

2001. Smolts that were RV-marked at Mannser Creek provided the basis for the coho smolt production estimate.

5. **Trap efficiency**. In addition to the marked wild coho released from the Mannser Creek tributary trap and the groups of ad-marked/coded-wire tagged hatchery chinook fingerlings released from the three production facilities (Countyline Ponds, Baker River and Skagit Hatchery), we marked and released four groups of wild chinook and two groups of hatchery chinook above the trap to calibrate trapping efficiency.

6. **Visibility/Turbidity**. To better understand the influence of water clarity on migration behavior, we measured visibility each day over the 1999, 2000, 2001, and 2002 spring seasons. We analyzed these measurements with turbidity data taken at the Mount Vernon water withdrawal plant and found these readings agreed with the secchi readings taken daily at the traps. We believe the turbidity data is a better indicator of water clarity, as readings are averaged daily, taken using a defined method, and are not influenced by environmental factors such as sun light, clouds, and rain. Turbidity data will be correlated with flow and fish catch data.

Methods

Trapping Gear and Operation

We use two trap types: a floating inclined-plane screen trap (scoop trap) (Seiler *et al.* 1981) and a screw trap (Busack *et al.* 1991). Both traps are contained between steel pontoon barges, outfitted with two five-ton, bow-mounted anchor winches loaded with up to 600 ft of $^{3}/_{8}$-inch aircraft cable. Overall, the scoop trap barge measures 13-ft x 44-ft, while the screw trap barge is 15-ft x 30-ft. The inclined-screen of the scoop trap is 6-ft wide, and we fish it only 3.5-ft deep to maintain an oblique angle to the flow. We have found that the angle formed by the 16 ft-long screen, set 3.5-ft deep at the entrance, precludes impinging even such small migrants as pink and chum fry, as there is sufficient sweep across the surface relative to the flow through it. At this depth, the scoop trap screens a rectangular cross-sectional area of 21-ft^2. The 8-ft diameter screw trap screens a cross-sectional area of 25-ft^2, in the shape of a semi-circle.

The traps are placed in the lower Skagit River at R.M. 17 (Figure 1). With the permission of Burlington Northern, we attach the four anchor lines to the bridge support structures. The traps are positioned side by side in the zone of highest water velocity, which is just south of the southernmost pier, approximately 70-ft from the south bank. Velocity at this site varies as a function of discharge. At low flows it averages around 5 fps, and increases to around 9 fps at high flows.

The traps were fished every night and every third day unless flows and associated debris loads were excessive. All captured fish were enumerated by species and age and examined for external marks. Samples of wild chinook, coho, steelhead, and char were measured (fork length) over the season. We used the nonparametric Kolmogorov-Smirnov (K-S) two-sample test to test the size differences between the scoop and screw trap catches, and upper river marked releases versus those recaptured in the mainstem traps. The K-S test measures differences in the entire distributions of two samples (Sokal and Rohlf 1969). We used SYSTAT 8.0 (SPSS Inc.1998) to conduct the K-S test and generate the maximum unsigned difference between the two distributions with a corresponding probability value >0.05.

Environmental Parameters

Flow is the dominant factor affecting downstream migrant trapping operations in any system. This is particularly true in the lower Skagit River due to the quantity of large woody debris this system transports during rising and high flows. We used daily mean flow data provided by the USGS gauge, located at Mount Vernon. We also measured water temperature daily and obtained turbidity data from the Anacortes water withdrawal facility in Mount Vernon, located just below the trap site at R.M.16.

Estimating Migration

Estimating migration for any period, whether over a short time interval or an entire season, requires a catch and an estimate of capture rate or trap efficiency. Catch is the product of abundance and capture rate (Equation 1). As our objective is to estimate abundance, and catch is simply a count within a time period, estimating capture rate is the primary challenge. We directed our analysis of the catch data at correlating day and night catch rates with flow and turbidity data. We evaluated the value of these correlations to project 24-hour catches of wild 0+ chinook and selected groups of

marked fish to the standard of continuous trapping. Relating the projected numbers of marked fish recovered to the numbers released provides estimates of capture rates.

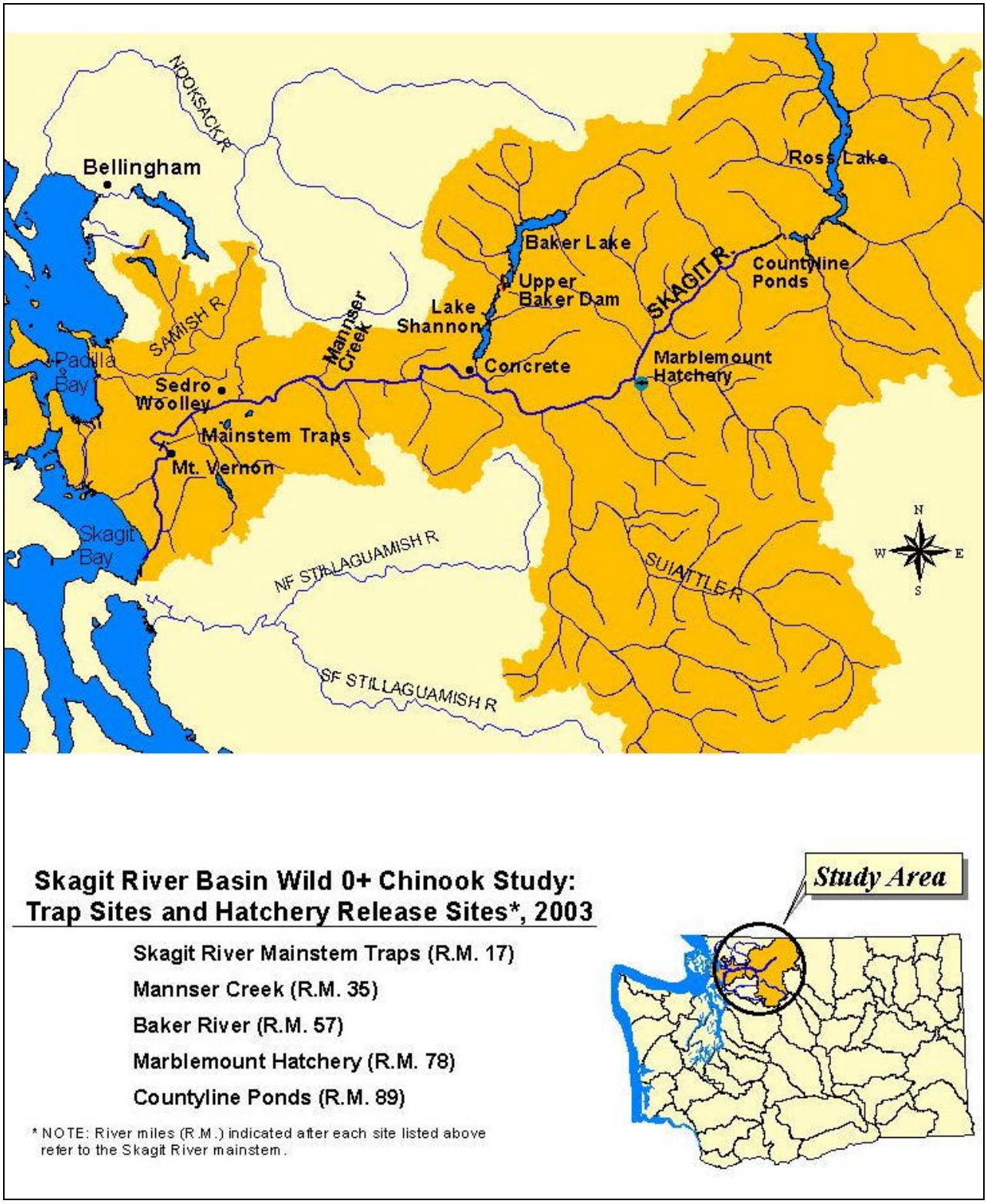

Figure 1. Map of tributary and mainstem trap sites, and hatchery release sites, Skagit River chinook production evaluation 2003.

Equation 1: Basic formulas

$$C=Me \qquad\qquad M=\frac{C}{e}$$

Where: M = *migrants;*
C = *catch; and*
e = *trap efficiency.*

To assess catch rates of wild coho smolts and wild and hatchery 0+ chinook for light and dark periods, we selected sunrise and sunset as the strata breaks. For each trap, we sorted through the trapping interval database to select daytime fishing periods that were preceded and followed by night fishing intervals. Catch rates from the nights before and after the day fished were analyzed to account for changing migration rates. Catch data were standardized by time fished in each interval and expressed as fish/hour rates. The ratio of day catch rate to night catch rate (d:n) was used to indicate relative catch rates as a function of daylight (Equation 2). We also computed season statistics for the day:night (d:n) catch ratios (Equation 3).

Equation 2: Comparing day catch rates to night catch rates

$$R_i = \frac{C_{di}}{h_{di}}\left(\frac{h_{ni-1}+h_{ni}}{C_{ni-1}+C_{ni}}\right)$$

Where: i = *24-hour period from sunrise to sunrise;*
R_i = *ratio of day to night catch rates for period i;*
C_{di} = *catch during daylight for period i;*
C_{ni-1} = *catch during the night before period i;*
C_{ni} = *catch during the night for period i;*
h_{ni-1} = *hours fished during the night before period i; and*
h_{ni} = *hours fished during the night for period i; and*
h_{di} = *hours fished during the day for period i.*

Equation 3: Season average ratio of day:night catch rates

$$\overline{R} = \frac{\sum R_i}{n}$$

Where: n = *total number of comparisons over the season.*

We expanded catch data to the standard of continuous trapping. To estimate catches for the nights that the traps did not fish, we expanded catches by the catch per hour rate using data from the nights prior to and after the trap outages. Catches during the daylight intervals that we did not fish were estimated from the d:n ratio correlations and/or the environmental parameter that best explained variation in d:n catch ratios.

Trap Efficiency

An estimate of instantaneous capture rate for both day and night intervals as a function of flow would be optimal. However, this may not be feasible with chinook for the reasons discussed above. We had three primary indicators of trap efficiency in 2003: recaptures of the wild coho marked at the

Mannser Creek trap over the season; recaptures of the six groups of marked wild and hatchery chinook that we released one mile upstream of the mainstem traps; and recoveries of the hatchery chinook fingerlings released from Skagit Hatchery, Countyline Ponds, and the Baker River. While the hatchery chinook are the same species and age, because they may behave differently than wild fish, their capture rate may not represent that of wild chinook. In addition, because the mortality and residualism of hatchery chinook between release and passing the trap is unknown, but probably significant, the resultant unadjusted estimates of capture rate are biased low. While wild coho are a different species, age, and somewhat larger size, because they are actively migrating smolts released over an extended period, their recaptures may actually represent season average trap efficiency for wild chinook better than the hatchery released chinook groups.

To project recapture rates for both hatchery chinook and the marked wild coho to the standard of continuous trapping, we expanded mark recoveries with the process described above. Recaptures of ad-marked hatchery chinook were complicated by the release of three different groups/stocks with the same external mark. Prior to the release of the summer chinook from Countyline Ponds on May 23 we systematically sacrificed a sample of ad-marked 0+ chinook over the rest of the migration to recover tags and thereby estimate catches of each group.

Egg-to-Migrant Survival

When we expanded our trapping season in 1997, we began to examine survival from egg deposition to migration based on the following equation.

Equation 4: Egg-to-migrant survival

$$\hat{S} = \frac{\hat{M}_{i+1}}{\hat{R}_{si}\hat{E}_i\hat{F}_i}$$

Where: $\hat{M}_{i+1}$ = e*stimated age-0+ chinook migration in year i+1;*

$\hat{R}_{si}$ = e*stimated proportion of females in chinook spawning population in year i;*

$\hat{E}_i$ = e*stimated chinook escapement in year i; and*

$\hat{F}_i$ = e*stimated chinook fecundity in year i.*

To estimate $\hat{R}$ and $\hat{F}$, we assumed females comprised 45% of the adult escapement, and assumed a fecundity of 5,500 eggs/female (Pete Castle, pers. comm.).

Results

Trap Operation and Flow

The traps were installed on January 15. Trapping began that night, and ended on July 30. Over this 198-day season, we operated the scoop trap every night with the exception of 13 nights. Trap operation on these nights was interrupted due to mechanical problems and/or high flows and debris. We also fished the scoop trap throughout the daytime on 56 days, usually at a frequency of every third day. In total, we fished this trap 2,658 hours out of a possible 4,693 hours, 56.6% of the total season. The screw trap fished on nearly the same schedule, although for slightly fewer hours. In total, the screw trap fished 2,651 hours, 56.5% of the total season (Table 1). From July 16 through 30 we operated the traps on a two night on and two night off basis due to low catches of chinook (less than 5 fish per night).

Flows generally remained near the 62-year mean daily stream flow throughout the year. Two notable peak-flow events occurred in February and March. During the 2003 trapping period daily averages ranged from 10,000 to 52,000 cfs (Figure 2).

Table 1. Record of Skagit River downstream migrant trap operations, all years.

Year	Gear Type	TRAPPING INTERVAL										
		Date		Season Total Days	Number of Days Fished					Hours		
					Nighttime		Daytime		Trap Out	Total	Trapped	Percent Fished
		Start	End		Full	Partial	Full	Partial				
1990	Scp/Scr	04/13	06/19	66	50	1	5	10	11	1,602.5	590.5	36.8%
1991	Scoop	04/08	06/20	73	72	1	4	18	0	1,741.5	858.0	49.3%
1992	Scoop	04/10	06/21	72	65		3	5	7	1,717.0	667.0	38.8%
1993	Scoop	04/11	06/07	57	53	2	0	8	2	1,355.5	539.5	39.8%
	Screw	04/22	06/07	46	32	0	4	5	14	1,095.0	366.5	33.5%
1994	Scoop	04/09	06/29	81	78	3	5	4	0	1,931.0	828.0	42.9%
	Screw	04/09	06/29	81	78	1	10	6	2	1,931.0	917.0	47.5%
1995	Scoop	03/25	07/15	112	112	0	5	8	0	2,724.0	1,189.0	43.6%
	Screw	03/25	07/17	114	110	2	8	8	2	2,729.5	1,207.0	44.2%
1996	Scoop	04/12	07/18	97	95	0	6	28	2	2,321.5	1,110.5	47.8%
	Screw	04/12	07/18	97	91	3	7	25	3	2,321.5	1,112.0	47.9%
1997	Scoop	02/14	09/10	208	182	9	58	53	17	4,996.0	2,719.0	54.4%
	Screw	02/14	09/10	208	174	11	56	21	23	4,996.0	2,667.0	53.4%
1998	Scoop	01/18	09/11	236	231	0	85	3	5	5,640.0	3,599.0	63.8%
	Screw	01/18	09/11	236	188	0	69	1	48	5,640.0	2,992.0	53.0%
1999	Scoop	01/16	09/06	234	223	0	72	3	11	5,595.3	3,326.9	59.5%
	Screw	01/16	09/06	234	215	0	70	1	19	5,594.8	2,353.2	42.1%
2000	Scoop	01/15	08/18	216	205	0	62	0	11	5,206.0	3,042.1	58.6%
	Screw	01/15	10/27	286	209	0	65	0	77	6,860.5	3,116.1	45.6%
2001	Scoop	01/16	07/30	195	191	1	57	3	4	4,648.7	2,701.2	58.1%
	Screw	01/16	07/30	195	184	6	53	6	5	4,648.7	2,712.8	58.4%
2002	Scoop	01/16	07/30	197	175	7	57	3	15	4,728.0	2,665.0	56.4%
	Screw	01/16	07/30	197	174	4	53	4	19	4,728.0	2,631.0	55.7%
2003	Scoop	01/15	07/30	198	180	5	56	0	13	4,693.0	2,658.0	56.6%
	Screw	01/15	07/30	198	181	2	58	2	15	4,693.0	2,651.0	56.5%

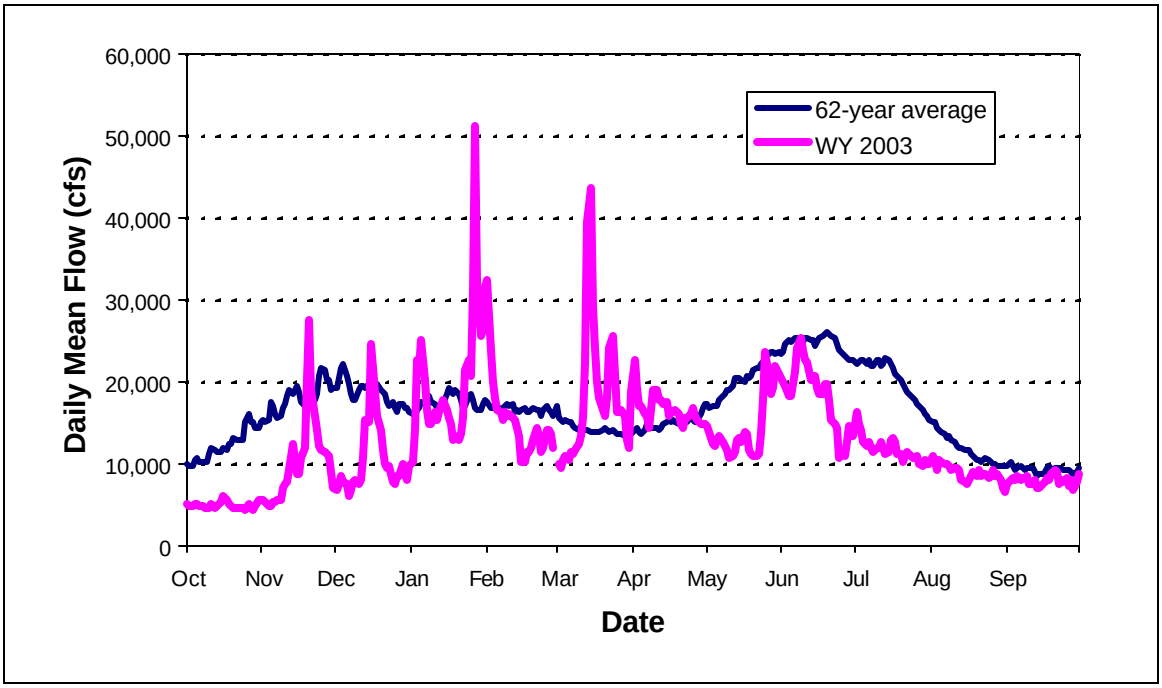

Figure 2. Comparison of daily mean flows in water year 2003 with 62-year average (1940-2002), Skagit River near Mount Vernon (USGS data).

Juvenile Chinook Catches

Chinook fry were moving downstream when we began trapping in mid-January. Catch rates remained low through January 21, averaging just over 1 chinook fry/hour per trap over the first six days of trapping. Beginning on the night of January 22, flow and catches increased. By the end of January, catch rates had increased to 60 and 12 zero-age chinook per hour in the scoop and screw traps, respectively. The highest average catch rate of wild chinook during a night (291/hour in the scoop trap) occurred on the night of March 11. Over the remaining season, wild 0+ chinook catch rates fluctuated, but generally declined (Figure 3). In early-July, catches were less than 10 chinook/night, and dropped to less than 5 fish/night by mid-July. By the end of July wild chinook catch rates averaged less than 1 fish/hour.

Day-to-day variation in wild chinook catch rates was nearly identical between traps. The scoop trap, however, consistently out-fished the screw trap (Figure 3). Through July 31, the scoop and screw traps captured wild 0+ chinook at average rates of 19 and 13 fry/hour fished, respectively. These rates are simply the ratio of total catches to the total hours fished for each trap.

Over the season, we captured 85,814 wild and 3,644 hatchery 0+ chinook. The hatchery 0+ chinook catch does not include the numbers of hatchery chinook that we released above the traps to estimate trap efficiency. Over the previous thirteen seasons, catches have ranged between 1,700 and 96,000 wild zero-age chinook (Table 2 and Table 3).

Day:Night Catch Ratios

Wild Chinook 0+

We compared wild 0+ chinook catch rates during daylight hours to respective night time catch rates for the scoop and screw traps on 49 and 55 days, respectively (Table 4 and Table 5). Day:night catch rate ratios (d:n ratios) varied from 0% to over 60% in the scoop trap, and from 0% up to 124% in the screw trap. For the season, d:n catch rate ratios averaged 16% and 28% for the scoop and screw traps, respectively.

To better predict catch on days the trap was not fished, we correlated d:n ratios with river discharge and turbidity. Over the dates that we computed d:n catch rate ratios for wild 0+ chinook, flows varied just over two-fold (10,100 to 24,200 cfs). Given the moderate flows that dominated much of the season, we expected the brief flow increases to positively affect d:n ratios. Regression analysis found that flow did explain a significant portion of the variation in d:n ratios for wild zero-age chinook in the scoop trap and screw traps over the season, with R^2 values of 28% and 20% for wild fish, and 27% and 20% for hatchery fish. However, these relationships were deemed too weak to be used for predictive purposes.

Similarly, we correlated d:n ratios for wild 0+ chinook with daily turbidity data through the season, and found that turbidity also affected daytime migration rates. However, as with the flow relationships, the effect of turbidity on d:n ratios was considered too weak for predictive purposes. We opted, therefore, to use a measure of central tendency to estimate d:n ratios for the scoop and screw traps. Since the ratios were not normally distributed, the seasonal median scoop and screw trap d:n ratios were used to project catch during unfished daytime periods. These values were estimated for both the wild (Table 4 and Table 5) and hatchery (Table 6 and Table 7) zero-age chinook.

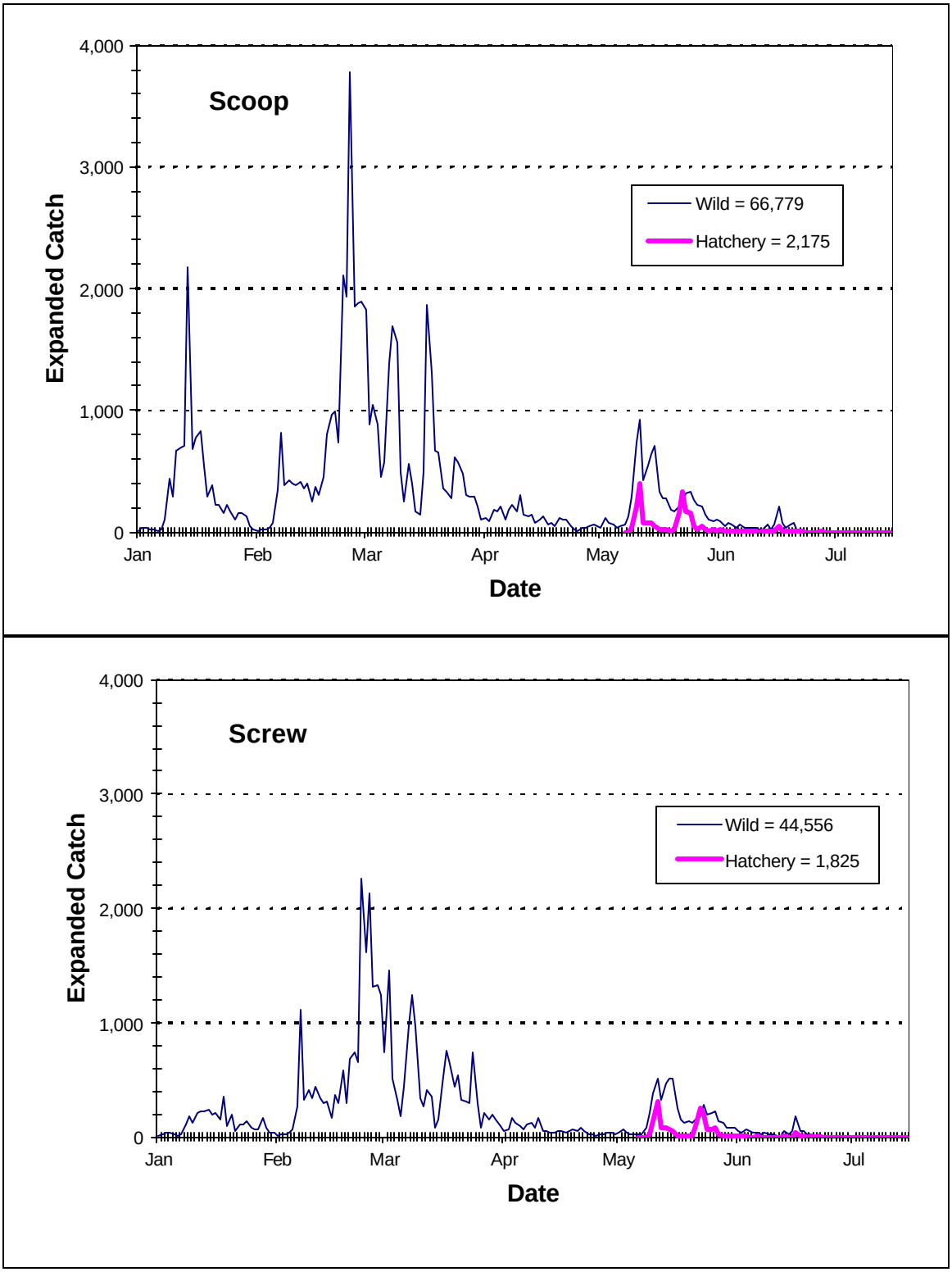

Figure 3. Projected wild and hatchery chinook 0+ catches, Skagit River mainstem traps 2003.

Table 2. Downstream-migrant salmonids captured in the Skagit River mainstem traps, 1997-2003.

Species	1997		1998		1999		2000		2001		2002		2003	
	Scoop	Screw	Scoop	Screw	Scoop	Screw	Scoop	Screw	Scoop	Screw	Scoop	Screw	Scoop	Screw
Coho 1+														
Wild	6,437	5,975	13,879	9,076	4,904	3,314	13,449	14,861	2,581	4,354	8,807	9,347	6,236	7,537
Hatchery	334	362	623	1,028	673	635	624	946	103	398	453	668	447	1,229
Coho 0+	364	220	1,216	409	744	311	115	27	2,604	871	1,896	435	1,303	366
Chinook 1+														
Wild	46	52	876	350	198	87	129	105	32	26	199	228	95	94
Hatchery	376	249	24	12	201	41	511	360	26	50	177	161	170	122
Chinook 0+														
Wild	26,798	20,780	33,698	20,001	55,254	41,492	23,289	14,944	54,762	40,180	35,332	24,908	51,316	34,498
Hatchery	1,163	684	5,837	2,127	3,449	2,213	2,554	2,152	1,667	1,354	3,310	2,726	2,033	1,611
Sockeye 1+	59	48	111	84	72	23	9	11	5	1	27	35	1	7
Chum 0+	38,243	39,174	37,162	18,498	172,774	108,730	39,608	40,234	133,890	105,200	16,526	16,664	82,668	70,059
Pink 0+	9	17	338,520	102,338	476	265	207,530	198,015	2,644	1,350	104,782	153,668	1,604	1,731
Steelhead 1+														
Wild	319	531	389	1,100	99	334	95	597	32	317	118	437	32	366
Hatchery	982	2,401	446	2,325	122	511	75	736	23	465	75	534	26	474
Steelhead Adult	3	4	1	3	11	1	1	2	0	0	1	2	0	0
Cutthroat 1+	58	89	98	401	30	150	51	248	11	318	53	196	32	151
Cutthroat adult	2	13	2	5	4	0	0	7	0	0	0	7	0	0
Native char 1+	65	77	153	206	101	98	109	138	20	125	74	115	81	73
Trout Parr	40	61	90	83	42	57	116	155	86	123	31	44	83	102

Table 3. Downstream-migrant salmonids captured in the Skagit River mainstem traps, 1990-1996.

Species	1990	1991	1992	1993		1994		1995		1996	
	Scoop	Scoop	Scoop	Scoop	Screw	Scoop	Screw	Scoop	Screw	Scoop	Screw
Coho 1+											
Wild	10,204	6,904	8,620	3,636	3,690	10,767	10,211	8,661	8,824	11,520	9,134
Hatchery	234	382	596	[a]714	[a]723	1,880	1,873	4,800	5,274	973	1,208
Coho 0+	48	22	64	79	4	57	5	204	57	246	50
Chinook 1+											
Wild	[b]45	[b]1,132	[b]299	[b]3,567	[b]262	308	212	184	112	80	32
Hatchery	---	---	---	---	---	---	---	1,754	570	415	117
Chinook 0+											
Wild	[c]8,528	[d]1,706	[e]8,812	[f]7,463	[f]3,415	9,721	4,743	10,536	5,767	2,834	1,731
Hatchery	---	---	---	---	---	2,320	1,098	6,083	2,022	4,165	2,888
Sockeye 1+	2	21	2	32	16	108	45	31	17	36	56
Chum 0+	617	48,505	3,081	66,790	13,939	5,113	7,689	66,139	55,824	10,578	5,384
Pink 0+	697	0	18,682	0	0	48,532	22,952	0	0	27,482	9,778
Steelhead 1+											
Wild	198	301	332	304	663	601	1,297	532	1,184	364	778
Hatchery	223	66	124	658	2,381	670	3,107	1,282	4,579	751	1,751
Steelhead Adult	0	0	0	0	0	0	0	4	1	1	0
Cutthroat 1+	117	60	153	45	91	198	437	107	263	165	332
Cutthroat adult	0	0	0	0	0	0	0	1	0	0	2
Native char 1+	130	112	132	76	74	197	255	189	179	142	102
Trout Parr	N/A	N/A	N/A	12	7	47	69	56	47	110	68

[a] Estimated by proportion of total catch.
[b] Includes both hatchery and wild.
[c] 1989 brood released from Clark Creek = 1,728,100: falls = 1,170,800 Samish stock + 236,000 Clark Creek stock, released on June 8, 1990; and summers = 73,800 + 246,900 Clark Creek stock released on June 28, 1990.
[d] Clark Creek stock released on June 18, 1991: 1,144,500 falls and 111,120 summers.
[e] Clark Creek stock: 786,100 falls released February 25, 1992; 483,280 summers released on April 20, 1992; and 120,000 released on May 21, 1992.
[f] Clark Creek stock: 1,588,800 falls released in February 1993; 250,000 falls released on March 16, 1993; and 160,000 summers released on May 16, 1993.

Table 4. Catch rates and day:night catch rate ratios of wild 0+ chinook during day and night periods, Skagit River scoop trap 2003.

NIGHT TIME							DAY TIME								
Trap Down		Trap Up		Hours	Chin	Catch	Date	Time		Hours	Chin	Catch	D:N	Flow	Turbidity
Date	Time	Date	Time	Fished	0+	Rate		Down	Up	Fished	0+	Rate	Ratio	cfs	NTU
01/17	17.50	01/19	8.00	29.34	57	1.94	01/18	8.50	17.17	8.67	0	0.00	0.00%	13,100	2.0
01/20	17.50	01/22	8.00	29.33	33	1.13	01/21	8.33	17.00	8.67	0	0.00	0.00%	13,600	1.9
01/23	17.33	01/25	8.00	28.92	619	21.40	01/24	8.00	17.50	9.50	93	9.79	45.74%	22,700	13.4
02/09	17.67	02/11	7.75	28.00	224	8.00	02/10	7.92	17.67	9.75	14	1.44	17.95%	16,100	2.9
02/12	18.00	02/14	7.75	27.83	159	5.71	02/13	8.17	17.75	9.58	11	1.15	20.10%	14,500	2.4
02/15	18.00	02/17	7.50	26.83	31	1.16	02/16	7.67	18.00	10.33	3	0.29	25.14%	10,200	2.2
02/18	18.00	02/20	7.75	27.50	94	3.42	02/19	8.00	17.75	9.75	4	0.41	12.00%	12,100	2.2
02/21	18.00	02/23	7.50	26.33	1,015	38.55	02/22	7.25	18.00	10.75	135	12.56	32.58%	13,500	5.2
02/24	18.00	02/26	7.00	25.83	671	25.98	02/25	8.00	18.00	10.00	63	6.30	24.25%	12,100	2.8
02/27	17.50	03/01	7.00	27.00	709	26.26	02/28	7.25	17.50	10.25	19	1.85	7.06%	12,000	1.6
03/03	18.00	03/05	6.00	24.83	655	26.38	03/04	7.25	18.00	10.75	14	1.30	4.94%	11,000	1.6
03/06	17.50	03/08	7.00	26.17	1,801	68.82	03/07	7.25	18.17	10.92	52	4.76	6.92%	11,300	2.4
03/09	18.00	03/11	7.00	26.00	3,471	133.50	03/10	7.50	18.00	10.50	182	17.33	12.98%	13,500	5.5
03/17	18.75	03/19	6.75	24.25	1,682	69.36	03/18	6.75	18.00	11.25	143	12.71	18.33%	18,000	9.3
03/20	19.00	03/22	6.50	23.83	1,637	68.69	03/21	6.75	18.00	11.25	76	6.76	9.83%	18,200	7.4
03/23	20.00	03/25	6.50	22.83	1,758	77.00	03/24	7.17	18.50	11.33	230	20.30	26.36%	21,000	13.4
03/26	18.75	03/28	6.50	23.25	817	35.14	03/27	6.67	19.00	12.33	100	8.11	23.08%	16,700	5.5
03/29	19.00	03/31	6.50	22.83	423	18.53	03/30	6.67	19.00	12.33	36	2.92	15.76%	12,100	4.9
04/01	19.00	04/03	6.50	23.33	1,656	70.98	04/02	6.67	18.50	11.83	229	19.36	27.27%	19,300	5.4
04/04	19.50	04/06	7.00	23.33	606	25.98	04/05	6.67	18.50	11.83	37	3.13	12.04%	16,200	3.6
04/07	19.75	04/09	6.50	21.75	922	42.39	04/08	6.50	19.50	13.00	172	13.23	31.21%	16,700	5.1
04/10	19.75	04/12	6.50	21.08	471	22.34	04/11	6.67	20.00	13.33	84	6.30	28.20%	17,900	4.6
04/13	19.50	04/15	6.50	21.75	266	12.23	04/14	6.50	19.50	13.00	36	2.77	22.64%	17,600	4.1
04/16	20.00	04/18	6.50	21.33	206	9.66	04/17	6.67	19.50	12.83	35	2.73	28.25%	16,500	3.3
04/20	20.50	04/22	6.50	19.83	246	12.41	04/21	6.67	20.50	13.83	5	0.36	2.91%	14,400	3.3
04/24	20.00	04/26	6.50	20.42	379	18.56	04/25	6.50	20.50	14.00	48	3.43	18.47%	17,000	3.3
04/28	20.50	04/30	6.00	19.33	153	7.92	04/29	6.75	20.50	13.75	7	0.51	6.43%	15,000	3.2
05/01	20.50	05/03	6.50	20.50	119	5.80	05/02	6.75	20.00	13.25	3	0.23	3.90%	14,000	2.6
05/04	20.50	05/06	6.00	19.33	201	10.40	05/05	6.67	20.50	13.83	4	0.29	2.78%	13,000	2.2
05/08	20.00	05/10	6.00	19.75	32	1.62	05/09	6.50	20.25	13.75	1	0.07	4.49%	11,700	1.4
05/11	20.50	05/13	6.00	18.83	79	4.20	05/12	6.50	20.50	14.00	0	0.00	0.00%	11,600	2.0
05/14	20.00	05/16	6.25	20.08	75	3.74	05/15	6.67	20.50	13.83	0	0.00	0.00%	12,700	1.8
05/17	21.00	05/19	6.00	18.33	125	6.82	05/18	6.25	20.50	14.25	0	0.00	0.00%	11,800	2.7
05/20	21.00	05/22	6.00	17.83	87	4.88	05/21	6.17	21.00	14.83	0	0.00	0.00%	11,000	1.7
05/23	21.00	05/25	5.00	17.25	715	41.45	05/24	6.25	20.50	14.25	102	7.16	17.27%	17,900	2.9
05/26	21.00	05/28	6.00	17.83	778	43.63	05/27	6.17	21.00	14.83	68	4.59	10.51%	18,600	5.7
05/29	21.25	05/31	6.00	16.58	678	40.89	05/30	5.75	21.50	15.75	283	17.97	43.94%	21,100	6.0
06/01	21.50	06/03	5.50	15.83	304	19.20	06/02	5.75	21.50	15.75	102	6.48	33.72%	19,600	3.8
06/04	21.50	06/06	5.50	15.75	308	19.56	06/05	5.67	21.50	15.83	67	4.23	21.64%	19,900	4.1
06/10	21.50	06/12	5.50	15.75	263	16.70	06/11	5.67	21.50	15.83	63	3.98	23.83%	22,400	6.6
06/13	21.75	06/15	5.50	15.75	123	7.81	06/14	5.50	21.25	15.75	40	2.54	32.52%	20,700	5.2
06/16	21.50	06/18	5.50	16.00	98	6.13	06/17	5.75	21.00	15.25	8	0.52	8.56%	18,500	5.1
06/19	21.50	06/21	5.75	16.08	83	5.16	06/20	5.75	21.50	15.75	5	0.32	6.15%	17,800	3.5
06/22	21.50	06/24	5.50	16.00	53	3.31	06/23	5.67	21.25	15.58	11	0.71	21.31%	14,400	2.5
06/25	21.50	06/27	5.50	16.00	25	1.56	06/26	5.75	21.25	15.50	8	0.52	33.03%	11,100	2.2
07/01	21.50	07/03	5.25	15.83	66	4.17	07/02	5.67	21.25	15.58	39	2.50	60.04%	14,900	3.7
07/05	21.50	07/07	5.50	15.83	32	2.02	07/06	5.75	21.50	15.75	0	0.00	0.00%	12,600	3.3
07/11	21.50	07/13	5.50	16.67	11	0.66	07/12	6.33	21.00	14.67	0	0.00	0.00%	12,000	3.6
07/18	21.00	07/20	6.00	17.75	4	0.23	07/19	6.25	21.00	14.75	0	0.00	0.00%	11,300	3.1
		Season Total		1,042.60	25,020	24.00				633.87	2,632	4.15	17.30%		
		Season Median											15.76%		
		Season Mean											16.41%		

Table 5. Catch/hour rates and day:night catch rate ratios of wild 0+ chinook during day and night periods, Skagit River screw trap 2003.

NIGHT TIME							DAY TIME								
Trap Down		Trap Up		Hours	Chin	Catch	Date	Time		Hours	Chin	Catch	D:N	Flow	Turbidity
Date	Time	Date	Time	Fished	0+	Rate		Down	Up	Fished	0+	Rate	Ratio	cfs	ntu
01/17	17.50	01/19	8.00	29.50	83	2.81	01/18	8.00	17.00	9.00	1	0.11	3.95%	13,100	2.0
01/20	17.50	01/22	8.00	29.50	38	1.29	01/21	8.25	17.00	8.75	1	0.11	8.87%	13,600	1.9
01/23	17.25	01/25	8.00	29.00	232	8.00	01/24	8.00	17.50	9.50	73	7.68	96.05%	22,700	13.4
02/01	17.50	02/03	7.83	28.91	383	13.25	02/02	8.42	17.50	9.08	47	5.18	39.07%	23,900	15.3
02/03	17.50	02/05	8.00	29.00	202	6.97	02/04	8.00	17.50	9.50	41	4.32	61.96%	18,100	8.4
02/06	17.50	02/08	8.00	29.00	216	7.45	02/07	8.17	17.50	9.33	24	2.57	34.54%	15,400	3.3
02/09	17.67	02/11	7.75	28.00	106	3.79	02/10	7.92	17.67	9.75	13	1.33	35.22%	16,100	2.9
02/12	18.00	02/14	7.75	27.92	118	4.23	02/13	8.00	17.75	9.75	10	1.03	24.27%	14,500	2.4
02/15	18.00	02/17	7.50	27.25	29	1.06	02/16	7.75	18.00	10.25	2	0.20	18.33%	10,200	2.2
02/18	18.00	02/20	7.75	27.50	82	2.98	02/19	8.00	17.75	9.75	6	0.62	20.64%	12,100	2.2
02/21	18.00	02/23	7.50	26.33	1,025	38.93	02/22	7.00	18.00	11.00	359	32.64	83.84%	13,500	5.2
02/24	18.00	02/26	7.00	25.83	605	23.42	02/25	8.00	18.00	10.00	102	10.20	43.55%	14,200	2.8
02/27	17.50	03/01	7.00	27.00	527	19.52	02/28	7.25	17.50	10.25	47	4.59	23.49%	12,000	1.6
03/03	18.00	03/05	6.00	25.00	785	31.40	03/04	7.00	18.00	11.00	17	1.55	4.92%	11,000	1.6
03/06	17.50	03/08	7.00	26.17	1,248	47.69	03/07	7.00	18.17	11.17	69	6.18	12.95%	11,300	2.4
03/09	18.00	03/11	7.00	26.00	3,186	122.54	03/10	7.50	18.00	10.50	370	35.24	28.76%	13,500	5.5
03/15	16.50	03/17	6.50	26.00	1,757	67.58	03/16	6.67	18.50	11.83	273	23.08	34.15%	24,200	20.0
03/17	18.75	03/19	6.75	24.00	671	27.96	03/18	6.75	18.25	11.50	118	10.26	36.70%	18,000	9.3
03/20	19.00	03/22	6.50	24.00	1,098	45.75	03/21	6.50	18.00	11.50	105	9.13	19.96%	18,200	7.4
03/23	20.00	03/25	6.50	22.50	1,029	45.73	03/24	6.50	18.50	12.00	233	19.42	42.46%	21,000	13.4
03/26	18.75	03/28	6.50	23.25	621	26.71	03/27	6.50	19.00	12.50	97	7.76	29.05%	16,700	5.5
03/29	19.00	03/31	6.50	23.00	506	22.00	03/30	6.50	19.00	12.50	44	3.52	16.00%	12,100	4.9
04/01	19.00	04/03	6.50	23.50	793	33.74	04/02	6.67	18.50	11.83	208	17.58	52.10%	19,300	5.4
04/04	19.50	04/06	7.00	23.50	528	22.47	04/05	7.00	18.50	11.50	61	5.30	23.61%	16,200	3.6
04/07	19.75	04/09	6.50	21.75	577	26.53	04/08	6.50	19.50	13.00	429	33.00	124.39%	16,700	5.1
04/10	19.75	04/12	6.50	21.75	207	9.52	04/11	6.50	19.50	13.00	123	9.46	99.41%	17,900	4.6
04/13	19.50	04/15	6.50	21.75	163	7.49	04/14	6.50	19.75	13.25	81	6.11	81.57%	17,600	4.1
04/16	20.00	04/18	6.50	21.50	190	8.84	04/17	6.50	19.50	13.00	13	1.00	11.32%	16,500	3.3
04/20	20.50	04/22	6.50	20.25	146	7.21	04/21	6.50	20.25	13.75	9	0.65	9.08%	14,400	3.3
04/24	20.00	04/26	6.50	20.75	148	7.13	04/25	6.50	20.25	13.75	74	5.38	75.45%	17,000	3.3
04/28	20.50	04/30	6.00	20.00	71	3.55	04/29	6.50	20.00	13.50	8	0.59	16.69%	15,000	3.2
05/01	20.50	05/03	6.50	20.50	70	3.41	05/02	6.50	20.00	13.50	7	0.52	15.19%	14,000	2.6
05/04	20.50	05/06	6.00	19.50	106	5.44	05/05	6.00	20.00	14.00	14	1.00	18.40%	13,000	2.2
05/08	20.00	05/10	6.00	20.25	24	1.19	05/09	6.50	20.25	13.75	4	0.29	24.55%	11,700	1.4
05/11	20.50	05/13	6.00	19.00	51	2.68	05/12	6.00	20.50	14.50	1	0.07	2.57%	11,600	2.0
05/14	20.00	05/16	6.25	19.75	58	2.94	05/15	6.00	20.50	14.50	1	0.07	2.35%	12,700	1.8
05/17	21.00	05/19	6.00	17.50	55	3.14	05/18	5.67	20.50	14.83	2	0.13	4.29%	11,800	2.7
05/20	21.00	05/22	6.00	17.50	44	2.51	05/21	5.50	21.00	15.50	5	0.32	12.83%	11,000	1.7
05/23	21.00	05/25	5.00	16.50	341	20.67	05/24	6.00	20.67	14.67	122	8.32	40.24%	17,900	2.9
05/26	21.00	05/28	6.00	17.50	586	33.49	05/27	5.50	21.00	15.50	83	5.35	15.99%	18,600	5.7
05/29	21.00	05/31	6.00	17.00	517	30.41	05/30	5.00	21.00	16.00	201	12.56	41.31%	21,100	6.0
06/01	21.50	06/03	5.50	15.50	182	11.74	06/02	5.00	21.50	16.50	40	2.42	20.65%	19,600	3.8
06/04	21.50	06/06	5.50	15.50	232	14.97	06/05	5.00	21.50	16.50	38	2.30	15.39%	19,900	4.1
06/10	21.50	06/12	5.50	15.25	191	12.52	06/11	5.00	21.50	16.50	44	2.67	21.29%	22,400	6.6
06/13	21.75	06/15	5.50	15.25	109	7.15	06/14	5.50	21.25	15.75	39	2.48	34.64%	20,700	5.2
06/16	21.50	06/18	5.50	15.25	78	5.11	06/17	5.00	21.50	16.50	5	0.30	5.92%	18,500	5.1
06/19	21.50	06/21	5.75	16.25	71	4.37	06/20	5.50	21.50	16.00	3	0.19	4.29%	17,800	3.5
06/22	21.50	06/24	5.50	16.00	41	2.56	06/23	5.50	21.25	15.75	10	0.63	24.78%	14,400	2.5
06/25	21.50	06/27	5.50	16.08	17	1.06	06/26	5.50	21.25	15.75	2	0.13	12.01%	11,100	2.2
07/01	21.50	07/03	5.50	16.25	68	4.18	07/02	5.50	21.25	15.75	19	1.21	28.83%	14,900	3.7
07/05	21.50	07/07	5.50	16.00	27	1.69	07/06	5.50	21.50	16.00	0	0.00	0.00%	12,600	3.3
07/08	23.50	07/10	6.00	14.50	5	0.34	07/09	5.50	21.50	16.00	0	0.00	0.00%	12,000	3.1
07/11	21.50	07/13	5.50	17.00	8	0.47	07/12	6.00	21.00	15.00	0	0.00	0.00%	12,000	3.6
07/18	21.00	07/20	6.00	18.00	7	0.39	07/19	6.00	21.00	15.00	0	0.00	0.00%	11,300	3.1
07/26	21.00	07/28	6.00	18.00	1	0.06	07/27	6.00	21.00	15.00	0	0.00	0.00%	10,100	3.5
			Season Total	1,189.24	20,259	17.04				715.74	3,698	5.17	30.33%		
			Season Median										20.65%		
			Season Mean										28.32%		

Table 6. Catch rates of hatchery 0+ chinook during day and night periods, Skagit River scoop trap 2003.

NIGHT TIME							DAY TIME								
Trap Down		Trap Up		Hours	Chin	Catch	Date	Time		Hours	Chin	Catch	D:N	Flow	Turbidity
Date	Time	Date	Time	Fished	0+	Rate		Down	Up	Fished	0+	Rate	Ratio	cfs	ntu
05/23	21.00	05/25	5.00	17.25	213	12.35	05/24	6.25	20.50	14.25	8	0.56	4.55%	17,900	2.9
05/26	21.00	05/28	6.00	17.83	135	7.57	05/27	6.17	21.00	14.83	6	0.40	5.34%	18,600	5.7
05/29	21.25	05/31	6.00	16.58	47	2.83	05/30	5.75	21.50	15.75	13	0.83	29.12%	21,100	6.0
06/01	21.50	06/03	5.50	15.83	25	1.58	06/02	5.75	21.50	15.75	7	0.44	28.14%	19,600	3.8
06/04	21.50	06/06	5.50	15.75	457	29.02	06/05	5.67	21.50	15.83	7	0.44	1.52%	19,900	4.1
06/10	21.50	06/12	5.50	15.75	46	2.92	06/11	5.67	21.50	15.83	14	0.88	30.28%	22,400	6.6
06/13	21.75	06/15	5.50	15.75	26	1.65	06/14	5.50	21.25	15.75	11	0.70	42.31%	20,700	5.2
06/16	21.50	06/18	5.50	16.00	14	0.88	06/17	5.75	21.00	15.25	0	0.00	0.00%	18,500	5.1
06/19	21.50	06/21	5.75	16.08	11	0.68	06/20	5.75	21.50	15.75	1	0.06	9.28%	17,800	3.5
06/22	21.50	06/24	5.50	16.00	7	0.44	06/23	5.67	21.25	15.58	0	0.00	0.00%	14,400	2.5
06/25	21.50	06/27	5.50	16.00	4	0.25	06/26	5.75	21.25	15.50	0	0.00	0.00%	11,100	2.2
07/01	21.50	07/03	5.25	15.83	5	0.32	07/02	5.67	21.25	15.58	2	0.13	40.64%	14,900	3.7
07/05	21.50	07/07	5.50	15.83	4	0.25	07/06	5.75	21.50	15.75	0	0.00	0.00%	12,600	3.3
07/11	21.50	07/13	5.50	16.67	2	0.12	07/12	6.33	21.00	14.67	0	0.00	0.00%	12,000	3.6
		Season Total		227.15	996	4.38				216.07	69	0.32	7.28%		
		Season Median											4.95%		
		Season Mean											13.66%		

Table 7. Catch ratios of hatchery 0+ chinook during day and night periods, Skagit River screw trap 2003.

NIGHT TIME							DAY TIME								
Trap Down		Trap Up		Hours	Chin	Catch	Date	Time		Hours	Chin	Catch	D:N	Flow	Turbidity
Date	Time	Date	Time	Fished	0+	Rate		Down	Up	Fished	0+	Rate	Ratio	cfs	ntu
05/23	21.00	05/25	5.00	16.50	138	8.36	05/24	6.00	20.67	14.67	13	0.89	10.60%	17,900	2.9
05/26	21.00	05/28	5.50	17.50	138	7.89	05/27	5.50	21.00	15.50	12	0.77	9.82%	18,600	5.7
05/29	21.00	05/31	6.00	17.00	62	3.65	05/30	5.00	21.00	16.00	9	0.56	15.42%	21,100	6.0
06/01	21.50	06/03	5.50	15.50	19	1.23	06/02	5.00	21.50	16.50	5	0.30	24.72%	19,600	3.8
06/04	21.50	06/06	5.50	15.50	328	21.16	06/05	5.00	21.50	16.50	10	0.61	2.86%	19,900	4.1
06/10	21.50	06/12	5.50	15.25	37	2.43	06/11	5.00	21.50	16.50	2	0.12	5.00%	22,400	6.6
06/13	21.75	06/15	5.50	15.25	22	1.44	06/14	5.50	21.25	15.75	5	0.32	22.01%	20,700	5.2
06/16	21.50	06/18	5.50	15.25	17	1.11	06/17	5.00	21.50	16.50	0	0.00	0.00%	18,500	5.1
06/19	21.50	06/21	5.75	16.25	8	0.49	06/20	5.50	21.50	16.00	0	0.00	0.00%	17,800	3.5
06/22	21.50	06/24	5.50	16.00	5	0.31	06/23	5.50	21.25	15.75	0	0.00	0.00%	14,400	2.5
07/01	21.50	07/03	5.50	16.25	10	0.62	07/02	5.50	21.25	15.75	2	0.13	20.63%	14,900	3.7
07/05	21.50	07/07	5.50	16.00	4	0.25	07/06	5.50	21.50	16.00	0	0.00	0.00%	12,600	3.3
07/08	23.50	07/10	6.00	14.50	3	0.21	07/09	5.50	21.50	16.00	0	0.00	0.00%	12,000	3.1
07/11	21.50	07/13	5.50	17.00	2	0.12	07/12	6.00	21.00	15.00	0	0.00	0.00%	12,000	3.6
		Season Total		223.75	793	3.54				222.42	58	0.26	7.36%		
		Season Median											3.93%		
		Season Mean											7.93%		

Chinook Trap Efficiency

We released six groups of juvenile chinook, four wild and two hatchery, using two different mark types (Bismark-brown dye and ad-marked/CWT) over the season. The first group was released on the night of February 27 and the last on the night of May 14. We operated the traps continuously for more than 36 continuous hours after each release. Recoveries of five calibration groups occurred entirely on the first night or the day after the releases. The sixth group of ad-marked/CWT hatchery chinook was released on the night of May 14. This group was compromised by an unscheduled release of ad-marked/CWT chinook at Marblemount Hatchery and was therefore excluded from further consideration. Recapture rates for the other five calibration groups ranged from 1.24% to 3.64%, and averaged 2.13% (Table 8). Wild release groups were recaptured at lower rates than the single hatchery group. Recovery rate for the four wild groups released February and April ranged from 1.2% to 2.3% versus 3.64% for the single hatchery group released on May 8.

Hatchery 0+ Chinook Production Groups

Three releases of ad-CWT hatchery chinook fingerlings occurred in Spring 2003 (Table 8). The location of these releases are shown in Figure 1:

- May 23, the volitional release of 200,024 summer chinook from Countyline Ponds (R.M. 89)
- May 27, the release of 34,202 fall chinook from Baker River (R.M. 57)
- June 3, the release of 252,335 spring chinook from the Skagit Hatchery (R.M. 78)

Over the season, we caught a total of 3,644 ad-marked and coded-wire tagged (ad-CWT) hatchery 0+ chinook in the mainstem traps, 2,033 in the scoop trap and 1,611 in the screw trap, not including the calibration groups.

Portioning the catch among the three release groups required recovering tags. On May 19, we began sampling hatchery smolts for tag recovery. Over the season, we sacrificed 401 ad-marked chinook and recovered 395 tags, which we used to estimate the proportions of Countyline Ponds summers, Skagit Hatchery springs, and Baker River fall chinook in our total hatchery catch (Table 9).

Applying daily tag recovery results to the sum of actual and projected catches estimates 4,001 hatchery chinook: 118 fall 0+ chinook (released at Baker River), 1,883 summer 0+ chinook (released at Countyline Ponds) and 2,000 spring 0+ chinook (released at Skagit Hatchery) (Table 10). Relating these projected catches to the numbers released yields capture rates of 0.4%, 0.9%, and 0.8% for falls, summers and spring chinook, respectively. As these rates are simply the ratio of estimated recoveries to estimated release, they are biased low by such factors as mortality, residualism and fewer fish released than reported.

Table 8. Groups of marked salmon released into the Skagit River in 2003 and the numbers recovered at the mainstem traps.

Stock		Species/ Age	Mark Type	RELEASE		Recapture Dates	ACTUAL CATCH			CAPTURE RATE		
				Date	Number		Scoop	Screw	Total	Scoop	Screw	Total
Wild (Mannser Creek)		Coho 1+	LV	April 9-June 12	17,965	April 25-June 14	80	98	178	0.44%	0.54%	0.99%
Hatchery		Coho 1+	Ad/CWT	See below	160,445	May 30-June 30	183	597	780	0.11%	0.37%	0.49%
			Ad-only		34,421	April 29-June 24	218	490	708	0.63%	1.42%	2.06%
			Unmk/CWT		69,633	May 30-June 18	45	142	187	0.06%	0.20%	0.26%
			ALL[c]	May 29-May 30	262,499	April 29-June 30	446	1,229	1,675	0.17%	0.47%	0.64%
Calibration Groups[a]	Wild	Chinook 0+	Dye	February 27	667	Feb 27- March 01	6	3	9	0.89%	0.45%	1.34%
	Wild	Chinook 0+	Dye	April 04	643	April 04-05	5	3	8	0.77%	0.47%	1.24%
	Wild	Chinook 0+	Dye	April 10	598	April 10-11	9	5	14	1.51%	0.84%	2.34%
	Wild	Chinook 0+	Dye	April 24	725	April 24-25	3	10	13	0.41%	1.38%	1.79%
	Hatchery/ spring	Chinook 0+	Ad/CWT	May 08	797	May 08-09	10	19	29	1.25%	2.38%	3.64%
Hatchery Releases[b]	Countyline Ponds/ summer	Chinook 0+	Ad/CWT	May 23	200,024	May 23-July 03	----	----	1,781	See Table 10		
	Marblemount Hatchery/ spring	Chinook 0+	Ad/CWT	June 03	252,335	May 23-July 15	----	----	94			
	Baker River Hatchery/ fall	Chinook 0+	Ad/CWT	May 27	34,202	May 29-July 11	----	----	1,769			
Hatchery/ spring		Chinook 1+	Ad/CWT	See below	76,674	See below	[d] 85	[f] 63	148	0.11%	0.08%	0.19%
			Unmk/CWT		73,823		[e] 85	[g] 59	144	0.12%	0.08%	0.20%
			ALL	April 25	150,497	April 19-May 25	170	122	292	0.11%	0.08%	0.19%

[a] Mark groups used for trap efficiency tests; not included in wild and hatchery migration estimate.
[b] Hatchery 0+ chinook catch is apportioned, based on tag recovery results.
[c] Reported release dates for all hatchery coho smolt groups.
[d] Includes 18 ad-only and 67 ad-mark/CWTs.
[e] Includes 27 unmarked/untagged and 58 unmarked/CWTs.
[f] Includes 13 ad-only and 50 ad-mark/CWTs.
[g] Includes 12 unmarked/untagged and 47 unmarked/CWTs.

Table 9. Breakdown of tag recoveries from ad-marked/CWT 0+ chinook and estimated tags in total catch, Skagit River mainstem traps 2003.

Date	Number Sampled			Total	Cntyln-Summer		Baker R-Fall		Marblemt-Spring	
	Scoop	Screw	Total	Catch	Total	%	Total	%	Total	%
05/23/03	27	11	38	49	4	5.3%	0	0.0%	67	94.7%
05/24/03	3	3	6	9	181	60.0%	0	0.0%	120	40.0%
05/25/03	19	12	31	43	679	100.0%	0	0.0%	0	0.0%
05/26/03	37	30	67	97	142	95.4%	0	0.0%	7	4.6%
05/27/03	7	8	15	23	142	100.0%	0	0.0%	0	0.0%
05/28/03	7	7	14	21	145	100.0%	0	0.0%	0	0.0%
05/29/03	9	8	17	25	100	100.0%	0	0.0%	0	0.0%
05/30/03	4	3	7	10	27	85.7%	4	14.3%	0	0.0%
05/31/03	1	2	3	5	24	66.7%	12	33.3%	0	0.0%
06/01/03	2	2	4	6	38	100.0%	0	0.0%	0	0.0%
06/02/03	3	1	4	5	13	75.0%	0	0.0%	5	25.0%
06/03/03	0	1	1	2	0	0.0%	26	100.0%	0	0.0%
06/04/03	2	1	3	4	87	33.3%	0	0.0%	175	66.7%
06/05/03	16	10	26	36	104	19.2%	0	0.0%	436	80.8%
06/06/03	30	24	54	78	0	0.0%	0	0.0%	352	100.0%
06/07/03	16	20	36	56	0	0.0%	0	0.0%	270	100.0%
06/08/03	18	9	27	36	1	3.7%	0	3.7%	19	92.6%
06/09/03	2	0	2	2	0	0.0%	0	0.0%	20	100.0%
06/10/03	2	0	2	2	34	50.0%	0	0.0%	35	50.0%
06/11/03	4	2	6	8	0	0.0%	0	0.0%	30	100.0%
06/12/03	2	2	4	6	0	0.0%	0	0.0%	17	100.0%
06/13/03	1	1	2	3	40	100.0%	0	0.0%	0	0.0%
06/14/03	2	1	3	4	0	0.0%	8	33.3%	16	66.7%
06/15/03	1	1	2	3	0	0.0%	0	0.0%	23	100.0%
06/16/03	2	1	3	4	0	0.0%	0	0.0%	16	100.0%
06/17/03	1	0	1	1	0	0.0%	0	0.0%	15	100.0%
06/18/03	0	2	2	4	0	0.0%	0	0.0%	11	100.0%
06/19/03	1	0	1	1	0	0.0%	4	100.0%	0	0.0%
06/20/03	0	0	0	0	4	25.0%	8	50.0%	4	25.0%
06/21/03	1	1	2	3	5	50.0%	0	0.0%	5	50.0%
06/22/03	1	0	1	1	0	0.0%	0	0.0%	7	100.0%
06/23/03	1	1	2	3	0	0.0%	0	0.0%	5	100.0%
06/24/03	0	0	0	0	0	0.0%	3	50.0%	4	50.0%
06/25/03	0	0	0	0	0	0.0%	0	0.0%	1	100.0%
06/26/03	0	0	0	0	0	0.0%	1	50.0%	2	50.0%
06/27/03	1	0	1	1	0	0.0%	13	100.0%	0	0.0%
06/28/03	0	1	1	2	0	0.0%	0	0.0%	4	100.0%
06/29/03	1	0	1	1	0	0.0%	0	0.0%	6	100.0%
06/30/03	0	0	0	0	5	7.1%	5	7.1%	64	85.7%
07/01/03	4	3	7	10	2	14.3%	2	14.3%	8	71.4%
07/02/03	1	1	2	3	3	50.0%	0	0.0%	4	50.0%
07/03/03	0	0	0	0	1	25.0%	1	25.0%	2	50.0%
07/04/03	0	0	0	0	0	12.5%	0	37.5%	0	50.0%
07/05/03	0	0	0	0	0	0.0%	1	50.0%	1	50.0%
07/06/03	0	0	0	0	0	0.0%	3	50.0%	3	50.0%
07/07/03	1	1	2	3	0	0.0%	0	0.0%	1	100.0%
07/08/03	0	0	0	0	0	0.0%	1	50.0%	1	50.0%
07/09/03	0	0	0	0	0	0.0%	1	25.0%	2	75.0%
07/10/03	0	0	0	0	0	0.0%	1	25.0%	2	75.0%
07/11/03	0	0	0	0	0	0.0%	0	0.0%	3	100.0%
07/12/03	0	1	1	2	0	0.0%	0	0.0%	1	100.0%
07/13/03	0	0	0	0	0	0.0%	0	0.0%	1	100.0%
07/14/03	0	0	0	0	0	0.0%	0	0.0%	2	100.0%
07/15/03	0	0	0	0	0	0.0%	0	0.0%	2	100.0%
07/16/03	0	0	0	0	0	0.0%	0	0.0%	0	100.0%
Total	230	171	401	572	1,781	47.1%	94	2.9%	1,769	50.0%

Note: Does not include 10 sampled (8 from scoop, 2 from screw) before May 23.
"No tags" and lost tags excluded from the tag breakdown.

Table 10. Projected 24-hour hatchery 0+ chinook catches, by tag group, Skagit River mainstem traps 2003.

Stock	Tag Code	Number Released	Recovery Period	Projected 24-Hour Catch [a]	Catch Rate
Countyline Ponds/summer	21-04/82	200,024	May 23-July 03	1,883	0.94%
Marblemount Hatchery/ spring	63-17/67	252,335	May 23-July 15	2,000	0.79%
Baker River/ fall	21-05/10	34,202	May 29-July 11	118	0.35%
	Total	486,661	May 23-July 15	4,001	0.82%

[a] Estimated by applying the proportion of the tagged groups in the total hatchery catch (Table 9), by day, to the projected 24-hour catch.

Wild & Hatchery 0+ Chinook Production Estimates

Catch Projection

Expansion of catches for the intervals not fished estimates an additional 15,463 and 10,058 wild 0+ chinook would have been captured in the scoop and screw traps, respectively (Table 11). Combining these projected catches with the actual catches (51,316 and 34,498 fry, respectively), estimates 111,335 wild 0+ chinook would have been caught in the two traps had we fished continuously from January 15 through July 30. Actual catches represent 77% of the total projected catches.

Expanding actual catches for the intervals not fished following release of the hatchery production groups, estimates an additional 357 hatchery 0+ chinook would have been captured in the scoop and screw traps (Table 11). Actual catches represent 90% of the total projected hatchery catch.

Table 11. Summary of actual and projected wild and hatchery 0+ chinook catches in the Skagit River mainstem traps 2003.

Group	Scoop Trap			Screw Trap			Total		
	Actual	Projected	Total	Actual	Projected	Total	Actual	Projected	Total
Wild	51,316	15,463	66,779	34,498	10,058	44,556	85,814	25,521	111,335
Hatchery	2,033	143	2,176	1,611	214	1,825	3,644	357	4,001

Production

We selected a value of 2.03% to represent season average trap efficiency. This rate is the mean capture rate of 25 zero-age chinook calibration groups that we released upstream of the mainstem traps from 1998 through 2003, and is nearly identical to the mean capture rate of the five release groups in 2003. Expansion of the projected season catch in both traps by this rate yields a system production estimate of approximately 5.5-million zero-age chinook (Figure 4).

Applying this same rate to the projected season hatchery catch yields a combined estimate of 197,000 0+ chinook. Relating this estimate to the 486,500 chinook released, estimates in-river survival above Mt. Vernon at 40%.

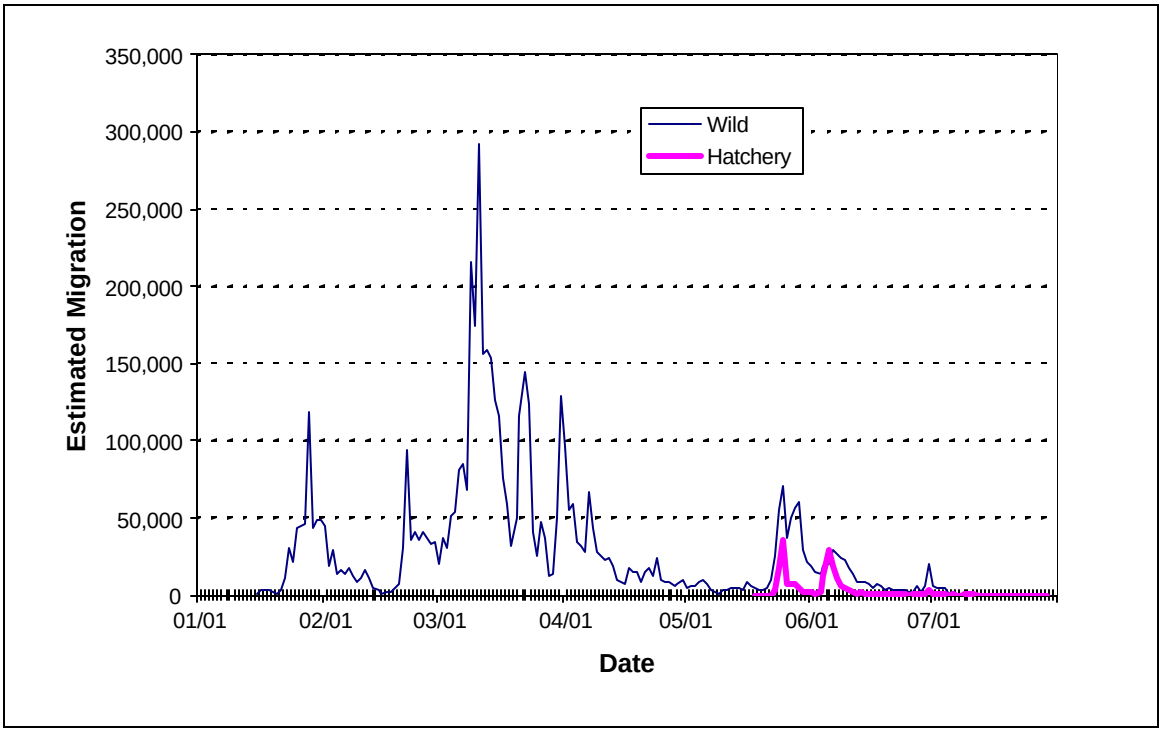

Figure 4. Estimated wild and hatchery 0+ chinook migration past the Skagit River mainstem traps in 2003.

Migration Timing

Wild 0+ chinook were caught on the first night of trap operation, indicating that the migration was under way before we began trapping. The low initial catches, however, indicated that relatively few chinook fry had passed the trap before we started. Similarly, low catches in July indicated the chinook migration was virtually over when trapping ceased on July 31. While catch data exhibited considerable day-to-day variation, the months of January, February, March, and April accounted for 84% of the season total migration (Figure 5). By March 15, we estimate that 50% of the migration had passed the mainstem traps. Over the seven years we have trapped throughout the entire migration (1997 through 2003), the median migration date has ranged from March 10 (1999) to May 2 (1998) (Figure 6).

Ad-marked hatchery spring, summer and fall zero-age chinook were released from three sites in the Skagit River basin: Skagit Hatchery, Countyline acclimation ponds, and Baker River, respectively (Table 8, Figure 1). Hatchery migrants entered catches two to nine days prior to the documented release dates (Table 10, Figure 7). Baker River fall chinook, released lowest in the watershed (R.M. 57), had a median migration timing to the traps of 21 days, and took 46 days to completely migrate past the traps. Skagit Hatchery spring chinook were released higher in the river (R.M. 78) and had a median migration timing to the traps of 15 days, and took up to 42 days to emigrate. Countyline summer chinook, released earliest and highest in the watershed (R.M. 89), had a median migration timing of four days, and took the longest to migrate past the mainstem traps (52 days). In addition to inherent stock differences, migration timing for hatchery 0+ chinook groups is potentially influenced by condition, size, flow, turbidity, release date, and release site.

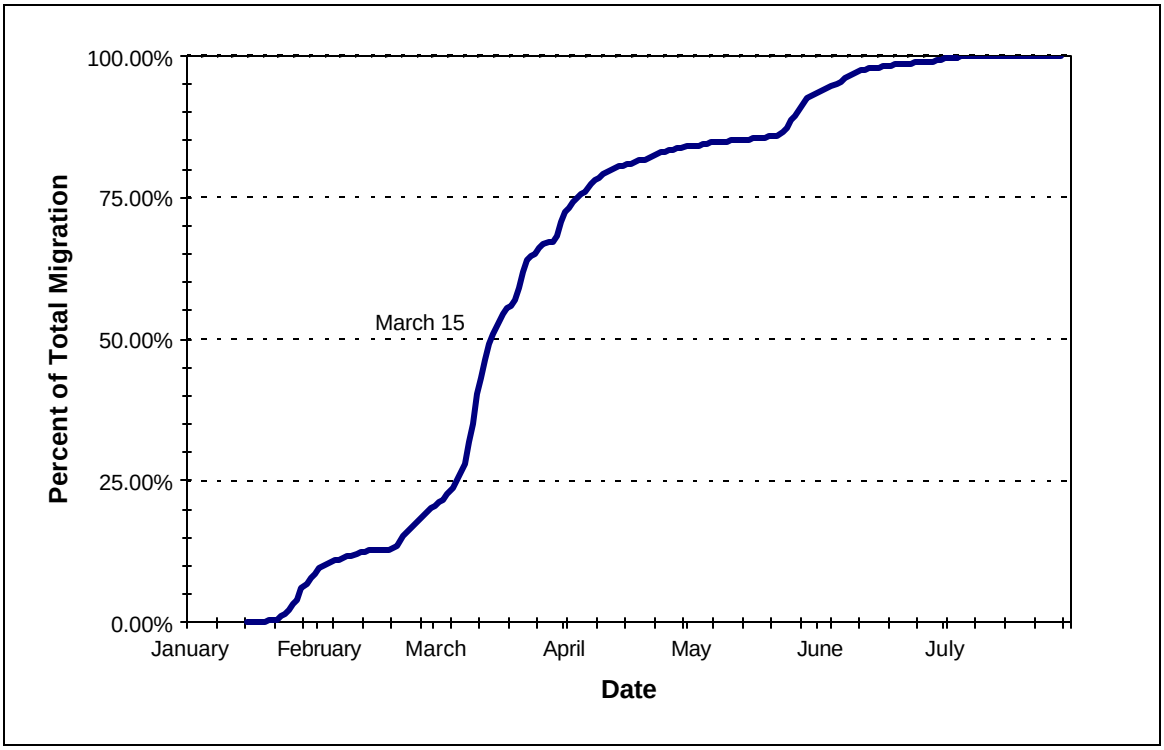

Figure 5. Migration timing of wild 0+ chinook past the Skagit River mainstem traps, 2003.

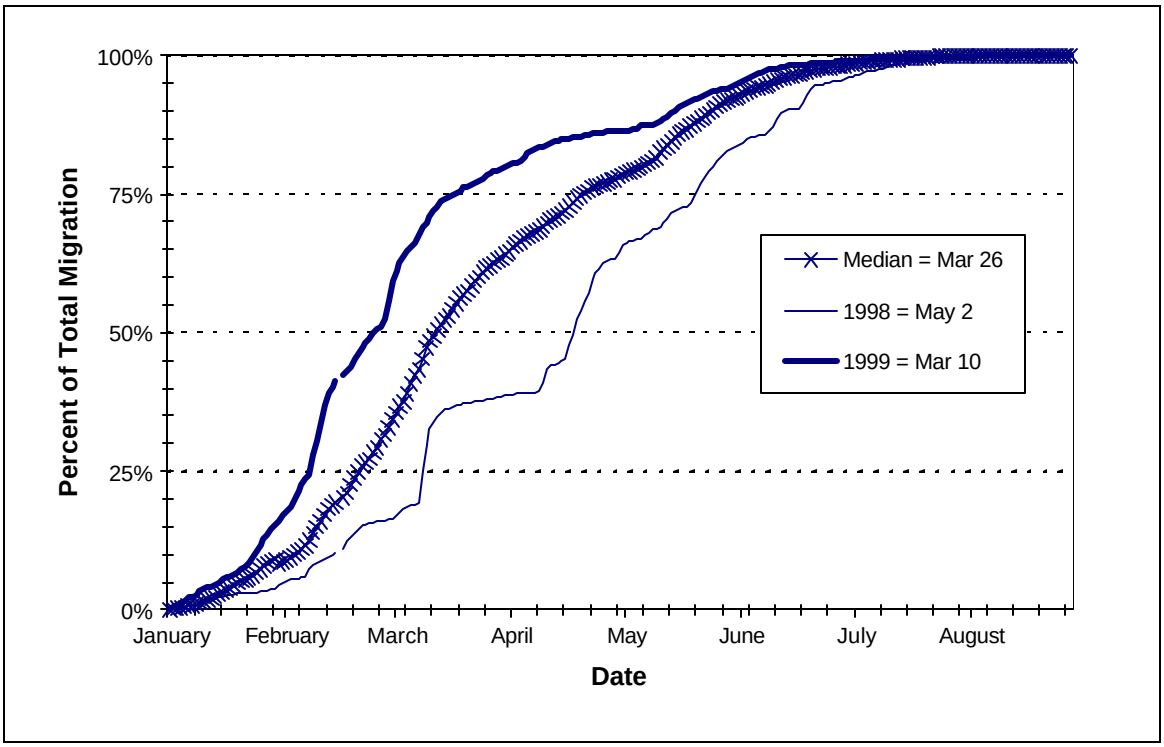

Figure 6. Migration timing variations of wild 0+ chinook, Skagit River mainstem traps 1997-2003.

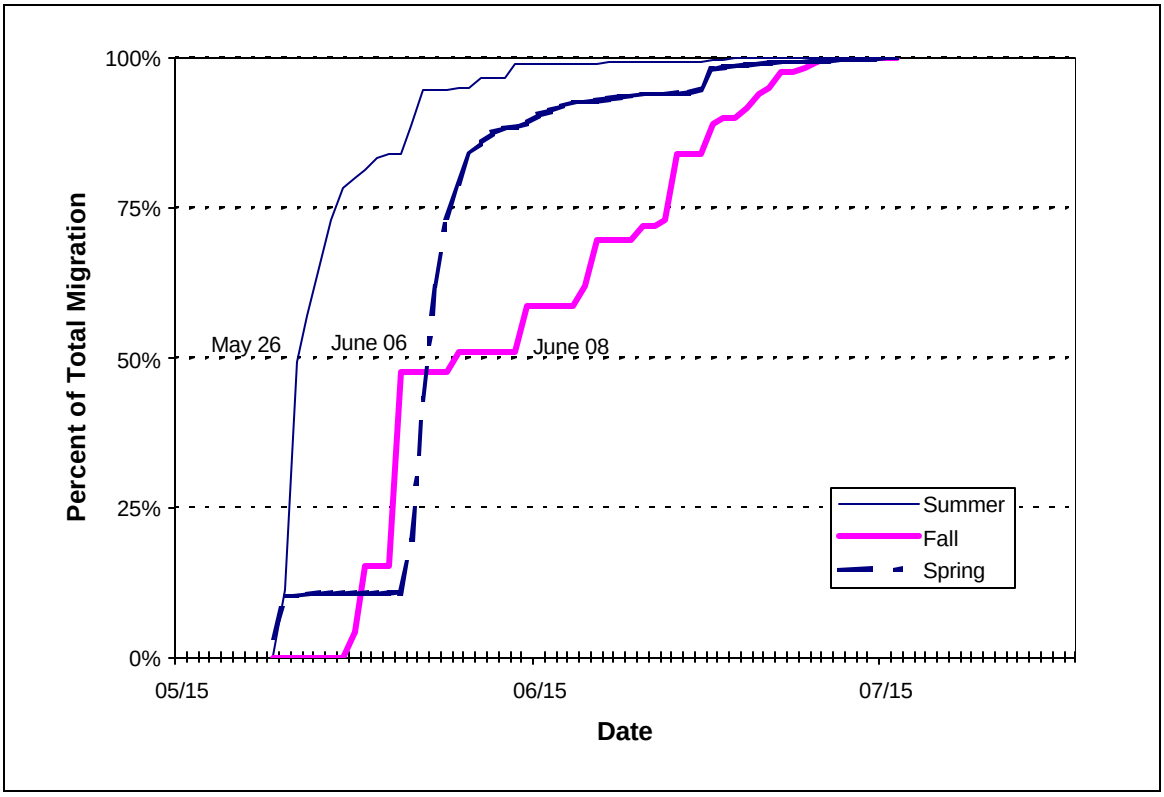

Figure 7. Estimated migration timing of three groups of hatchery 0+ chinook past the Skagit River mainstem traps, 2003.

Wild 0+ Chinook Size

Over the season, wild 0+ chinook captured in the traps increased in size from 40 mm in January and February, to above 80 mm by mid-July (Table 12 and Figure 8). The lower end of the weekly size range did not exceed 40 mm until mid-May, indicating protracted emergence and/or slow growth for a component of the population. These length distributions are similar to previous years. Comparing mean chinook fork lengths between the scoop and screw trap catches by statistical week showed no significant difference (Figure 9).

Length Analysis and Size Selectivity

Moderate river flows dominated the Spring 2003 season, resulting in decreased velocity at the trap site. At lower velocities, larger smolts can avoid capture by swimming away from the trap entrance, and/or out of the traps. Each year, to assess this bias, we compare length distributions (fork length) of LV-marked coho smolts captured in the scoop and screw traps with that of the LV-marked smolts released from the Mannser Creek trap. Length distributions of LV marked smolts recaptured in the scoop and screw traps showed no statistical differences. The mean size of LV-marked smolts captured in the scoop trap was slightly less than the mean size of LV marked smolts captured in the screw trap (91.6 mm and 92.0 mm respectively). Overall, smolts from Mannser Creek averaged 93.4 mm at release, slightly larger. We used the Kolmogorov-Smirnov (K-S) test to analyze fork length distributions of LV-marked smolts released at Mannser Creek compared to those recaptured in the mainstem traps. This test showed no significant differences for the scoop and screw traps individually or combined at the 0.05 probability level (D_{max} = 0.092, " = 0.860).

Table 12. Mean fork length (mm), standard deviation, range, sample size, and catch, by statistical week, of wild 0+ chinook in the Skagit River mainstem traps, 2003.

STAT WEEK			SCOOP TRAP						SCREW TRAP					
			Mean	s.d.	Range		n	Catch	Mean	s.d.	Range		n	Catch
No.	Begin	End			Min	Max					Min	Max		
3	01/14	01/20	40.5	1.70	37	44	20	102	40.4	2.23	35	44	20	120
4	01/21	01/27	40.1	1.38	38	43	41	1,021	40.3	1.32	37	43	39	563
5	01/28	02/03	39.9	1.79	37	43	10	3,403						816
6	02/04	02/10	41.0	1.93	37	47	66	1,491	41.3	3.46	37	64	58	722
7	02/11	02/17	40.8	1.27	38	43	41	560	41.3	2.87	38	53	41	431
8	02/18	02/24	41.2	2.57	38	51	50	1,728	41.2	2.18	38	50	45	1,868
9	02/25	03/03	41.6	3.04	38	56	40	2,437	41.6	2.42	38	51	41	2,089
10	03/04	03/10	41.8	2.09	38	50	36	4,782	41.6	2.53	39	52	43	3,764
11	03/11	03/17	40.9	1.81	38	49	56	7,801	41.9	3.48	39	65	55	5,927
12	03/18	03/24	43.4	4.29	36	59	61	6,495	42.7	4.31	37	57	61	4,101
13	03/25	03/31	42.5	3.50	39	57	43	3,040	42.9	3.91	37	55	43	2,298
14	04/01	04/07	43.0	3.79	38	55	61	4,986	43.3	4.32	38	57	60	2,993
15	04/08	04/14	43.3	4.05	38	56	63	2,527	44.3	5.04	38	60	64	1,746
16	04/15	04/21	45.1	6.87	38	69	61	912	46.6	6.21	39	64	60	644
17	04/22	04/28	44.0	5.54	37	64	70	1,101	48.6	8.73	39	73	70	581
18	04/29	05/05	53.2	10.00	39	75	60	546	51.6	8.65	39	68	60	288
19	05/06	05/12	52.5	8.16	40	75	50	371	56.3	7.49	40	75	50	225
20	05/13	05/19	54.2	9.18	40	79	69	376	57.9	7.68	38	72	70	228
21	05/20	05/26	52.6	7.80	39	71	79	1,297	57.0	8.11	41	75	69	738
22	05/27	06/02	54.7	5.73	44	66	80	3,077	58.4	6.88	45	76	80	2,181
23	06/03	06/09	58.3	6.92	48	87	70	1,502	56.9	5.90	45	73	70	953
24	06/10	06/16	59.4	4.85	45	70	60	821	60.0	7.50	45	74	40	454
25	06/17	06/23	65.5	6.38	51	78	54	321	64.0	6.59	52	81	53	252
26	06/24	06/30	68.8	6.76	55	83	60	199	67.6	6.91	56	82	54	154
27	07/01	07/07	70.3	6.03	58	84	50	351	72.1	7.22	57	93	50	300
28	07/08	07/14	73.9	7.82	57	89	23	40	79.8	5.70	71	92	29	35
29	07/15	07/21	79.5	8.00	68	92	13	26	83.6	6.23	78	96	8	21
30	07/22	07/28	101.0	4.24	98	104	2	3	85.8	14.68	65	99	4	4
					36	104	1,389	51,316			35	99	1,337	34,496

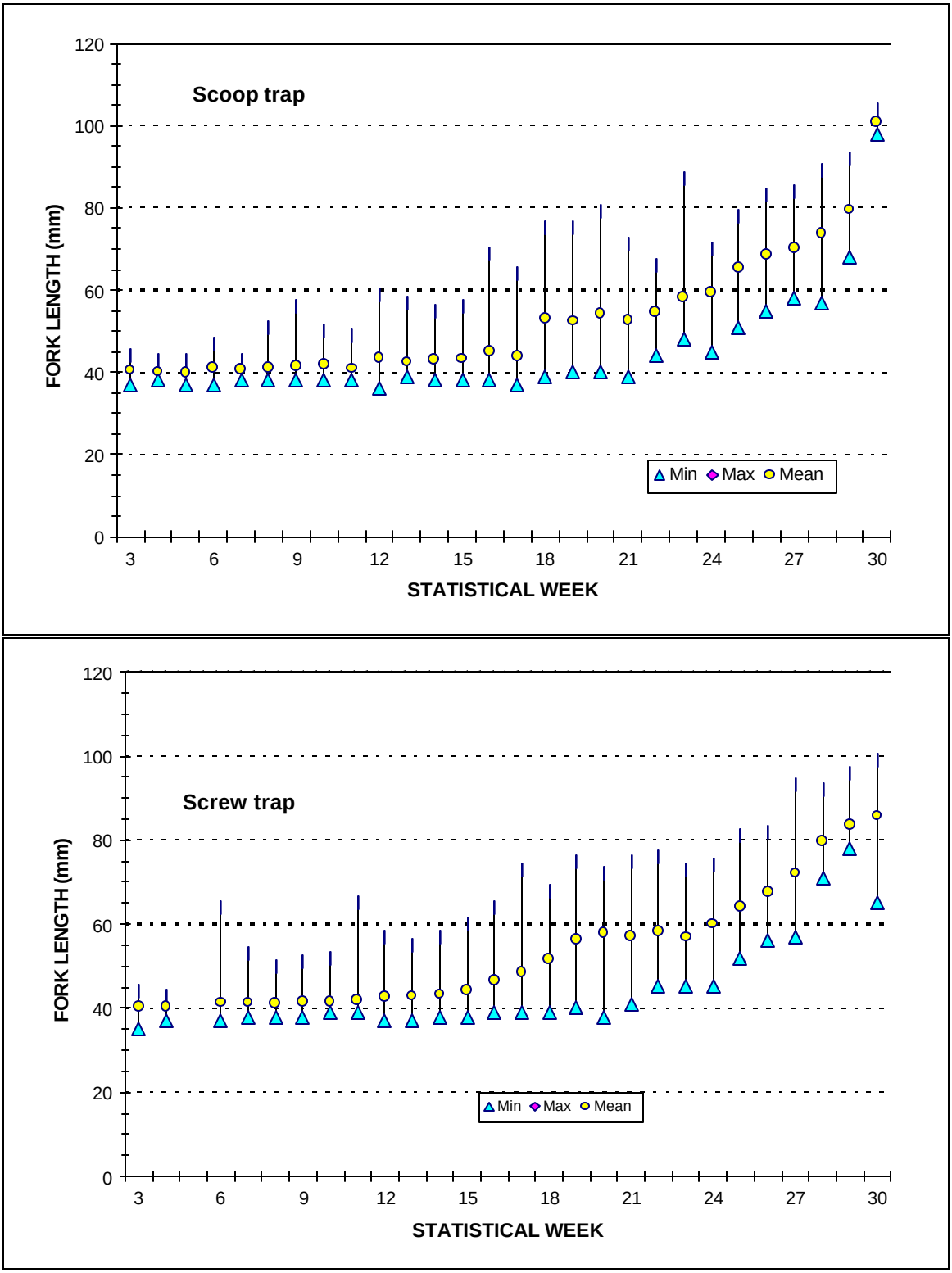

Figure 8. Weekly range and mean fork lengths of wild 0+ chinook measured at the Skagit River mainstem traps, 2003.

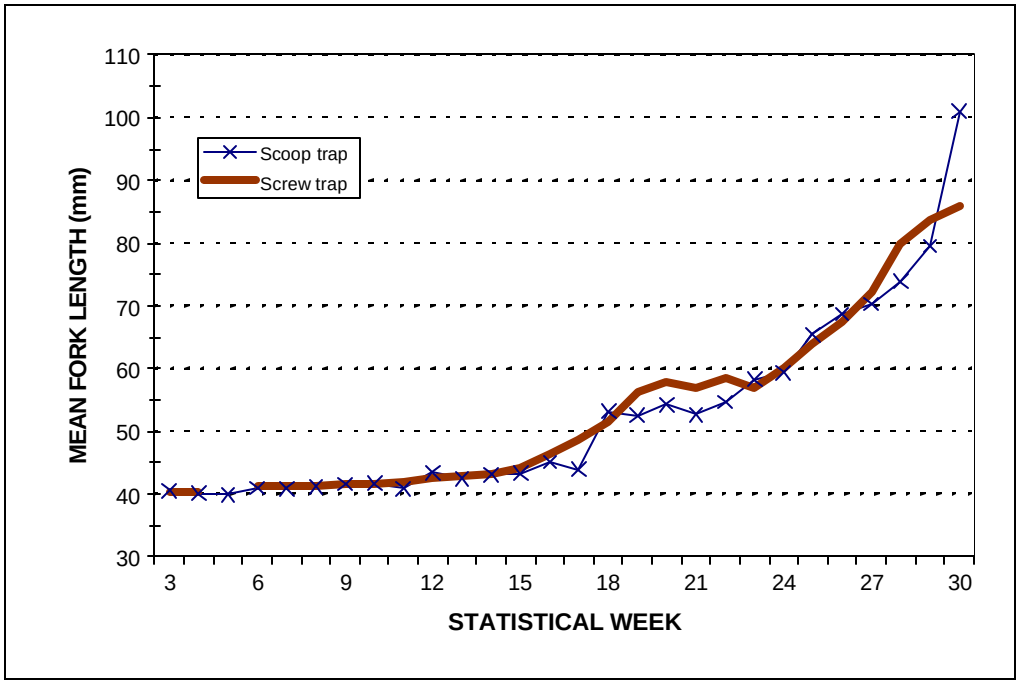

Figure 9. Comparison of mean size of 0+ chinook in the scoop and screw traps, by statistical week, Skagit River 2003.

Egg-to-Migrant Survival

Relating our estimate of 5.5 million downstream-migrant chinook to a potential deposition of 51.1 million eggs, results in an average survival-to-migration of 10.8%. This estimate of potential egg deposition (P.E.D.) is the product of 9,295 females and a fecundity of 5,500 eggs/female (Table 13)

Table 13: Estimated freshwater survival (egg deposition to migration), by brood year, Skagit River wild 0+ chinook (includes spring chinook).

Brood Year (i)	Migr Year (i+1)	Estimated Esc		PED @ 5,500[a] million	Wild Smolts (millions)[b]	Survival to Migration	Winter High Flow Nov 1 – Feb 15	
		Total	Females (@45%)				cfs	Date
1989	1990	8,084	3,638	20.0	1.8	9.0%	88,200	12/05
1990	1991	18,303	8,236	45.3	0.5	1.2%	142,000	11/25
1991	1992	7,062	3,178	17.5	2.4	13.7%	40,100	02/01
1992	1993	8,334	3,750	20.6	3.0	14.4%	27,600	01/26
1993	1994	6,584	2,963	16.3	2.7	16.7%	32,100	12/11
1994	1995	6,019	2,709	14.9	1.5	10.2%	55,700	12/28
1995	1996	7,932	3,569	19.6	0.7	3.8%	132,000	11/30
1996	1997	11,664	5,249	28.9	4.5	15.6%	47,600	01/20
1997	1998	5,913	2,661	14.6	2.4	16.4%	35,600	11/01
1998	1999	15,695	7,063	38.8	6.4	16.5%	51,900	12/14
1999	2000	5,395	2,428	13.4	1.7	12.7%	76,800	11/13
2000	2001	17,951	8,078	44.4	6.0	13.5%	19,300	01/06
2001	2002	15,649	7,042	38.7	5.0	12.9%	73,700	01/08
2002	2003	20,656	9,295	51.1	5.5	10.8%	53,000	01/27

[a] Personal communication, Pete Castle, WDFW.
[b] Prior to the 1996 brood, estimates were based on trapping during the coho migration period (April-June). Full-season trapping commenced in 1997.

Wild Coho Smolt Production Evaluation

Mean d:n ratios for wild coho smolts during their migration period (April through June) were much lower than those observed for wild chinook, 2.4% and 2.6% in the scoop and screw traps, respectively (Table 14 and Table 15). Flows on the days coho d:n ratios were assessed varied two-fold (11,000 to 22,000 cfs), but explained little of the variation in d:n ratios. D:N ratios were not normally distributed. Thus, as with chinook ratios, we opted to use the seasonal median values to estimate the daily d:n ratio.

Smolts marked at Mannser Creek provided the basis for the coho smolt estimate. Projecting total catch of 178 left ventral-marked (LV) wild coho smolts to continuous 24-hour trapping using the seasonal median d:n catch ratio estimates that we would not have captured any additional marked coho. Relating the total projected catch in the mainstem traps of 178 LV-marked smolts from Mannser Creek to the total catch of 13,773 wild smolts estimates the mark incidence at 1.3%. Application of this rate to the 17,965 smolts marked and released at Mannser Creek estimates system production at 1,382,000 wild coho smolts (Table 16). This estimate assumes that all of the LV-marked wild coho smolts survived and passed the mainstem traps during the season.

Table 14. Catch rates of wild coho smolts during day and night periods, Skagit River scoop trap 2003.

NIGHT TIME							DAY TIME							
Trap Down		Trap Up		Hours	Coho	Catch	Date	Time		Hours	Coho	Catch	D:N	Flow
Date	Time	Date	Time	Fished	1+	Rate		Down	Up	Fished	1+	Rate	Ratio	cfs
04/01	19.00	04/03	6.50	23.33	9	0.39	04/02	6.67	18.50	11.83	0	0.00	0.00%	19,300
04/04	19.50	04/06	7.00	23.33	14	0.60	04/05	6.67	18.50	11.83	0	0.00	0.00%	16,200
04/07	19.75	04/09	6.50	21.75	12	0.55	04/08	6.50	19.50	13.00	1	0.08	13.94%	16,700
04/10	19.75	04/12	6.50	21.08	11	0.52	04/11	6.67	20.00	13.33	0	0.00	0.00%	17,900
04/13	19.50	04/15	6.50	21.75	16	0.74	04/14	6.50	19.50	13.00	0	0.00	0.00%	17,600
04/16	20.00	04/18	6.50	21.33	32	1.50	04/17	6.67	19.50	12.83	0	0.00	0.00%	16,500
04/20	20.50	04/22	6.50	19.83	32	1.61	04/21	6.67	20.50	13.83	0	0.00	0.00%	14,400
04/24	20.00	04/26	6.50	20.42	71	3.48	04/25	6.50	20.50	14.00	0	0.00	0.00%	17,000
04/28	20.50	04/30	6.00	19.33	147	7.60	04/29	6.75	20.50	13.75	0	0.00	0.00%	15,000
05/01	20.50	05/03	6.50	20.50	179	8.73	05/02	6.75	20.00	13.25	0	0.00	0.00%	14,000
05/04	20.50	05/06	6.00	19.33	315	16.30	05/05	6.67	20.50	13.83	0	0.00	0.00%	13,000
05/08	20.00	05/10	6.00	19.75	168	8.51	05/09	6.50	20.25	13.75	0	0.00	0.00%	11,700
05/11	20.50	05/13	6.00	18.83	222	11.79	05/12	6.50	20.50	14.00	2	0.14	1.21%	11,600
05/14	20.00	05/16	6.25	20.08	202	10.06	05/15	6.67	20.50	13.83	1	0.07	0.72%	12,700
05/17	21.00	05/19	6.00	18.33	261	14.24	05/18	6.25	20.50	14.25	4	0.28	1.97%	11,800
05/20	21.00	05/22	6.00	17.83	180	10.10	05/21	6.17	21.00	14.83	0	0.00	0.00%	11,000
05/23	21.00	05/25	5.00	17.25	1,203	69.74	05/24	6.25	20.50	14.25	58	4.07	5.84%	17,900
05/26	21.00	05/28	6.00	17.83	172	9.65	05/27	6.17	21.00	14.83	2	0.13	1.40%	18,600
05/29	21.25	05/31	6.00	16.58	209	12.61	05/30	5.75	21.50	15.75	33	2.10	16.62%	21,100
06/01	21.50	06/03	5.50	15.83	110	6.95	06/02	5.75	21.50	15.75	4	0.25	3.65%	19,600
06/04	21.50	06/06	5.50	15.75	106	6.73	06/05	5.67	21.50	15.83	0	0.00	0.00%	19,900
06/10	21.50	06/12	5.50	15.75	35	2.22	06/11	5.67	21.50	15.83	0	0.00	0.00%	22,400
06/13	21.75	06/15	5.50	15.75	17	1.08	06/14	5.50	21.25	15.75	3	0.19	17.65%	20,700
06/16	21.50	06/18	5.50	16.00	23	1.44	06/17	5.75	21.00	15.25	0	0.00	0.00%	18,500
06/19	21.50	06/21	5.75	16.08	16	1.00	06/20	5.75	21.50	15.75	0	0.00	0.00%	17,800
06/22	21.50	06/24	5.50	16.00	4	0.25	06/23	5.67	21.25	15.58	0	0.00	0.00%	14,400
		April-June Total		489.62	3,766	7.69				369.71	108	0.29	3.80%	
		April-June Median											0.00%	
		April-June Mean											2.42%	

Table 15. Catch rates of wild coho smolts during day and night periods, Skagit River screw trap 2003.

NIGHT TIME							DAY TIME							
Trap Down		Trap Up		Hours	Coho	Catch	Date	Time		Hours	Coho	Catch	D:N	Flow
Date	Time	Date	Time	Fished	1+	Rate		Down	Up	Fished	1+	Rate	Ratio	cfs
04/01	19.00	04/03	6.50	23.50	14	0.60	04/02	6.67	18.50	11.83	0	0.00	0.00%	19,300
04/04	19.50	04/06	7.00	23.50	23	0.98	04/05	7.00	18.50	11.50	0	0.00	0.00%	16,200
04/07	19.75	04/09	6.50	21.75	14	0.64	04/08	6.50	19.50	13.00	0	0.00	0.00%	16,700
04/10	19.75	04/12	6.50	21.75	21	0.97	04/11	6.50	19.50	13.00	0	0.00	0.00%	17,900
04/13	19.50	04/15	6.50	21.75	22	1.01	04/14	6.50	19.75	13.25	1	0.08	7.46%	17,600
04/16	20.00	04/18	6.50	21.50	22	1.02	04/17	6.50	19.50	13.00	0	0.00	0.00%	16,500
04/20	20.50	04/22	6.50	20.25	52	2.57	04/21	6.50	20.25	13.75	0	0.00	0.00%	14,400
04/24	20.00	04/26	6.50	20.75	103	4.96	04/25	6.50	20.25	13.75	0	0.00	0.00%	17,000
04/28	20.50	04/30	6.00	20.00	168	8.40	04/29	6.50	20.00	13.50	0	0.00	0.00%	15,000
05/01	20.50	05/03	6.50	20.50	254	12.39	05/02	6.50	20.00	13.50	21	1.56	12.55%	14,000
05/04	20.50	05/06	6.00	19.50	453	23.23	05/05	6.00	20.00	14.00	6	0.43	1.84%	13,000
05/08	20.00	05/10	6.00	20.25	193	9.53	05/09	6.50	20.25	13.75	0	0.07	0.00%	11,700
05/11	20.50	05/13	6.00	19.00	334	17.58	05/12	6.00	20.50	14.50	1	0.07	0.39%	11,600
05/14	20.00	05/16	6.25	19.75	239	12.10	05/15	6.00	20.50	14.50	5	0.34	2.85%	12,700
05/17	21.00	05/19	6.00	17.50	369	21.09	05/18	5.67	20.50	14.83	7	0.47	2.24%	11,800
05/20	21.00	05/22	6.00	17.50	322	18.40	05/21	5.50	21.00	15.50	1	0.06	0.35%	11,000
05/23	21.00	05/25	5.00	16.50	991	60.06	05/24	6.00	20.67	14.67	69	4.70	7.83%	17,900
05/26	21.00	05/28	6.00	17.50	301	17.20	05/27	5.50	21.00	15.50	4	0.26	1.50%	18,600
05/29	21.00	05/31	6.00	17.00	320	18.82	05/30	5.00	21.00	16.00	23	1.44	7.64%	21,100
06/01	21.50	06/03	5.50	15.50	117	7.55	06/02	5.00	21.50	16.50	7	0.42	5.62%	19,600
06/04	21.50	06/06	5.50	15.50	95	6.13	06/05	5.00	21.50	16.50	3	0.18	2.97%	19,900
06/10	21.50	06/12	5.50	15.25	22	1.44	06/11	5.00	21.50	16.50	0	0.00	0.00%	22,400
06/13	21.75	06/15	5.50	15.25	22	1.44	06/14	5.50	21.25	15.75	3	0.19	13.20%	20,700
06/16	21.50	06/18	5.50	15.25	23	1.51	06/17	5.00	21.50	16.50	0	0.00	0.00%	18,500
06/19	21.50	06/21	5.75	16.25	13	0.80	06/20	5.50	21.50	16.00	0	0.00	0.00%	17,800
06/22	21.50	06/24	5.50	16.00	6	0.38	06/23	5.50	21.25	15.75	0	0.00	0.00%	14,400
		April-June Total		488.75	4,513	9.23				376.83	151	0.40	4.34%	
		April-June Median											0.18%	
		April-June Mean											2.56%	

Table 16. Estimation of wild coho smolt production, Skagit River 2003.

	Number	Formula
Total mainstem trap catches	15,449	
Skagit Hatchery/Lake Shannon	-1,676	
Wild coho captured (c)	**13,773**	
LVs recaptured (r)	178	N = (m+1)(c+1)
LVs released (m)	17,965	(r+1)
Total production (N)	**1,382,479**	
Variance (Var)	1.04E+10	Var = (m+1)(c+1)(m-r)(c-r)
Standard Deviation (sd)	102,145	(r+1)^2(r+1)
Coefficient of Var (CV)	7.39%	CV = sd/N
Confindence Interval (CI)	200,204	CI = +/- 1.96(sd)
Estimated coho production		
Skagit River	1,382,479	
Upper CI (95%)	1,582,683	
Lower CI (95%)	1,182,274	

Assumptions

Every estimate relies on assumptions. Although we know that trap efficiency varies over time, we assume it is a relatively constant fraction of smolt abundance. We presently do not have a flow-based correlation model to indicate its variation. Therefore, we selected a value based on the recapture rates of several groups of marked chinook released over many years to represent a season average rate. We made the following assumptions to estimate the numbers of wild 0+ chinook migrating from the Skagit River in 2003.

1. **Catch Expansion**. Moderate to low flows dominated the trapping season in 2003. Expansion of catch to the standard of continuous trap operation involved estimation of fish passing the traps on missed nights and estimating catch for the daytime periods that we did not fish.

2. **Trap Efficiency**. Estimating trap efficiency also involves the expansion for daytime catch for all marked fish categories used to indicate capture rates. Inherent in this approach is the assumption that trap efficiency during the daytime is identical to that during the night hours. Basic assumptions for every trap calibration group of marked fish include:
    a. The number passing the gear is known (survival from release to the trap is 100%);
    b. All marked fish captured are identified and enumerated;
    c. Marked hatchery chinook were captured at the same rate as wild chinook; and
    d. Instantaneous trap efficiency is not a function of light.

Discussion of Assumptions

Although direct assessment of the above assumptions is not possible, we have some intuition as to how important they are and in which direction some of them may be violated. These beliefs and their effects on our estimate of the zero-age chinook production from the Skagit River follows:

Assumption #1: Catch Projection
We have no reason to believe that the catch projections using expansions of the day/night ratios for the day light periods not fished are biased. We believe that the catch projection for the season is a reasonable estimate of the numbers of wild zero-age chinook that we would have caught in both traps had we fished continuously from mid-January to July 30.

Assumption #2a: 100% Survival of Calibration Fish
It is unlikely that all of the calibration fish in each group survived to pass the trap. However, for calibration tests involving the release of marked hatchery chinook, the short distance from the release site to the traps (about 1 mile), and condensed recovery time would support high survival to the traps. The recovery rate for chinook released from the upper river hatcheries varied little: 0.9% for Countyline Ponds summers; 0.8% for Skagit Hatchery springs; and 0.4% for the Baker River falls.

Assumption # 2b: Complete Identification/enumeration of All Marked Fish Captured
We are confident that virtually every marked fish captured was identified and recorded. The 2003 trap crew was comprised of trained scientific technicians with several years experience at this site. Consequently, we don't consider this potential bias to be significant.

Assumption # 2c: Marked Hatchery Chinook Were Captured at the Same Rate as Wild Chinook

The degree to which the hatchery chinook represent wild 0+ chinook is unknown. The similarity of d:n ratios over the season provides some evidence that hatchery fish are responding to the river conditions in a manner similar to that of the wild chinook. Presently, we do not have any indication that hatchery produced 0+ chinook are caught at different rates than wild chinook.

Assumption #2d: Trap Efficiency Is Not Affected by Light

If this assumption is not correct, then it is likely that efficiency during the day is lower relative to the night rate; trap avoidance enhanced by daylight is the likely reason, if a difference exists. Another factor that would contribute to lower capture rates during the daylight could be any shifting in the migration path to deeper water as a function of light. In an attempt to measure trap efficiency during the day and night, in Spring 1999, we released paired groups of hatchery chinook. As we expected, however, these fish did not pass the gear within their release strata (catches occurred primarily at night), so these tests provided no insight into this potential problem. If the hatchery calibration groups have the same diel migration behavior as wild fish, then different capture rates for day and night would not constitute a source of bias. Therefore, this assumption is really the same as #2c, for which we have little intuition.

Conclusion

As in previous years, we conclude that the critical assumption for producing unbiased estimates of wild 0+ chinook production is the estimate of trap efficiency. Bias in the production estimate results largely from variation in this critical parameter. Trap efficiency in 2003 was estimated by the recoveries from five calibration groups (four wild and one hatchery). The assumption "that hatchery fish represent their wild cohorts in every aspect that affects capture rate" is inherent to these estimates (Seiler *et al.* 2002). Although recovery rates of the four wild groups were lower than for the single hatchery release group, we do not believe inclusion of the hatchery biased the capture rate estimate. Low flows (11,700 cfs) during release of the hatchery group may have increased their capture rate. Mean trap efficiency for 2003 was estimated at 2.13% by the release of these five groups. This rate is nearly identical to the average over all years (2.03%). We believe that the estimate of trap efficiency obtained over all years, which includes recoveries from 25 calibration groups, is the best approximation of season trap efficiency in 2003. Application of this rate (2.03%) estimates that 5.5 million wild 0+ chinook passed the traps in the Skagit River in 2003. If this estimate is biased, we believe that it is high, because it is unlikely that all marked chinook, wild and hatchery, survived to pass the traps. Therefore, actual capture rate may be somewhat higher than indicated by the calibration groups released over the six-year period.

Discussion

Relatively moderate flows, which prevailed throughout the 2003 season, allowed almost continuous trapping. Migration timing in 2003 was similar to previous years, with a median migration date of March 15. The influence of flow on migration timing may become more evident as we compare results from subsequent seasons, which may include a wider range of flow patterns. It is important to remember, however, that these estimates are based on catch and the assumption of constant trap efficiency within each season.

Trap efficiency is the link between catch and estimating production. The accuracy of all of our within-season estimates and inter-annual comparisons depend on the veracity of this most critical parameter (Seiler *et al.* 2002). In each year since 1998, we conducted several test releases in an attempt to improve our understanding of capture rates. Recovery rates of the 25 calibration groups we have released over the years ranged from 0.7% to 3.6%, and averaged 2.0%. The recovery rates of hatchery chinook groups released from the upper basin (Skagit Hatchery and Countyline Ponds) have been more uniform than the calibration release groups (0.7% to 1.7%), indicating that inter-annual variation in trap efficiency may be lower than that indicated by the variation among the smaller calibration groups.

In-river mortality, presumably due to predation, is a function of the distance traveled. In most years, average recovery rates of the calibration groups released approximately one mile upstream of the traps have exceeded that of the hatchery production groups released further upstream. In 2003, we believe low flows decreased survival of the hatchery chinook groups to the traps. Therefore, release location and flow are important sources of bias in using these hatchery groups to estimate capture rate. In addition, such other factors as release timing relative to flows, fish health, and fish size at release could explain some of the differences between recovery rates of wild chinook and the hatchery production groups.

Improving our estimates of the 0+ chinook production from the Skagit River largely depends on calibrating the traps for a range of conditions. Instantaneous trap efficiency is not constant over the season; it varies as a function of flow, velocity, turbidity, light, water temperature (possibly), and fish size. Flow is undoubtedly the most important variable because it integrates other physical parameters that affect fish behavior and trap operation. At the trap site, velocity is a positive function of flow, as evidenced by the rotational speed of the screw trap. Even for a given discharge, however, velocity and flow vectors can be altered by large woody debris, both upstream of the railroad bridge and locally, at the trap site. Turbidity also appears to be an important parameter that affects the rate that chinook migrate during the day and, potentially, their vertical and lateral locations in the channel. Using hatchery fish to represent the responses of wild fish to the complex interactions of these variables with fish size, their physiological status, and the traps may present incalculable biases.

Over the previous thirteen seasons, flow during egg incubation has explained most of the inter-annual variation in our estimates of egg-to-migrant survival rates (Figure 10). The production in 2003 is lower than predicted by this relationship, which may indicate other factors at work. We will undertake additional analyses of flow effects during freshwater life stages to assess such variation. One explanation for the lower-than-predicted survival involves the potential density-dependent effects of the spawning population in 2002. This return, estimated at 20,656 adults, is the highest from which we have estimated production in this system (Table 13). Continued monitoring including

future broods with higher spawning populations will further define the constraints to chinook production in the Skagit River.

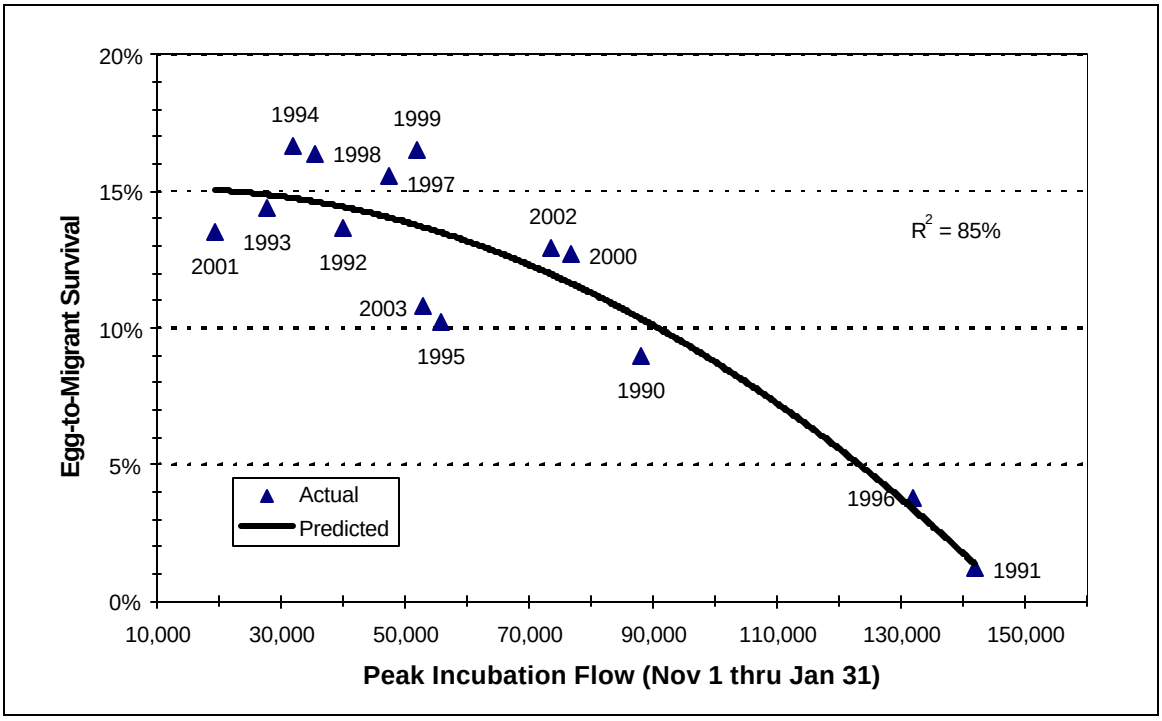

Figure 10. Wild 0+ chinook egg-to-migrant survival and peak incubation flow, migration years 1990-2003, Skagit River

Recommendations

The following recommendations, compiled from the past five years' work, are listed so that we can assess the progress made during the 2003 season. As noted in last year's report, these measures include actions that we may reasonably and cost-effectively implement within the current scope and funding level of our trapping program in the lower Skagit River.

1. Continue trapping during an extended season over a sufficient span of years and flow conditions to gain an understanding of the inter-annual variation in migration timing.

2. Count catches at or near sunrise and sunset to increase information in the database to enable day:night catch comparisons.

3. Analyze turbidity to assess correlations with migration and flow.

4. Increase the numbers of release groups of marked wild and hatchery 0+ chinook and, if possible, release paired groups of hatchery and wild chinook to assess differences in recovery rates.

Progress:

1. **Accomplished**. We trapped each night with the exception of 13 nights, from January 15 through July.

2. **Accomplished**. On most dates over the season, we counted catches at dusk and dawn.

3. **Accomplished**. We analyzed turbidity data and measured visibility throughout the 2003 season.

4. **Accomplished**. As documented in this report, we released five groups of marked chinook.

Recommendations for 2004

Our study plan for the 2004 season includes continuing all of the above recommendations.

1. We will continue to assess the relationship of flow, turbidity, and migration rates

2. Increase the number of marked wild and hatchery 0+ chinook release groups to assess recapture rates at various flow levels.

3. When possible, conduct paired releases of hatchery and wild fish to test the assumption of similar capture rates.

4. Conduct pilot 0+ chinook releases early in the season with dye marked chum, pink, and chinook fry to assess recapture rates for these fish.

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