STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE

Annual Report

2002 Skagit River
Wild 0+ Chinook Production Evaluation

Funded by Seattle City Light

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Acknowledgements

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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, Trace Swann, Scott Schueltzer, and Tim Eichler, 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, Mark Hino developed the computer database and analyzed much of the trap data contained in this report, and Laurie Peterson helped with editing and final compilation of this report.

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 2002 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 2002 was in its thirteenth 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 gulper 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 resultant 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 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 previous 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 and 1999, 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 2002

The study plan for the 2002 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 eleven years, the 2002 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 2002 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 six groups of hatchery chinook above the trap to serve as calibration groups.

6. **Measuring visibility**. 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. Visibility data will be correlated with flow, turbidity measured at the Mount Vernon water intake, 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 in steel pontoon barges, outfitted with two five-ton, bow-mounted anchor winches loaded with up to 600 ft of -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 appropriate external marks. Samples of wild chinook, coho, steelhead, and char were measured (fork length) over the season.

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 and visibility daily using a standard secchi disk, which we compared with 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 visibility and turbidity data. These correlations were used 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.

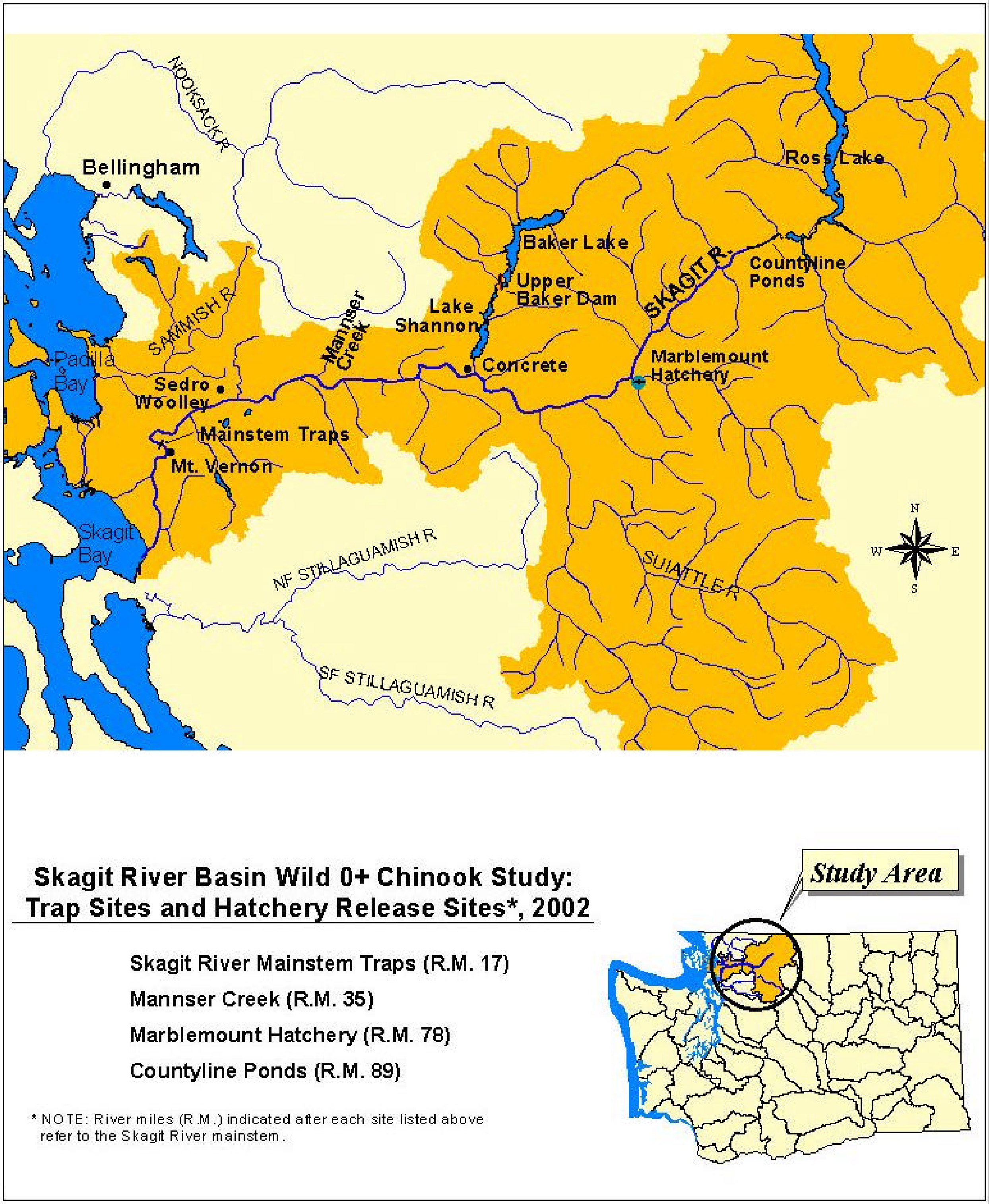


Figure 1: Map of tributary and mainstem trap sites, and hatchery release sites, Skagit River chinook production evaluation 2002.

Equation 1: Basic formulas

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

Where: M = *migrants*
C = *catch*
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 average day:night (d:n) catch ratios (Equation 3).

Equation 2: Comparing day catch rates to night catch rates

$$R_i = C_{h_{di}} \frac{h_{ni-1} + h_{ni}}{C_{ni-1} + C_{ni}}$$

Where: i = *24-hour period from sunrise to sunrise;*
R_i = *ratio of day to night catch rates for period i;*
$C_{h(di)}$ = *catch/hour during daylight for period i;*
C_{ni-1} = *catch/hour during the night before period i;*
C_{ni} = *catch/hour 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*

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 contiguous nights that the traps did not fish, we expanded catches by the catch per hour rates prior to and after the trap outages. Catches during the daylight intervals that we did not fish were estimated from night catches or the d:n ratio correlations with 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. As discussed above, however, this may not be feasible with chinook. We had three primary indicators of trap efficiency in 2002: recaptures of the wild coho marked at the tributary 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. Following an accidental release of the summer chinook from Countyline Ponds on May 17 and the spring chinook from Skagit Hatchery on June 1, 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:

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

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

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

$\hat{F}_i$ = *estimated 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 (pers. comm. Pete Castle, WDFW).

Results

Trap Operation and Flow

The traps were installed on January 15. Trapping began on the night of January 16, and ended on July 30. Over this 197-day season, we operated the scoop trap every night with the exception of 15 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 57 days, usually at a frequency of every third day. In total, we fished this trap 2,665 hours out of a possible 4,728 hours, 56.4% of the total season. The screw trap fished on nearly the same schedule, although for slightly fewer hours. In total, the screw trap fished 2,631 hours, 55.7% of the total season (Table 1).

Flows generally exceeded the 61-year mean daily stream flow throughout the year, with daily averages ranging from 11,000 to 65,700 cfs during the 2002 trapping period (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			
		Start	End		Full	Partial	Full	Partial		Total	Trapped	Percent Fished
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%

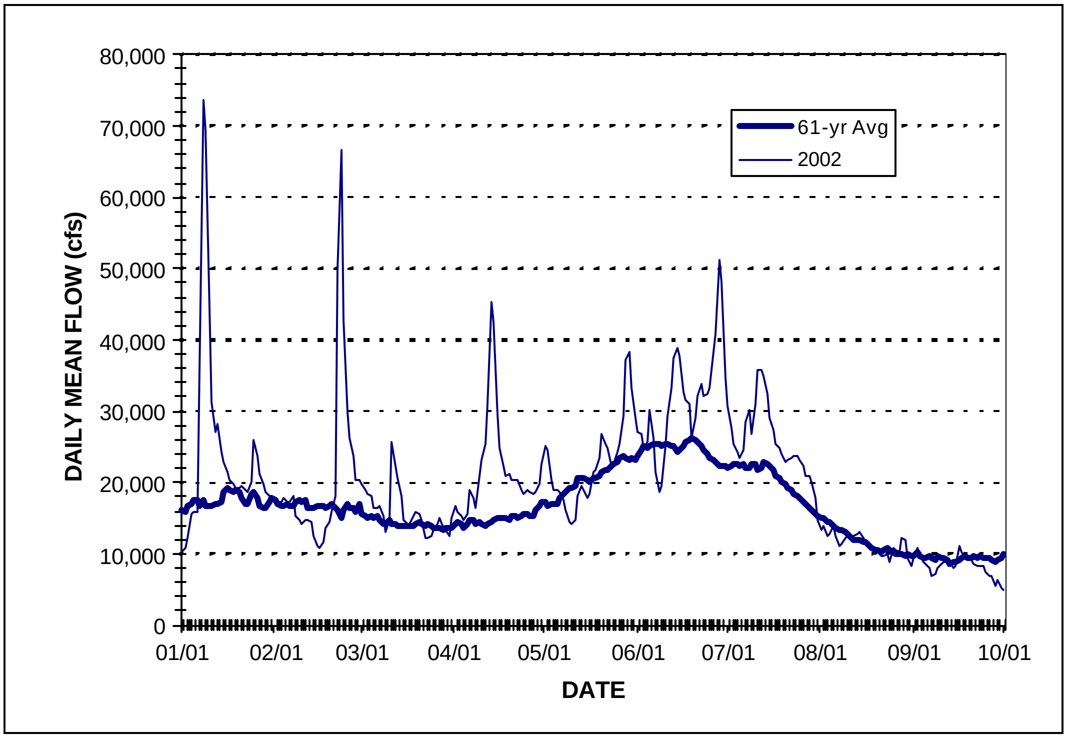


Figure 2: Comparison of daily mean flows in 2002 with the 61-year average (1940-2001), Skagit River near Mt. Vernon (USGS data), January through September.

Visibility and Turbidity

We used a secchi disk to measure visibility each day, with the exception of eleven days in May, when the disc was lost. Over the season, secchi disk values ranged from 21 to 278 cm. Day-to-day variation rarely exceeded a factor of two. Monthly averages ranged from a low of 84 cm in June to a high of 175 cm in May (Table 2). For the period we operated the traps, flow explained 46% of the daily variation in visibility. We also compared average daily turbidity data recorded at the Anacortes water withdrawal facility in Mt. Vernon. These readings agreed with the secchi readings taken daily at the traps, although not perfectly (R^2 = 77%, Figure 3). Flow explained 62% of the daily variation in turbidity measurements over the period trapped (Figure 4). Our secchi data represents one value at a specific point in time, rather than an average over a 24-hour period. 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 rain, clouds, or sunlight (Table 2).

Table 2: Summary of secchi measurements, turbidity data, and flow (USGS) measured, Skagit River mainstem traps at Mt Vernon, 2002.

Month	VISIBILITY (cm)			TURBIDITY			FLOW		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
January	21	126	86	5.5	24.7	11.6	17,700	25,600	20,140
February	26	188	106	2.5	30.0	9.9	11,300	29,400	17,900
March	72	278	167	2.3	15.5	5.8	12,500	21,900	15,730
April	84	167	138	3.7	22.0	7.2	15,100	25,000	18,600
May	106	260	175	2.6	6.4	4.3	17,800	25,000	20,988
June	70	100	84	6.2	11.8	9.1	21,200	37,200	28,400
July	73	144	112	6.6	15.8	10.1	20,900	30,300	24,571
All	21	278	128	2.3	30.0	7.9	11,300	37,200	20,280

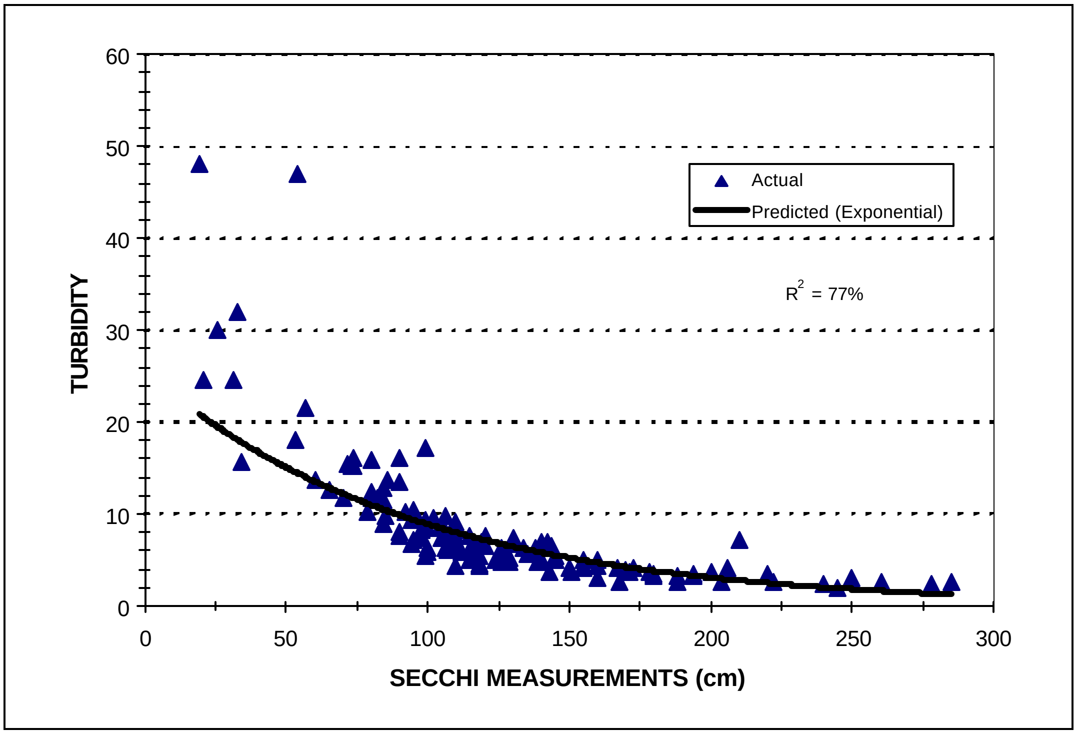


Figure 3: Comparison of secchi disk measurements taken at the mainstem traps and average daily turbidity data taken at the Anacortes water withdrawal facility in Mt. Vernon, Skagit River 2002.

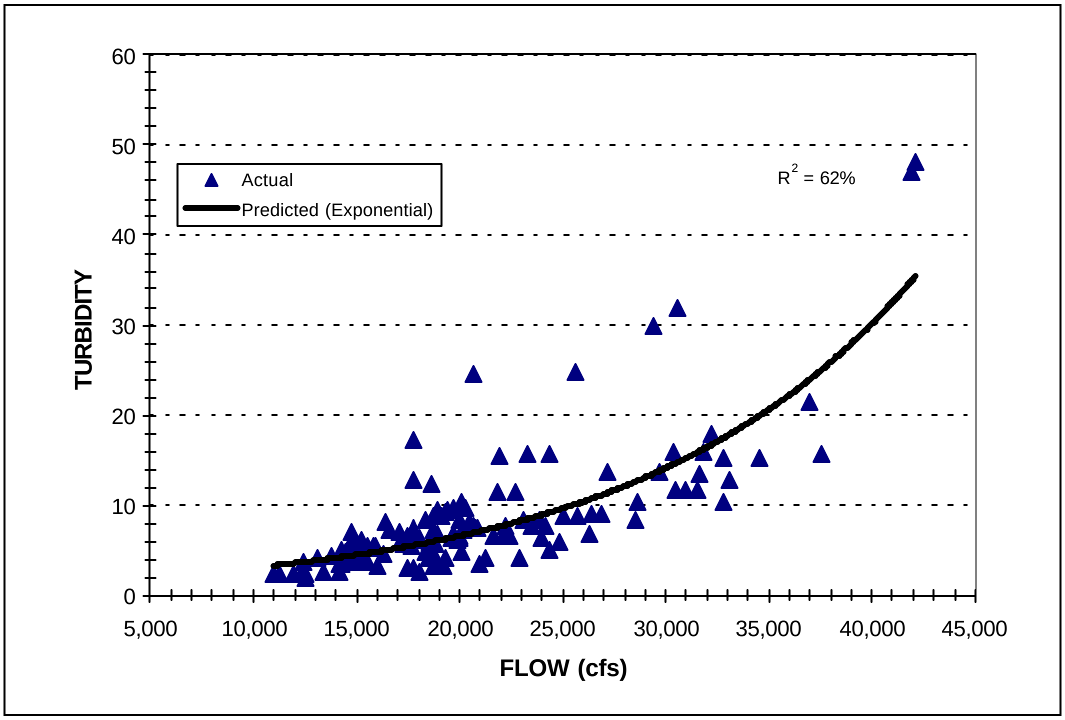


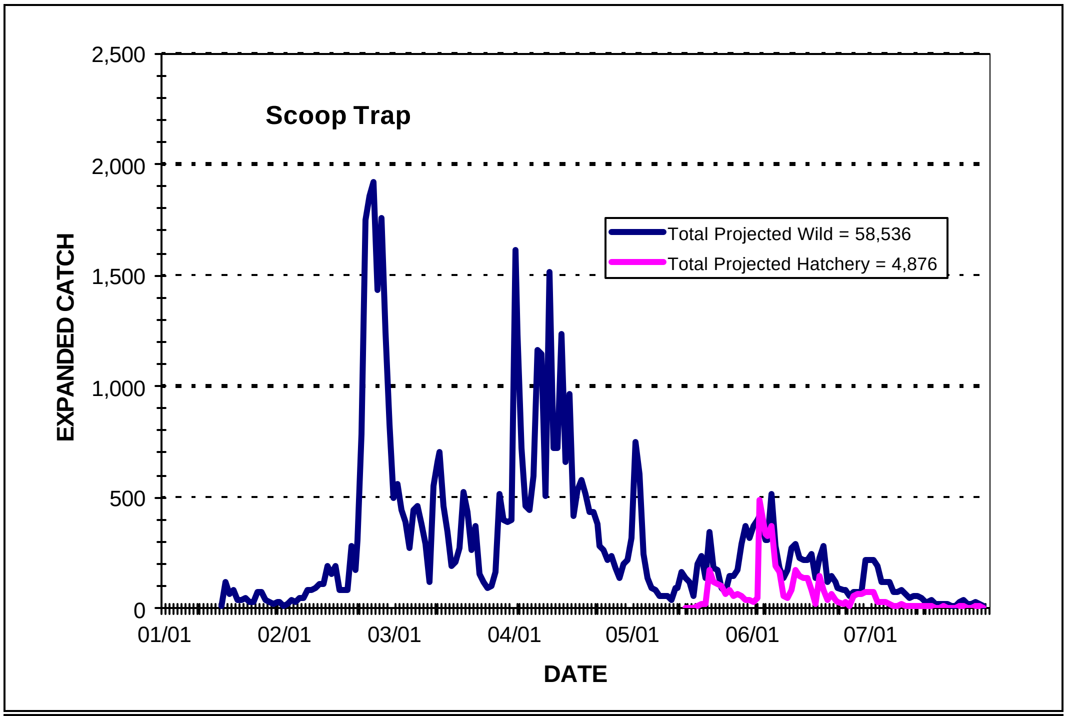
Figure 4: Correlation of daily mean turbidity (measured at the Anacortes water withdrawal facility) and flow (USGS data), Skagit River mainstem traps 2002.

Juvenile Chinook Catches

Chinook fry were moving downstream when we began trapping in mid-January. Catch rates remained low through January, and averaged just 2 and 4 chinook fry/hour over the first three days of trapping for the scoop and screw traps, respectively. By the end of January, catch rates had decreased, to less than one zero-age chinook/hour. The highest average catch rate of wild chinook over a night (110/hour in the scoop trap) occurred on the night of February 21. Over the remaining season, wild 0+ chinook catch rates fluctuated (Figure 5). In early-July, catches were less than 50 chinook/night, and dropped to less than 20 fish/night by mid-July. By the end of July wild chinook catch rates averaged less than 2 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 5). Through July 31, the scoop and screw traps captured wild 0+ chinook at average rates of 13 and 9 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 60,240 wild and 6,036 hatchery 0+ chinook (Table 3). The hatchery 0+ chinook catch does not include the numbers of fin-marked chinook that we released above the trap on four dates to estimate trap efficiency. Catches for the years prior to the extended trapping season are listed in Table 4.



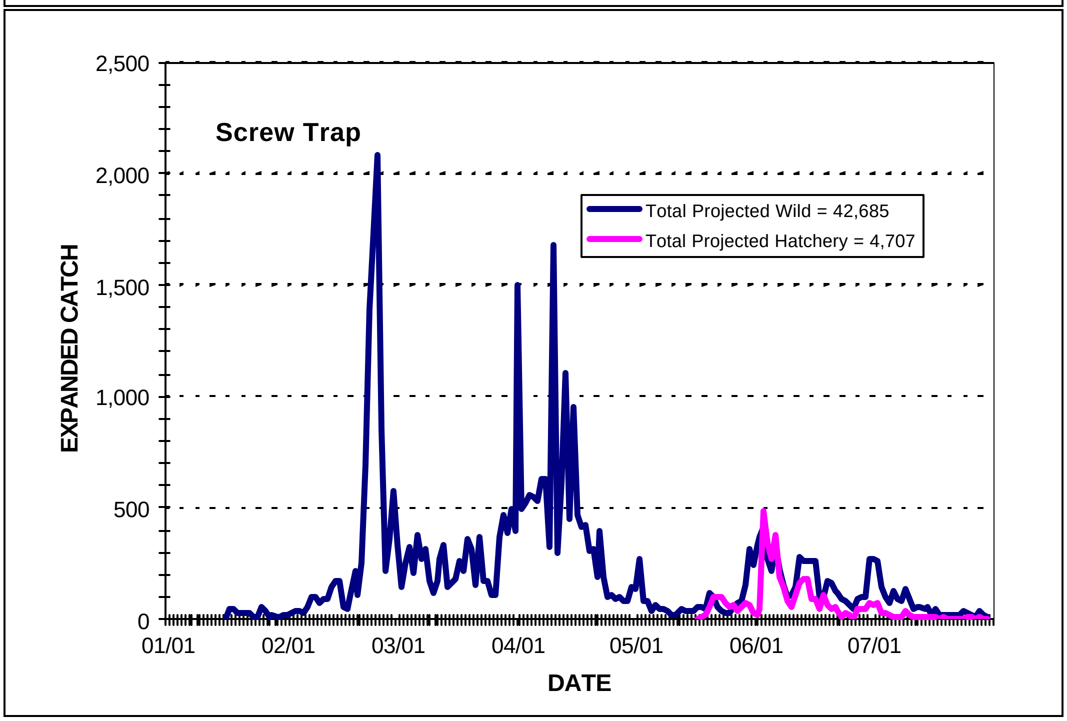


Figure 5: Projected wild and hatchery 0+ chinook catches, Skagit River mainstem traps, 2002.

Table 3: Downstream-migrant salmonids captured in the Skagit River mainstem traps, 1997-2002.

Species	1997		1998		1999		2000		2001		2002	
	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
Hatchery	334	362	623	1,028	673	635	624	946	103	398	453	668
Coho 0+	364	220	1,216	409	744	311	115	27	2,604	871	1,896	435
Chinook 1+												
Wild	46	52	876	350	198	87	129	105	32	26	199	228
Hatchery	376	249	24	12	201	41	511	360	26	50	177	161
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
Hatchery	1,163	684	5,837	2,127	3,449	2,213	2,554	2,152	1,667	1,354	3,310	2,726
Sockeye 1+	59	48	111	84	72	23	9	11	5	1	27	35
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
Pink 0+	9	17	338,520	102,338	476	265	207,530	198,015	2,644	1,350	104,782	153,668
Steelhead 1+												
Wild	319	531	389	1,100	99	334	95	597	32	317	118	437
Hatchery	982	2,401	446	2,325	122	511	75	736	23	465	75	534
Steelhead Adult	3	4	1	3	11	1	1	2	0	0	1	2
Cutthroat 1+	58	89	98	401	30	150	51	248	11	318	53	196
Cutthroat adult	2	13	2	5	4	0	0	7	0	0	0	7
Native char 1+	65	77	153	206	101	98	109	138	20	125	74	115
Trout Parr	40	61	90	83	42	57	116	155	86	123	31	44

Table 4: 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.

Day:Night Catch Ratios

Wild Chinook 0+

We compared wild 0+ chinook catch rates during daylight hours to respective nighttime catch rates for the scoop and screw traps on 51 and 49 days, respectively (Table 5, Table 6). Day:night catch rate ratios (d:n ratios) varied from 9% to over 166% in the scoop trap, and from 5% up to 389% in the screw trap. For the season, mean d:n catch rate ratios were 50% and 92% for the scoop and screw traps, respectively.

Flow

On the dates that we computed d:n ratios for wild 0+ chinook, flows varied approximately three-fold (11,300 to 37,200 cfs). Given the atypical high flows that dominated much of the season, we expected flow to be an influential variable. However, regression analysis determined that flow explained very little of the variation in d:n ratios for wild 0+ chinook in the scoop trap and screw traps over the season, with R^2 values of 0.6% and 2.2%, respectively (Figure 6).

Turbidity

We correlated day:night catch ratios for wild 0+ chinook with daily turbidity data through the season, and found that turbidity explained little of the variation in daytime migration rates. Turbidity explained 17% and 2% of the variation in the wild chinook d:n ratios for the scoop and screw traps, respectively, a stronger relationship than with flow (Figure 7). From January through June, turbidity explained approximately 9% and 2% of the variation in the scoop and screw traps, respectively (Figure 8). During the May through July period, however, correlations with turbidity data were higher, explaining 80% and 30% of the variation in the scoop and screw traps, respectively (Figure 9).

Hatchery 0+ Chinook Migration Period

Analysis of d:n ratios for hatchery 0+ chinook was limited by release timing to the mid-May through July period (Table 7, Table 8). Approximately 85% of the wild 0+ chinook had emigrated before the hatchery releases began. Unlike results from past years, hatchery 0+ chinook d:n ratios in 2002 were similar to wild chinook rates relative to the same day/night periods. From May 19 through July 31, mean d:n ratios for hatchery chinook were 51% and 33% in the scoop and screw traps, respectively. Similarly, mean ratios for wild chinook were 46% in the scoop trap and 50% in the screw trap over the same period.

Relating d:n ratios for hatchery chinook with flow indicated a positive relationship, explaining 43% of the variation in the scoop trap and 25% in the screw trap (Figure 10). Wild 0+ chinook d:n ratios in this same period showed the same strong correlations with flow (Figure 11). Also, daily day:night ratios varied similarly for both hatchery and wild chinook (Figure 12).

Flows increased just prior to the hatchery releases, in mid-May. Before late-April, flows averaged around 19,000 cfs and thereafter increased to average around 26,000 cfs through the end of the season.

Wild Coho Smolts

Mean day:night catch ratios for wild coho smolts during the migration period (April through June) were 13% and 7% in the scoop and screw traps, consistent with past years for coho, but low compared to the rates estimated for wild 0+ chinook (Table 9, Table 10). Flows on the days coho d:n ratios were assessed varied nearly three-fold (15,000 to 37,000 cfs) and averaged 27,500 cfs, but explained little of the variation in d:n ratios (Figure 13). As in past years, these relationships between flow and d:n ratios indicate that relatively few coho are captured during the daytime at flows less than 20,000 cfs.

Table 5: Catch rates of wild 0+ chinook during day and night periods, Skagit River scoop trap 2002.

NIGHTTIME Dates Begin	End	Hours Fished	Catch	Catch/ Hour	DAYTIME Date	Time Begin	Time End	Hours Fished	Catch	Catch/ Hour	D:N Ratio (D/N)	Flow (cfs)
01/17	01/19	30.67	125	4.08	01/18	7.92	16.75	8.83	9	1.02	25.01%	19,300
01/21	01/23	31.00	49	1.58	01/22	8.00	16.75	8.75	14	1.60	101.22%	18,700
01/24	01/26	31.83	112	3.52	01/25	8.00	16.50	8.50	26	3.06	86.93%	25,600
01/27	01/29	31.17	33	1.06	01/28	8.25	16.75	8.50	15	1.76	166.68%	19,400
01/30	02/01	31.67	31	0.98	01/31	8.75	16.75	8.00	5	0.63	63.85%	17,700
02/02	02/04	29.09	49	1.68	02/03	8.33	17.67	9.34	7	0.75	44.49%	17,200
02/05	02/07	30.67	107	3.49	02/06	8.75	17.00	8.25	6	0.73	20.85%	17,100
02/08	02/10	30.34	149	4.91	02/09	8.50	17.75	9.25	30	3.24	66.04%	14,800
02/11	02/13	29.00	238	8.21	02/12	7.92	17.75	9.83	68	6.92	84.29%	14,800
02/14	02/16	28.41	131	4.61	02/15	8.17	17.50	9.33	18	1.93	41.84%	11,300
02/17	02/19	27.82	306	11.00	02/18	7.92	17.50	9.58	89	9.29	84.46%	19,300
02/27	03/01	24.58	889	36.17	02/28	6.75	17.75	11.00	294	26.73	73.90%	19,400
03/03	03/05	26.33	486	18.46	03/04	7.50	18.00	10.50	95	9.05	49.02%	18,100
03/06	03/08	26.58	640	24.08	03/07	7.42	18.00	10.58	109	10.30	42.79%	16,200
03/09	03/11	27.42	173	6.31	03/10	8.17	18.25	10.08	14	1.39	22.01%	13,100
03/12	03/14	26.08	851	32.63	03/13	8.17	18.50	10.33	183	17.72	54.29%	21,900
03/15	03/17	26.00	306	11.77	03/16	7.67	18.25	10.58	28	2.65	22.49%	17,800
03/18	03/20	26.08	686	26.30	03/19	7.00	17.75	10.75	173	16.09	61.18%	14,200
03/21	03/23	24.17	368	15.23	03/22	7.00	18.75	11.75	105	8.94	58.69%	15,500
03/24	03/26	24.74	132	5.34	03/25	7.67	18.75	11.08	29	2.62	49.06%	12,500
03/27	03/29	24.00	594	24.75	03/28	7.67	18.33	10.66	231	21.67	87.55%	14,300
03/28	03/30	23.59	600	25.43	03/29	6.25	18.42	12.17	69	5.67	22.29%	13,700
03/31	04/02	23.08	1395	60.44	04/01	6.17	18.50	12.33	1,106	89.70	148.41%	15,100
04/02	04/04	23.50	784	33.36	04/03	6.75	18.00	11.25	243	21.60	64.74%	15,800
04/05	04/07	22.92	1181	51.53	04/06	6.50	18.92	12.42	139	11.19	21.72%	15,500
04/08	04/10	21.17	1486	70.19	04/09	6.67	19.75	13.08	86	6.57	9.37%	16,300
04/17	04/19	20.92	703	33.60	04/18	6.67	19.83	13.16	206	15.65	46.58%	21,800
04/20	04/22	20.76	562	27.07	04/21	6.75	20.00	13.25	122	9.21	34.01%	20,000
04/23	04/25	20.41	337	16.51	04/24	6.17	19.58	13.41	62	4.62	28.00%	18,800
04/26	04/28	19.58	194	9.91	04/27	6.17	20.17	14.00	63	4.50	45.42%	18,400
04/29	05/01	20.25	308	15.21	04/30	6.50	20.00	13.50	33	2.44	16.07%	19,300
05/02	05/04	19.17	672	35.05	05/03	6.17	20.42	14.25	96	6.74	19.22%	24,600
05/05	05/07	19.00	114	6.00	05/06	6.17	20.50	14.33	28	1.95	32.57%	18,600
05/08	05/10	21.17	81	3.83	05/09	7.42	19.00	11.58	8	0.69	18.06%	19,000
05/12	05/14	19.92	178	8.94	05/13	7.50	20.17	12.67	18	1.42	15.90%	17,800
05/16	05/18	19.24	150	7.80	05/17	6.58	20.75	14.17	32	2.26	28.97%	18,000
05/19	05/21	17.92	272	15.18	05/20	6.33	21.00	14.67	47	3.20	21.11%	22,900
05/23	05/25	19.00	110	5.79	05/24	7.00	20.83	13.83	15	1.08	18.73%	22,000
05/26	05/28	18.08	160	8.85	05/27	6.75	20.50	13.75	48	3.49	39.45%	25,000
06/01	06/03	17.17	457	26.62	06/02	6.25	20.83	14.58	179	12.28	46.13%	26,600
06/04	06/06	17.00	489	28.76	06/05	6.50	20.83	14.33	122	8.51	29.60%	25,400
06/07	06/09	16.50	182	11.03	06/08	5.75	21.33	15.58	72	4.62	41.90%	21,200
06/17	06/19	16.25	186	11.45	06/18	5.75	21.00	15.25	146	9.57	83.64%	37,200
06/20	06/22	16.00	164	10.25	06/21	5.50	21.33	15.83	52	3.28	32.05%	28,500
06/23	06/25	15.74	86	5.46	06/24	5.42	21.33	15.91	45	2.83	51.77%	31,500
07/01	07/03	16.58	166	10.01	07/02	5.83	21.00	15.17	160	10.55	105.34%	30,300
07/13	07/15	16.92	36	2.13	07/14	6.00	20.83	14.83	29	1.96	91.91%	25,300
07/16	07/18	17.83	36	2.02	07/17	6.00	21.00	15.00	16	1.07	52.83%	26,900
07/19	07/21	17.58	24	1.37	07/20	6.00	21.00	15.00	9	0.60	43.95%	22,600
07/22	07/24	17.00	24	1.41	07/23	6.17	21.33	15.16	4	0.26	18.69%	22,100
07/26	07/28	17.33	36	2.08	07/27	6.17	21.17	15.00	5	0.33	16.05%	20,900
Season Total		1,159.23	17,628	15.21				624.93	4,808	7.69	50.59%	
Season Median											43.95%	
Season Mean											50.02%	

Table 6: Catch/hour rates of wild 0+ chinook during day and night periods, Skagit River screw trap 2002.

NIGHTTIME					DAYTIME						D:N	
Dates		Hours	Catch	Catch/	Date	Time		Hours	Catch	Catch/	Ratio	Flow
Begin	End	Fished		Hour		Begin	End	Fished		Hour	(D/N)	(cfs)
01/17	01/19	30.67	26	0.85	01/18	7.92	16.75	8.83	23	2.60	307.26%	19,300
01/21	01/23	31.00	26	0.84	01/22	8.00	16.75	8.75	11	1.26	149.89%	18,700
01/27	01/29	31.17	18	0.58	01/28	8.25	16.75	8.50	11	1.29	224.10%	19,400
01/30	02/01	31.67	20	0.63	01/31	8.75	16.75	8.00	12	1.50	237.53%	17,700
02/02	02/04	29.09	47	1.62	02/03	8.33	17.67	9.34	17	1.82	112.65%	17,200
02/05	02/07	29.67	100	3.37	02/06	8.00	17.00	9.00	22	2.44	72.53%	17,100
02/08	02/10	30.34	120	3.96	02/09	8.50	17.75	9.25	23	2.49	62.87%	14,800
02/11	02/13	29.00	188	6.48	02/12	7.92	17.75	9.83	76	7.73	119.26%	14,800
02/14	02/16	28.58	63	2.20	02/15	8.00	17.50	9.50	19	2.00	90.73%	11,300
02/20	02/21	14.50	196		02/21	8.00	17.00	9.00	258	28.67	148.95%	17,800
02/24	02/26	27.34	678	24.80	02/25	8.00	11.00	9.67	439	45.40	183.07%	29,400
03/03	03/05	26.33	352	13.37	03/04	7.50	18.00	10.50	97	9.24	69.10%	18,100
03/06	03/08	26.58	371	13.96	03/07	7.42	18.00	10.58	125	11.81	84.65%	16,200
03/09	03/11	27.25	158	5.80	03/10	8.00	18.25	10.25	36	3.51	60.57%	13,100
03/12	03/14	26.16	276	10.55	03/13	8.17	18.50	10.33	141	13.65	129.37%	21,900
03/15	03/17	26.00	323	12.42	03/16	7.67	18.25	10.58	31	2.93	23.59%	17,800
03/18	03/20	24.91	488	19.59	03/19	7.00	18.75	11.75	102	8.68	44.31%	14,200
03/21	03/23	24.09	311	12.91	03/22	7.00	18.67	11.67	153	13.11	101.55%	15,500
03/24	03/26	24.91	122	4.90	03/25	7.67	18.75	11.08	36	3.25	66.34%	12,500
03/27	03/29	24.42	502	20.56	03/28	7.75	18.50	10.75	223	20.74	100.91%	14,300
03/28	03/30	23.42	616	26.30	03/29	6.33	18.50	12.17	118	9.70	36.86%	13,700
03/31	04/02	23.75	606	25.52	04/01	6.25	18.33	12.08	1,199	99.25	388.99%	15,100
04/02	04/04	23.50	527	22.43	04/03	6.75	19.00	12.25	322	26.29	117.21%	15,800
04/05	04/07	22.00	682	31.00	04/06	6.67	20.08	13.41	162	12.08	38.97%	15,500
04/08	04/10	21.25	1,320	62.12	04/09	6.75	19.83	13.08	165	12.61	20.31%	16,300
04/11	04/13	20.84	1,100	52.78	04/12	6.67	19.92	13.25	240	18.11	34.32%	25,000
04/17	04/19	20.91	296	14.16	04/18	6.58	20.00	13.42	281	20.94	147.92%	21,800
04/20	04/22	20.83	374	17.95	04/21	6.50	20.17	13.67	65	4.75	26.48%	20,000
04/23	04/25	20.66	115	5.57	04/24	6.42	19.50	13.08	45	3.44	61.81%	18,800
04/26	04/28	19.75	80	4.05	04/27	6.25	20.25	14.00	67	4.79	118.15%	18,400
04/29	05/01	20.17	90	4.46	04/30	6.50	20.00	13.50	87	6.44	144.43%	19,300
05/02	05/04	19.17	77	4.02	05/03	6.08	20.25	14.17	52	3.67	91.36%	24,600
05/05	05/07	18.75	43	2.29	05/06	6.08	20.42	14.34	41	2.86	124.67%	18,600
05/08	05/10	19.17	29	1.51	05/09	6.25	19.50	13.25	12	0.91	59.87%	19,000
05/16	05/18	18.51	44	2.38	05/17	6.00	21.25	15.25	42	2.75	115.86%	18,000
05/19	05/21	17.83	111	6.23	05/20	6.00	20.50	14.50	54	3.72	59.82%	22,900
05/23	05/25	18.84	35	1.86	05/24	7.17	20.00	12.83	7	0.55	29.37%	22,000
06/01	06/03	8.58	164		06/02	5.92	20.50	14.58	199	13.65	65.03%	26,600
06/04	06/06	17.50	256	14.63	06/05	5.50	20.50	15.00	121	8.07	55.14%	25,400
06/07	06/09	16.42	118	7.19	06/08	5.00	21.00	16.00	76	4.75	66.10%	21,200
06/20	06/22	16.00	147	9.19	06/21	5.58	14.92	9.34	15	1.61	17.48%	28,500
06/23	06/25	16.59	80	4.82	06/24	5.58	21.25	15.67	36	2.30	47.64%	31,500
07/01	07/03	16.34	152	9.30	07/02	5.92	21.50	15.58	181	11.62	124.89%	30,300
07/04	07/06	15.08	90	5.97	07/05	6.00	21.25	15.25	47	3.08	51.64%	23,900
07/13	07/15	17.50	50	2.86	07/14	5.67	20.50	14.83	26	1.75	61.36%	35,300
07/16	07/18	17.75	30	1.69	07/17	6.08	21.25	15.17	14	0.92	54.60%	26,900
07/19	07/21	18.00	20	1.11	07/20	6.00	20.75	14.75	7	0.47	42.71%	22,600
07/22	07/24	17.33	27	1.56	07/23	6.00	21.17	15.17	5	0.33	21.16%	22,100
07/26	07/28	17.75	27	1.52	07/27	6.25	21.00	14.75	1	0.07	4.46%	20,900
Season Total		1,099.62	12,009	10.92				601.50	5,542	9.21	84.37%	
Season Median											66.34%	
Season Mean											92.00%	

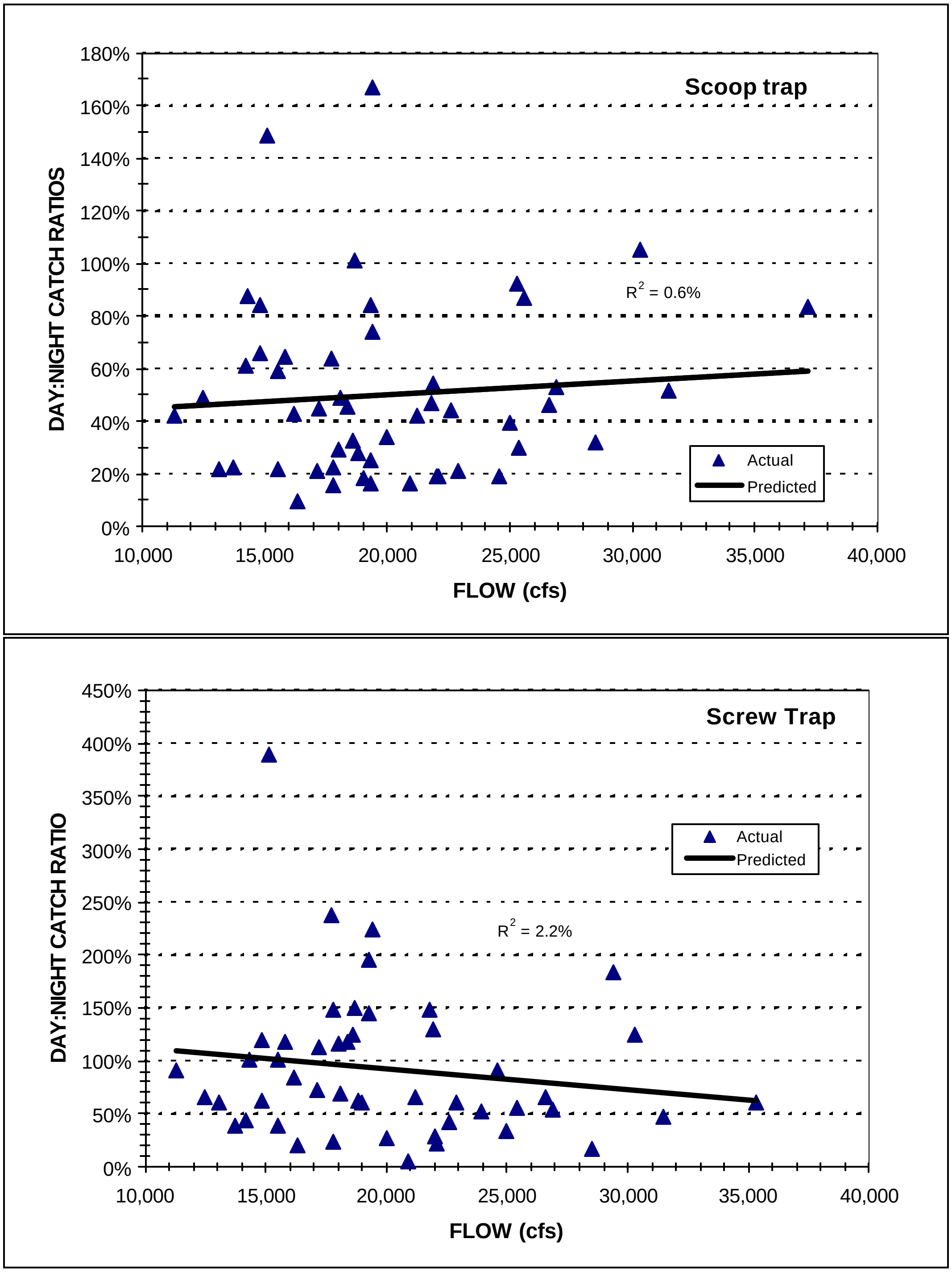


Figure 6: Day:night catch ratios for wild 0+ chinook and daily mean flow (cfs), Skagit River mainstem traps, January through July 2002.

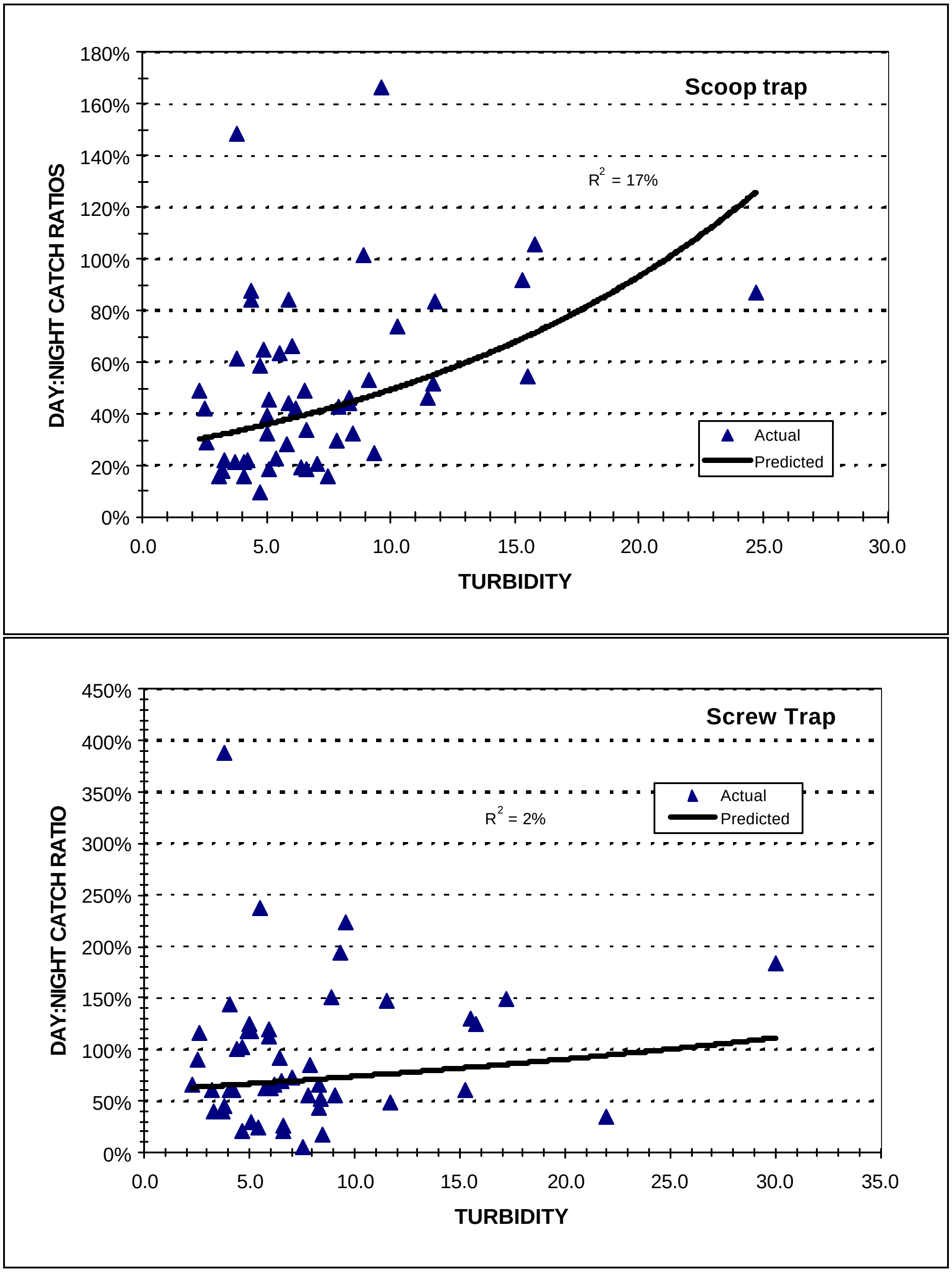


Figure 7: Day:night catch ratios for wild 0+ chinook and turbidity (from the Anacortes water withdrawal facility in Mt Vernon), Skagit River mainstem traps, January through July 2002.

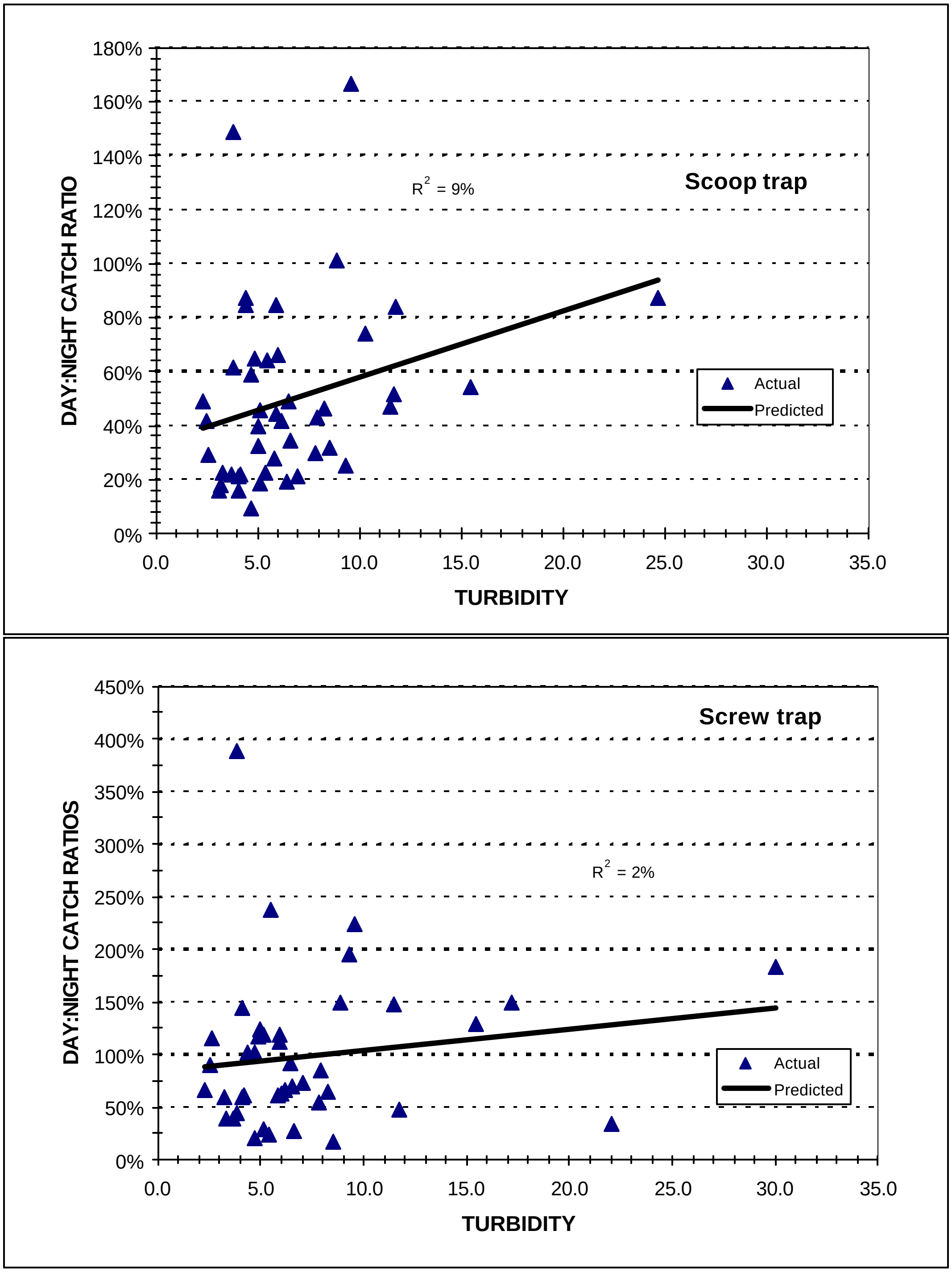


Figure 8: Day:night wild chinook catch ratios and turbidity (from the Anacortes water withdrawal facility in Mt Vernon), Skagit River mainstem traps, January through June 2002.

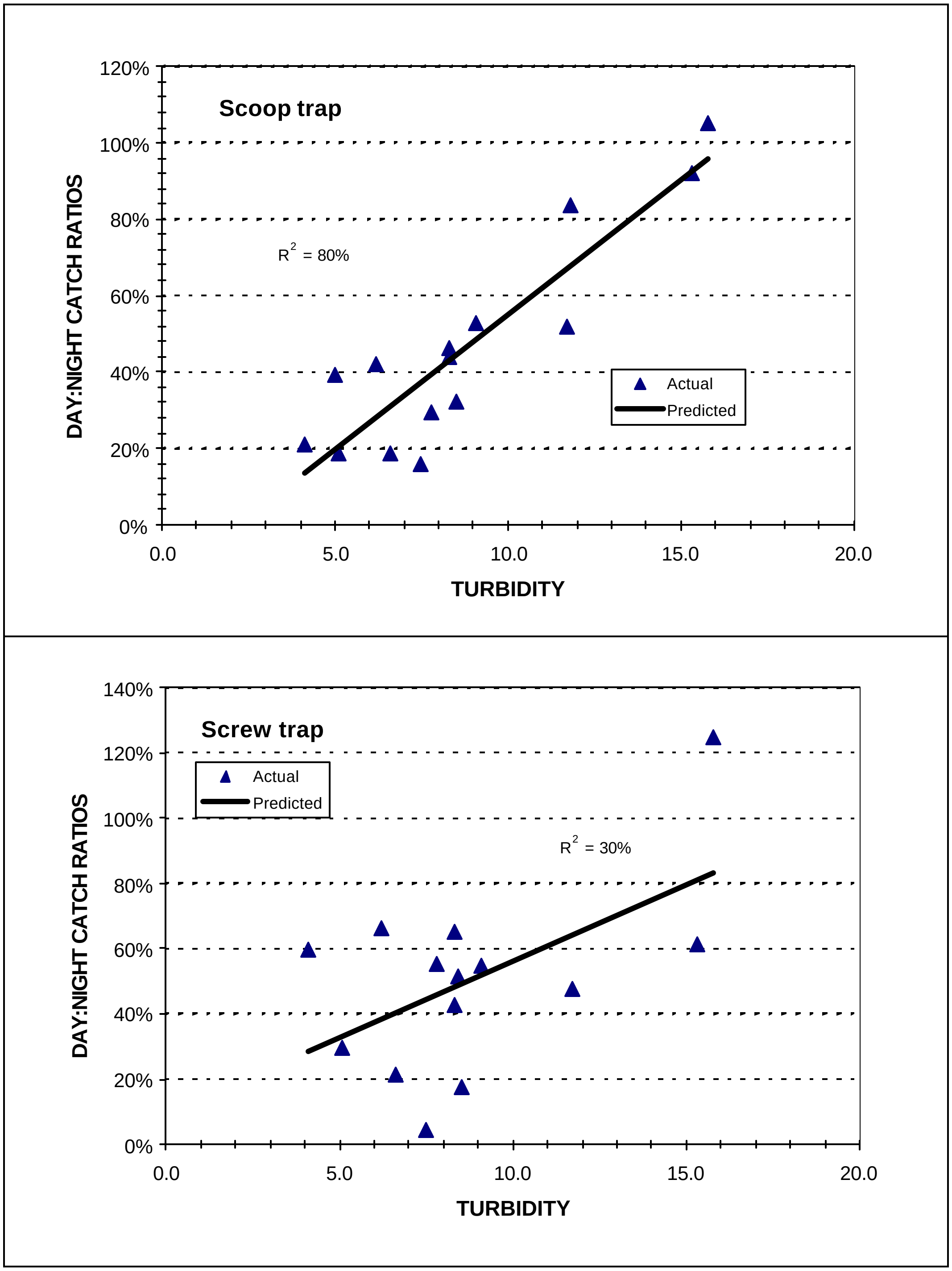


Figure 9: Day:night catch rate ratios of wild 0+ chinook and turbidity during the hatchery 0+ chinook migration period (May through July), Skagit River mainstem traps 2002.

Table 7: Catch rates of hatchery 0+ chinook during day and night periods, Skagit River scoop trap 2002.

NIGHTTIME					DAYTIME				DAY:NIGHT	
Date		Hours	Chin	Catch	Date	Hours	Chin	Catch	Catch	Flow
Down	Up	Fished	0+	Rate		Fished	0+	Rate	Ratio	cfs
05/19	05/21	17.92	119	6.64	05/20	14.67	9	0.61	9.24%	22,900
05/23	05/25	19.00	144	7.58	05/24	13.83	2	0.14	1.91%	22,000
05/26	05/28	18.08	93	5.14	05/27	13.75	8	0.58	11.31%	25,000
06/01	06/03	17.17	368	21.43	06/02	14.58	23	1.58	7.36%	26,600
06/04	06/06	17.00	454	26.71	06/05	14.33	134	9.35	35.01%	25,400
06/07	06/09	16.50	134	8.12	06/08	15.58	68	4.36	53.74%	21,200
06/17	06/19	16.25	67	4.12	06/18	15.25	129	8.46	205.16%	37,200
06/20	06/22	16.00	74	4.63	06/21	15.83	18	1.14	24.59%	28,500
06/23	06/25	15.74	32	2.03	06/24	15.91	8	0.50	24.73%	31,500
07/01	07/03	16.58	37	2.23	07/02	15.17	51	3.36	150.65%	30,300
07/13	07/15	16.92	14	0.83	07/14	14.83	6	0.40	48.90%	25,300
07/16	07/18	17.83	9	0.50	07/17	15.00	6	0.40	79.24%	26,900
07/19	07/21	17.58	5	0.28	07/20	15.00	5	0.33	117.20%	22,600
07/22	07/24	17.00	4	0.24	07/23	15.16	0	0.00	0.00%	22,100
07/26	07/28	17.33	6	0.35	07/27	15.00	0	0.00	0.00%	20,900
Season Total		256.90	1,560	6.07		223.89	467	2.09	34.35%	
Season Median									24.73%	
Season Mean									51.27%	

Table 8: Catch rates of hatchery 0+ chinook during day and night periods, Skagit River screw trap 2002.

NIGHT TIME					DAYTIME				DAY:NIGHT	
Date		Hours	Chin	Catch	Date	Hours	Chin	Catch	Catch	Flow
Down	Up	Fished	0+	Rate		Fished	0+	Rate	Ratio	cfs
05/19	05/21	17.83	103	5.78	05/20	14.50	11	0.76	13.13%	22,900
05/23	05/25	18.84	106	5.63	05/24	12.83	1	0.08	1.39%	22,000
06/01	06/03	17.58	331	18.83	06/02	14.58	34	2.33	12.39%	26,600
06/04	06/06	17.50	434	24.80	06/05	15.00	102	6.80	27.42%	25,400
06/07	06/09	16.42	136	8.28	06/08	16.00	61	3.81	46.03%	21,200
06/20	06/22	16.00	73	4.56	06/21	9.34	5	0.54	11.73%	28,500
06/23	06/25	16.59	25	1.51	06/24	15.67	14	0.89	59.29%	31,500
07/01	07/03	16.34	48	2.94	07/02	15.58	40	2.57	87.40%	30,300
07/04	07/06	15.08	17	1.13	07/05	15.25	10	0.66	58.17%	23,900
07/13	07/15	17.50	13	0.74	07/14	14.83	5	0.34	45.39%	35,300
07/16	07/18	17.75	7	0.39	07/17	15.17	4	0.26	66.86%	26,900
07/19	07/21	18.00	5	0.28	07/20	14.75	0	0.00	0.00%	22,600
07/22	07/24	17.33	3	0.17	07/23	15.17	1	0.07	38.08%	22,100
07/26	07/28	17.75	6	0.34	07/27	14.75	0	0.00	0.00%	20,900
Season Total		240.51	1,307	5.43		203.42	288	1.42	26.05%	
Season Median									32.75%	
Season Mean									33.38%	

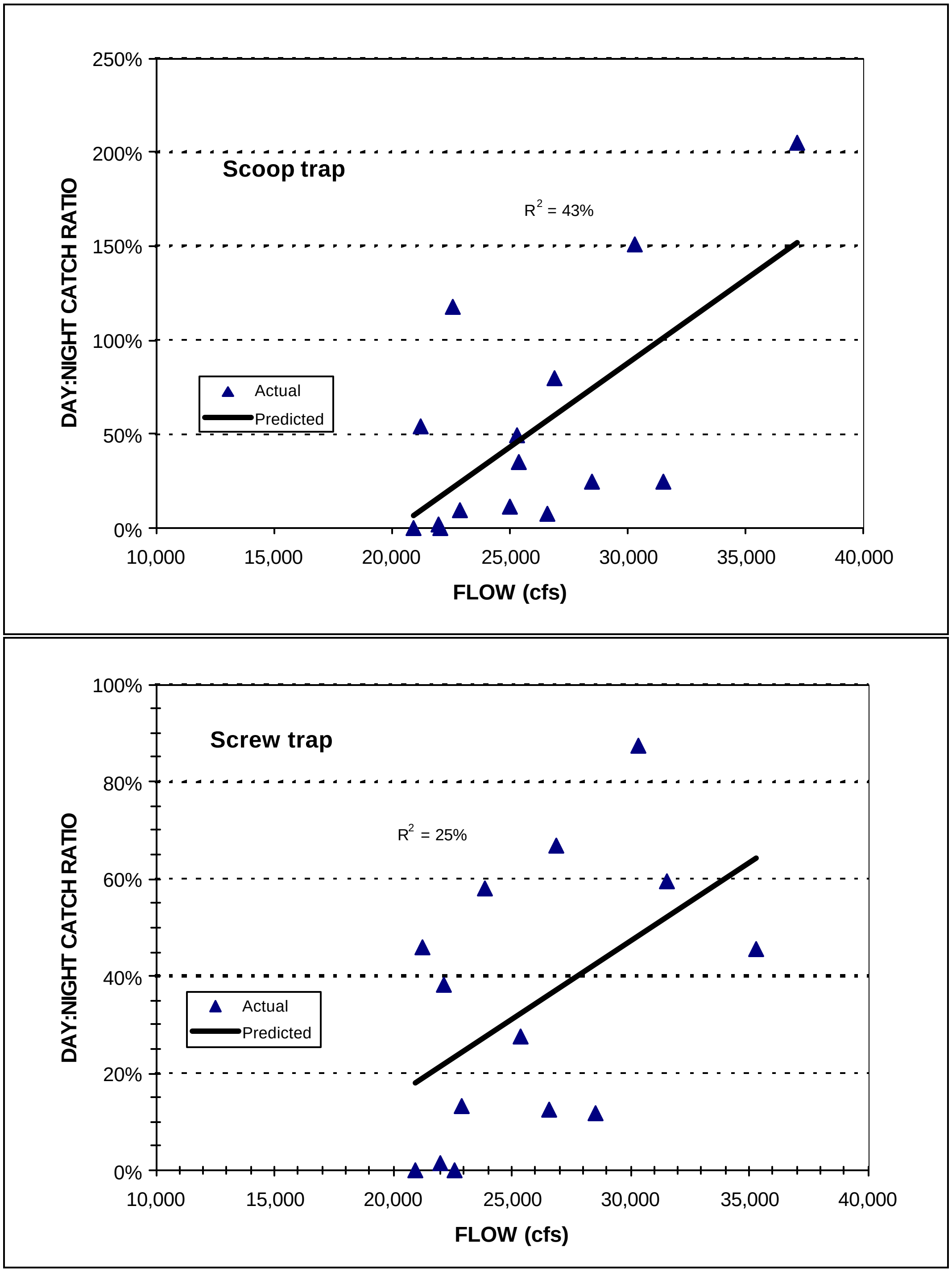
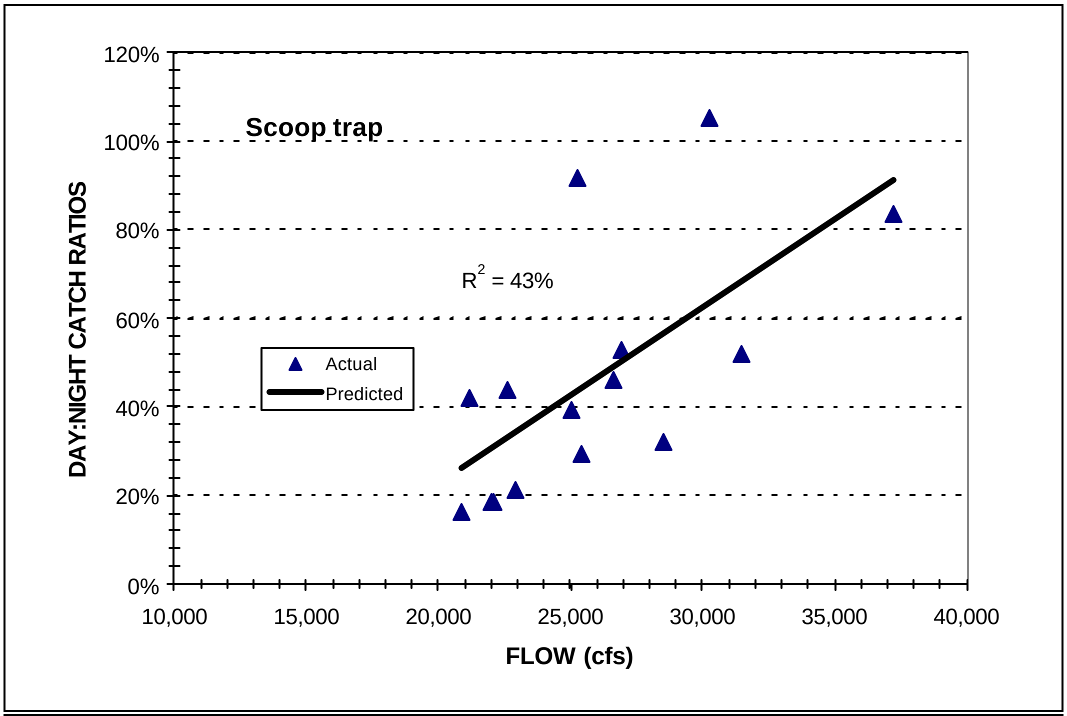


Figure 10: Day:night catch rate ratios for hatchery 0+ chinook and daily mean flow (cfs), Skagit River mainstem traps, May through July 2002.



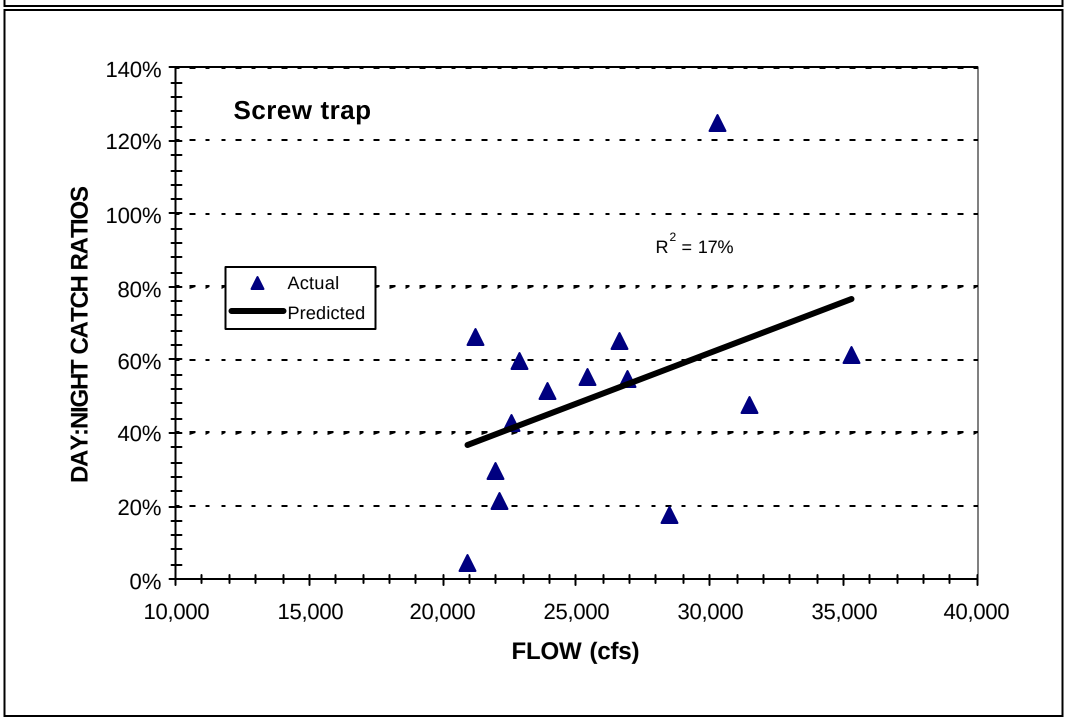


Figure 11: Day:night catch rate ratios of wild 0+ chinook and daily mean flow during the hatchery 0+ chinook migration period (May through July), Skagit River mainstem traps 2002.

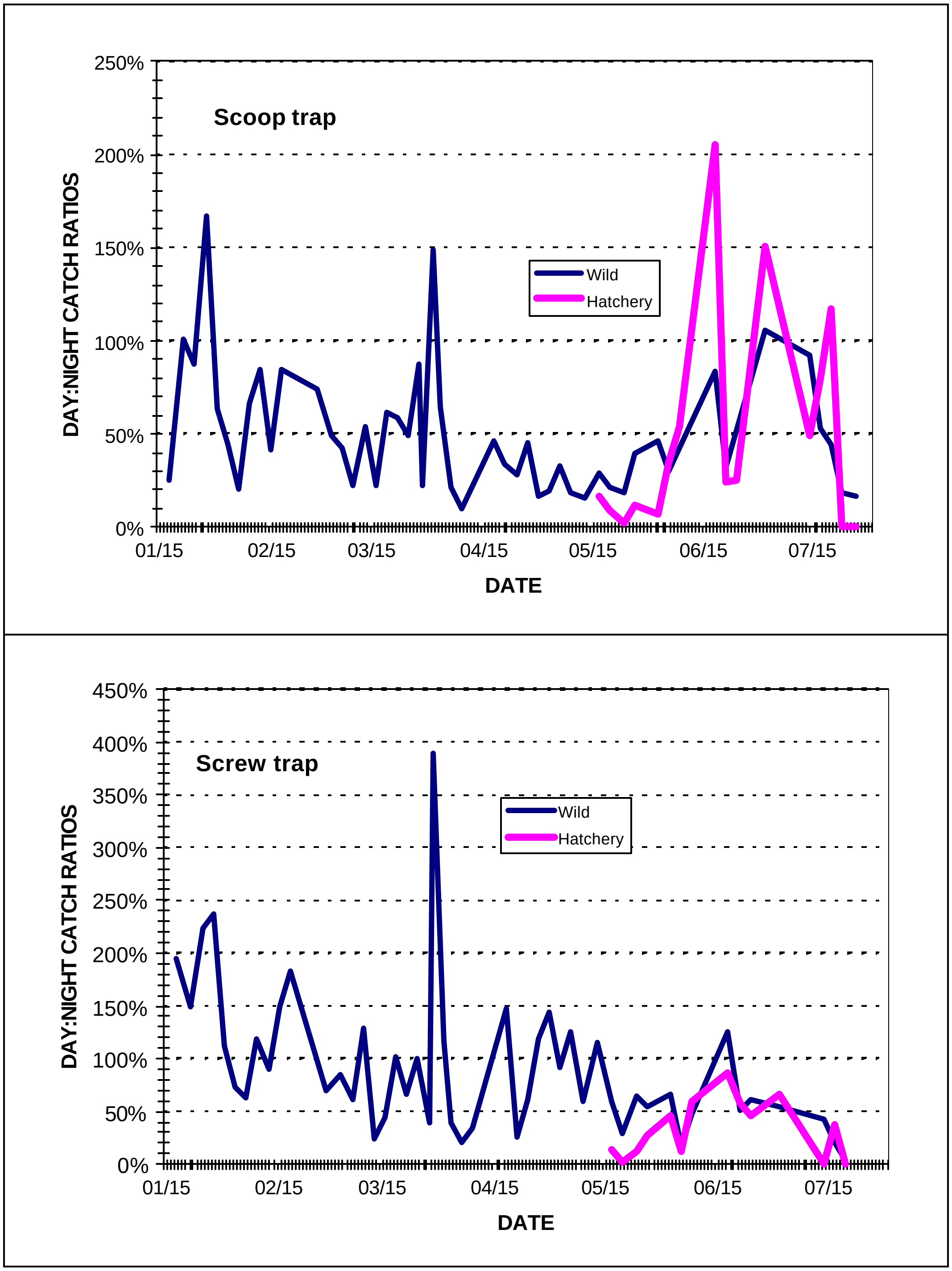


Figure 12: Comparison of day:night catch ratios for wild and hatchery 0+ chinook, Skagit River mainstem traps 2002.

Table 9: Catch rates of wild coho smolts during day and night periods, Skagit River scoop trap, 2002.

NIGHT TIME					DAYTIME				DAY:NIGHT	
Date		Hours	Catch	Catch/	Date	Hours	Catch	Catch/	Catch	Flow
Down	Up	Fished		Hour		Fished		Hour	Ratio	cfs
03/31	04/02	23.08	6	0.26	04/01	12.33	3	0.24	93.59%	15,100
04/02	04/04	23.50	6	0.26	04/03	11.25	1	0.09	34.81%	15,800
04/05	04/07	22.92	7	0.31	04/06	12.42	1	0.08	26.36%	15,500
04/08	04/10	21.17	12	0.57	04/09	13.08	0	0.00	0.00%	16,300
04/17	04/19	20.92	10	0.48	04/18	13.16	2	0.15	31.79%	21,800
04/20	04/22	20.76	41	1.97	04/21	13.25	0	0.00	0.00%	20,000
04/23	04/25	20.41	119	5.83	04/24	13.41	2	0.15	2.56%	18,800
04/26	04/28	19.58	138	7.05	04/27	14.00	1	0.07	1.01%	18,400
04/29	05/01	20.25	321	15.85	04/30	13.50	9	0.67	4.21%	19,300
05/02	05/04	19.17	305	15.91	05/03	14.25	16	1.12	7.06%	24,600
05/05	05/07	19.00	392	20.63	05/06	14.33	2	0.14	0.68%	18,600
05/08	05/10	21.17	324	15.30	05/09	11.58	0	0.00	0.00%	19,000
05/12	05/14	19.92	646	32.43	05/13	12.67	22	1.74	5.35%	17,800
05/16	05/18	19.24	493	25.62	05/17	14.17	20	1.41	5.51%	18,000
05/19	05/21	17.92	737	41.13	05/20	14.67	59	4.02	9.78%	22,900
05/23	05/25	19.00	642	33.79	05/24	13.83	15	1.08	3.21%	22,000
05/26	05/28	18.08	338	18.69	05/27	13.75	38	2.76	14.78%	25,000
06/01	06/03	17.17	180	10.48	06/02	14.58	21	1.44	13.74%	26,600
06/04	06/06	17.00	119	7.00	06/05	14.33	28	1.95	27.91%	25,400
06/07	06/09	16.50	61	3.70	06/08	15.58	6	0.39	10.42%	21,200
06/17	06/19	16.25	9	0.55	06/18	15.25	0	0.00	0.00%	37,200
06/20	06/22	16.00	19	1.19	06/21	15.83	1	0.06	5.32%	28,500
06/23	06/25	15.74	6	0.38	06/24	15.91	0	0.00	0.00%	31,500
Season Total		444.75	4,931	11.09		317.13	247	0.78	7.02%	
Season Median									5.35%	
Season Mean									12.96%	

Table 10: Catch/hour rates of wild coho smolts during day and night periods, Skagit River screw trap, 2002.

NIGHT TIME					DAYTIME				DAY:NIGHT	
Date		Hours	Catch	Catch/	Date	Hours	Catch	Catch/	Catch	Flow
Down	Up	Fished		Hour		Fished		Hour	Ratio	cfs
03/31	04/02	23.75	5	0.21	04/01	12.08	1	0.08	39.32%	15,100
04/02	04/04	23.50	4	0.17	04/03	12.25	0	0.00	0.00%	15,800
04/05	04/07	22.00	22	1.00	04/06	13.41	0	0.00	0.00%	15,500
04/08	04/10	21.25	16	0.75	04/09	13.08	1	0.08	10.15%	16,300
04/11	04/13	20.84	21	1.01	04/12	13.25	1	0.08	7.49%	25,000
04/17	04/19	20.91	44	2.10	04/18	13.42	2	0.15	7.08%	21,800
04/20	04/22	20.83	49	2.35	04/21	13.67	0	0.00	0.00%	20,000
04/23	04/25	20.66	187	9.05	04/24	13.08	1	0.08	0.84%	18,800
04/26	04/28	19.75	154	7.80	04/27	14.00	0	0.00	0.00%	18,400
04/29	05/01	20.17	335	16.61	04/30	13.50	4	0.30	1.78%	19,300
05/02	05/04	19.17	386	20.14	05/03	14.17	16	1.13	5.61%	24,600
05/05	05/07	18.75	464	24.75	05/06	14.34	2	0.14	0.56%	18,600
05/08	05/10	19.17	396	20.66	05/09	13.25	0	0.00	0.00%	19,000
05/16	05/18	18.51	509	27.50	05/17	15.25	18	1.18	4.29%	18,000
05/19	05/21	17.83	734	41.17	05/20	14.50	70	4.83	11.73%	22,900
05/23	05/25	18.84	415	22.03	05/24	12.83	9	0.70	3.18%	22,000
06/01	06/03	17.58	262	14.90	06/02	14.58	20	1.37	9.20%	26,600
06/04	06/06	17.50	154	8.80	06/05	15.00	19	1.27	14.39%	25,400
06/07	06/09	16.42	60	3.65	06/08	16.00	17	1.06	29.08%	21,200
06/20	06/22	16.00	16	1.00	06/21	9.34	1	0.11	10.71%	28,500
06/23	06/25	16.59	6	0.36	06/24	15.67	0	0.00	0.00%	31,500
Season Total		410.02	4,239	10.34		286.67	182	0.63	6.14%	
Season Median									4.29%	
Season Mean									7.40%	

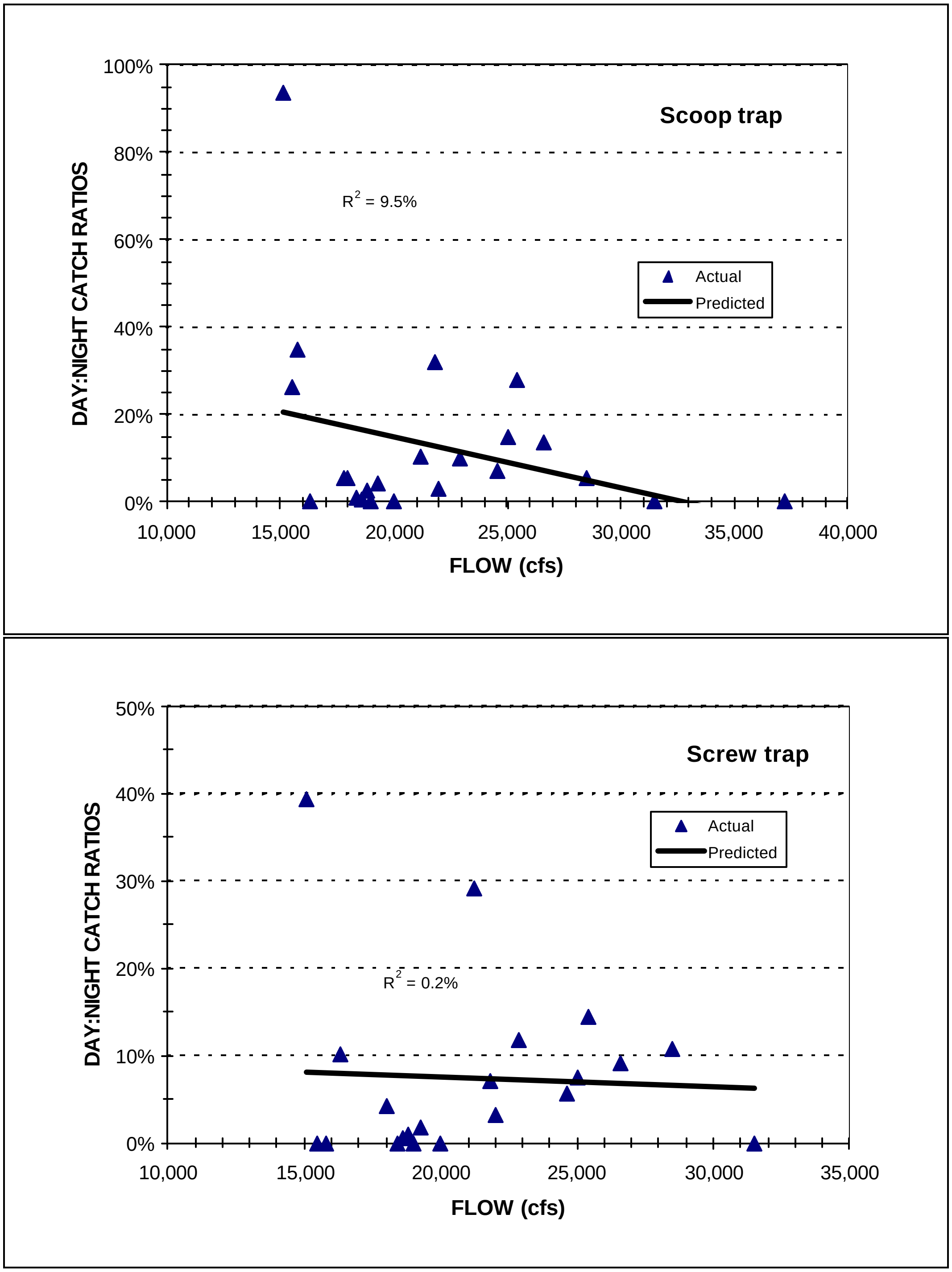


Figure 13: Day:night catch ratios for wild coho smolts during the migration period (April through June) and flow (cfs), Skagit River mainstem traps, 2002.

Wild Coho Smolt Production Evaluation

In Spring 1999, we initiated a new marking procedure that incorporated two different marks: one to identify coho smolts from the upper basin tributaries (left ventral-mark), and another (right ventral-mark) to identify fish from Mannser Creek, in the lower basin. In 1999, only 0.34% of the left ventral-mark (LV-mark) group was captured, compared to 1.24% of the right-ventral (RV-mark) group, a four-fold difference. During Spring 2000, we recovered 1.8% of the coho smolts marked at the lower tributary (RV-marks), and 0.9% of the upper tributary LV-marks, a two-fold difference. Although this discrepancy was only half that observed in 1999, these rates indicate a substantial difference between the release groups. While we expect some mortality occurs between marking at the tributary traps and passing the mainstem traps, we doubt that in-river mortality on wild coho smolts is as high as 50%-75%.

In Spring 2001, we stopped marking smolts from upper basin tributaries, given the low recovery rates observed in 1999 and 2000. Smolts RV-marked at Mannser Creek provided the basis for the coho smolt estimate in Spring 2001 and 2002. Relating the 2002 season catch in the mainstem traps of 346 RV-marked smolts from Mannser Creek to the total catch of 18,154 wild smolts estimates the mark incidence at 1.9%. Application of this rate to the 36,023 smolts marked and released at Mannser Creek estimates system production at 1,885,000 wild coho smolts (Table 11).

Table 11: Estimation of wild coho smolt production, Skagit River 2002.

	Number	Formula
Total mainstem trap catches	19,275	
Skagit Hatchery/Lake Shannon	-1,121	
Wild coho captured (c)	**18,154**	
RVs recaptured (r)	346	N = (m+1)(c+1)
RVs released (m)	36,023	(r+1)
Total production (N)	**1,884,772**	
Variance (Var)	9.92E+09	Var = (m+1)(c+1)(m-r)(c-r)
Standard Deviation (sd)	99,581	(r+1)^2(r+2)
Coefficient of Var (CV)	5.28%	CV = sd/N
Confidence Interval (CI)	195,179	CI = +/- 1.96(sd)
Estimated coho production		
Skagit River	1,884,772	
Upper CI (95%)	2,079,950	
Lower CI (95%)	1,689,593	

Capture Rate Indicators

Wild Coho Smolts

Projecting catches of right ventral-marked (RV) wild coho smolts to continuous 24-hour trapping on the basis of day:night catch ratios using the season median rate for the scoop and screw traps, estimates that we would have caught 7 and 14 additional marked coho (377 total projected RV-marked smolts) in the scoop and screw traps, respectively. Relating this total projected RV-marked catch to the 36,023 RV-marked smolts released from the Mannser Creek trap, estimates combined scoop and screw trap capture rates for the season at 1.1%. This estimate assumes that all of the RV-marked wild coho smolts survived and passed the mainstem traps during the season.

Fin-marked Hatchery Chinook

We released six groups of chinook, two wild fry groups and four hatchery fry groups, with three different mark types (Bismark-brown dye, ad-clip/CWT, and ad/CWT/upper caudal-clip) on six different evenings over the season. The first group was released on the night of February 21 with rising flows. We discontinued fishing at 2100 hours due to heavy debris and only recovered 5 fish from this group. Due to the truncated fishing time, this group was not used for the trap efficiency analysis. Although we operated the traps continuously for more than 36 hours after each release, recoveries of the five remaining calibration groups occurred entirely on the first night after the releases. Recapture rates for the calibration groups ranged from 1.15% to 1.83%, and averaged 1.54% (Table 12).

Table 12: Overall recapture rates and proportion of total recoveries during the first 24-hours after release of five fin-marked 0+ chinook calibration groups, Skagit River mainstem traps 2002.

Mark Group	RELEASE Date	Number	Avg Flow	Number Recaptured During the First 24 Hours Scoop	Screw	Total	Recap Rate
Dye	March 28	435	15,100	3	2	5	1.15%
Ad-CWT	May 16	600	17,500	5	6	11	1.83%
Ad-CWT/UC	June 07	635	21,200	4	6	10	1.57%
Ad-CWT/UC	June 20	650	25,700	3	8	11	1.69%
Ad-CWT/UC	July 16	600	29,600	3	5	8	1.33%
	Total	2,920		18	27	45	1.54%

Hatchery 0+ Chinook Production Groups

Over the season, we caught a total of 6,030 ad-marked and coded-wire tagged (ad-CWT) hatchery 0+ chinook in the mainstem traps, 3,310 in the scoop trap and 2,720 in the screw trap. These totals do not include recoveries from the calibration groups.

Three releases of ad-CWT hatchery chinook fingerlings occurred in Spring 2002 (Table 13, Figure 1):

- May 26, the volitional release of 186,640 summer chinook from Countyline Ponds (R.M. 89)
- June 4 the release of 242,721 spring chinook from the Skagit Hatchery (R.M. 78)
- June 6, 170,665 fall chinook from Baker River (R.M. 57)

Estimating our catch of these release groups required recovering tags. On May 17, we began sampling hatchery smolts for tag recovery. Over the season, we sacrificed 1,077 ad-marked chinook and recovered 1,064 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 14).

Applying daily tag recovery results to the sum of actual and projected catches of hatchery chinook estimates 2,773 fall 0+ chinook released at Baker River, 2,618 summer 0+ chinook released at Countyline Ponds and 4,192 spring 0+ chinook released at Skagit Hatchery (Table 15). Relating these projected catches to the numbers released yields capture rates of 1.6%, 1.4%, and 1.7% 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 and residualism.

Table 13: Groups of marked salmon released into the Skagit River in 2002 and the numbers recovered at the mainstem traps.

Group	Stock	Species/ Age	Mark Type	RELEASE		Recapture Dates	ACTUAL CATCH			CAPTURE RATE		
				Date	Number		Scoop	Screw	Total	Scoop	Screw	Total
	Wild	Coho 1+	RV	April-June	36,023	May – June	204	142	346	0.6%	0.4%	1.0%
	Hatchery	Coho 1+	Ad-CWT	May 16, 2002	247,408	April 21-July 02	453	668	1,121	0.2%	0.3%	0.5%
Calibration Groups[a]	Wild	Chinook 0+	Dye	March 28, 2002	435	March 28, 2002	3	2	5	0.7%	0.5%	1.1%
Calibration Groups[a]	Hatchery/ spring	Chinook 0+	Ad/CWT	May 16, 2002	600	May 16, 2002	5	6	11	0.8%	1.0%	1.8%
Calibration Groups[a]	Hatchery/ spring	Chinook 0+	Ad/CWT/UC	June 07, 2002	635	June 07, 2002	4	6	10	0.6%	0.9%	1.6%
Calibration Groups[a]	Hatchery/ spring	Chinook 0+	Ad/CWT/UC	June 20, 2002	650	June 20, 2002	3	8	11	0.5%	1.2%	1.7%
Calibration Groups[a]	Hatchery/ spring	Chinook 0+	Ad/CWT/UC	July 16, 2002	600	July 16, 2002	3	5	8	0.5%	0.8%	1.3%
Hatchery Releases[b]	Countyline Ponds/ summer	Chinook 0+	Ad/CWT	May 26, 2002	186,640	May 17 – July 29	n/a	n/a	2,618	n/a	n/a	1.4%
Hatchery Releases[b]	Skagit Hatchery/ spring	Chinook 0+	Ad/CWT	June 04, 2002	242,721	June 02 – July 28	n/a	n/a	4,192	n/a	n/a	1.7%
Hatchery Releases[b]	Baker River Hatchery/ fall	Chinook 0+	Ad/CWT	June 06, 2002	170,665	June 04 – July 28	n/a	n/a	2,773	n/a	n/a	1.6%
	Hatchery/ spring	Chinook 1+	Ad/CWT	April 2002	154,515	April 19 – May 07	177	161	338	0.1%	0.1%	0.2%

[a] Mark groups used for trap efficiency tests; not included in hatchery migration estimate.
[b] Hatchery 0+ chinook catches are projected totals.

Table 14: Breakdown of tag recoveries from ad-marked/CWT chinook 0+ and estimated total tags in the catch, Skagit River mainstem traps, 2002.

DATE	SAMPLED		RESULTS		Countyline-summer		Baker River-falls		Marblemount-springs	
	Screw	Scoop	No-Tags	Tags	Percent	Total	Percent	Total	Percent	Total
05/17	**0**	**0**	**0**	**0**	**100.0%**	5	**0.0%**	0	**0%**	0
05/18	**0**	**0**	**0**	**0**	**100.0%**	5	**0.0%**	0	**0%**	0
05/19	0	5	0	5	100.0%	33	0.0%	0	0%	0
05/20	5	4	0	9	100.0%	78	0.0%	0	0%	0
05/21	0	23	2	21	100.0%	164	0.0%	0	0%	0
05/22	13	18	2	29	100.0%	151	0.0%	0	0%	0
05/23	0	14	0	14	100.0%	140	0.0%	0	0%	0
05/24	15	20	0	35	100.0%	175	0.0%	0	0%	0
05/25	0	10	0	10	100.0%	78	0.0%	0	0%	0
05/26	9	11	0	20	100.0%	101	0.0%	0	0%	0
05/27	7	12	0	19	100.0%	96	0.0%	0	0%	0
05/28	**0**	**7**	**0**	**7**	**100.0%**	**44**	**0.0%**	**0**	**0%**	**0**
05/29	**0**	**8**	**0**	**8**	**100.0%**	**40**	**0.0%**	**0**	**0%**	**0**
05/30	**0**	**0**	**0**	**0**	**100.0%**	0	**0.0%**	0	**0%**	0
05/31	0	5	0	5	100.0%	45	0.0%	0	0%	0
06/01	2	3	0	5	100.0%	30	0.0%	0	0%	0
06/02	0	8	0	8	75.0%	65	0.0%	0	25.0%	22
06/03	59	35	2	92	4.3%	29	20.7%	138	75.0%	502
06/04	42	45	1	86	2.3%	10	0.0%	0	97.7%	432
06/05	55	63	3	115	7.8%	46	0.0%	0	92.2%	544
06/06	53	54	2	105	4.8%	25	0.0%	0	95.2%	509
06/07	24	26	0	50	8.0%	20	54.0%	138	38.0%	97
06/08	28	33	0	61	16.4%	50	23.0%	70	60.7%	185
06/09	11	8	0	19	21.1%	20	31.6%	30	47.4%	45
06/10	5	6	0	11	18.2%	10	27.3%	15	54.5%	29
06/11	13	9	0	22	9.1%	10	68.2%	73	22.7%	24
06/12	19	23	0	42	2.4%	5	76.2%	165	21.4%	46
06/13	5	29	0	34	11.8%	35	50.0%	148	38.2%	113
06/14	0	9	0	9	0.0%	0	66.7%	29	33.3%	15
06/15	**0**	**0**	**0**	**0**	0.0%	0	**83.4%**	0	**16.6%**	0
06/16	**0**	**0**	**0**	**0**	0.0%	0	**83.4%**	0	**16.6%**	0
06/17	0	3	0	3	0.0%	0	100.0%	15	0.0%	0
06/18	**0**	**28**	**0**	**28**	**14.3%**	**20**	**64.3%**	**91**	**21.4%**	**30**
06/19	**8**	**10**	**0**	**18**	**11.1%**	**10**	**83.3%**	**78**	**5.6%**	**5**
06/20	5	4	0	9	11.1%	5	77.8%	34	11.1%	5
06/21	9	12	0	21	4.8%	6	76.2%	88	19.0%	22
06/22	6	4	0	10	0.0%	0	70.0%	38	30.0%	16
06/23	2	3	0	5	0.0%	0	60.0%	16	40.0%	11
06/24	3	5	0	8	37.5%	15	50.0%	21	12.5%	5
06/25	3	5	0	8	0.0%	0	87.5%	33	12.5%	5
06/26	1	1	0	2	0.0%	0	100.0%	8	0.0%	0
06/27	6	9	0	15	26.7%	20	33.3%	25	40.0%	30
06/28	**0**	**0**	**0**	**0**	**29.4%**	0	**38.1%**	0	**32.5%**	0
06/29	**0**	**0**	**0**	**0**	**29.4%**	0	**38.1%**	0	**32.5%**	0
06/30	**0**	**0**	**0**	**0**	**29.4%**	0	**38.1%**	0	**32.5%**	0
07/01	**0**	**0**	**0**	**0**	**29.4%**	0	**38.1%**	0	**32.5%**	0
07/02	14	14	0	28	32.1%	44	42.9%	59	25.0%	34
07/03	3	4	0	7	14.3%	6	28.6%	11	57.1%	22
07/04	**2**	**1**	**0**	**3**	**0.0%**	**0**	**100.0%**	**15**	**0.0%**	**0**
07/05	4	5	0	9	11.1%	5	44.4%	19	44.4%	19
07/06	1	2	0	3	66.7%	13	0.0%	0	33.3%	7
07/07	2	2	0	4	25.0%	4	25.0%	4	50.0%	9
07/08	1	0	0	1	0.0%	0	0.0%	0	100.0%	9
07/09	5	4	0	9	44.4%	17	22.2%	8	33.3%	13
07/10	2	1	0	3	33.3%	5	66.7%	11	0.0%	0
07/11	1	0	0	1	0.0%	0	0.0%	0	100.0%	8
07/12	**0**	**0**	**0**	**0**	**0.0%**	0	**12.5%**	0	**87.5%**	0
07/13	**0**	**0**	**0**	**0**	**0.0%**	0	**12.5%**	0	**87.5%**	0
07/14	2	2	0	4	0.0%	0	25.0%	5	75.0%	14
07/15	2	2	0	4	0.0%	0	0.0%	0	100.0%	20
07/16	1	1	1	1	0.0%	0	0.0%	0	100.0%	9
07/17	2	3	0	5	20.0%	4	60.0%	13	20.0%	4
07/18	**0**	**0**	**0**	**0**	**10.0%**	1	**46.7%**	2	**43.3%**	2
07/19	**0**	**0**	**0**	**0**	**10.0%**	1	**46.7%**	4	**43.3%**	3
07/20	1	2	0	3	0.0%	0	33.3%	3	66.7%	7
07/21	**0**	**0**	**0**	**0**	**25.0%**	1	**41.7%**	2	**33.3%**	2
07/22	1	1	0	2	50.0%	2	50.0%	2	0.0%	0
07/23	**0**	**0**	**0**	**0**	**0.0%**	0	**0.0%**	0	**0.0%**	0
07/24	1	0	0	1	0.0%	0	0.0%	0	100.0%	6
07/25	1	2	0	3	0.0%	0	66.7%	10	33.3%	5
07/26	1	1	0	2	0.0%	0	50.0%	5	50.0%	5
07/27	**0**	**0**	**0**	**0**	**0.0%**	0	**50.0%**	1	**50.0%**	1
07/28	1	1	0	2	0.0%	0	50.0%	4	50.0%	5
07/29	0	1	0	1	100.0%	10	0.0%	0	0.0%	0
07/30	0	0	0	0	**100.0%**	3	**0.0%**	0	**0.0%**	0
Total	456	621	13	1,064	26.0%	1,702	24.6%	1,431	49.3%	2,896

Notes: Trap outages are in **bold,** estimated by D:N catch ratios or catch rates.

Table 15: Projected 24-hour hatchery 0+ chinook catches, by tag group, Skagit River mainstem traps, 2002.

Stock	Tag Code	Number Released	Recovery Period	Projected 24-hour Catch[a]	Catch Rate
Countyline Ponds/ summer	21-03/91	186,640	May 17 – July 30	2,618	1.4%
Marblemount Hatchery[b]/ spring	Pooled[b]	242,721	June 02 – July 28	4,192	1.7%
Baker River Hatchery/ fall	21-04/02	170,665	June 04 – July 28	2,773	1.6%
	Total	600,026	May 17 – July 30	9,583	1.6%

[a] Estimated by applying the proportion of the tagged groups in the total hatchery catch (Table 14) by day, to the projected 24-hour catch.
[b] Tag codes 63-08/96, 63-14/11, and 63-14/12.

Wild & Hatchery 0+ Chinook Production Estimates

Catch Projection

Expansion of catch rates for the intervals not fished estimates an additional 23,204 and 17,777 wild 0+ chinook would have been captured in the scoop and screw traps, respectively (Table 16). Combining these projected catches with the actual catches (35,332 and 24,908 fry, respectively), estimates that we would have caught 101,221 wild 0+ chinook in the two traps had we fished continuously from January 15 through July 30. Actual catches represent 60% of the estimated catches.

Expanding actual catch rates for the intervals not fished following release of the hatchery production groups, estimates an additional 3,553 hatchery 0+ chinook would have been captured in the scoop and screw traps (Table 16). Actual catches represent 63% of the total projected hatchery catch.

Table 16: Summary of actual and projected wild and hatchery 0+ chinook catches in the Skagit River mainstem traps, 2002.

Group	Scoop Trap			Screw Trap			Total		
	Actual	Projected	Total	Actual	Projected	Total	Actual	Projected	Total
Wild	35,332	23,204	58,536	24,908	17,777	42,685	60,240	40,981	101,221
Hatchery	3,310	1,566	4,876	2,720	1,987	4,707	6,030	3,553	9,583

Production

We selected a value of 2.0% to represent season average trap efficiency. This rate is the mean of twenty 0+ chinook calibration groups that we released upstream of the mainstem traps from 1998 through 2002. Expansion of the projected season catch in both traps by this rate yields a system production estimate of approximately 5 million zero-age chinook (Figure 14).

Applying this same rate to the projected hatchery catch yields a combined estimate of 480,000 0+ chinook. Relating this estimate to the 600,000 chinook released, estimates in-river survival above Mt. Vernon at 80%.

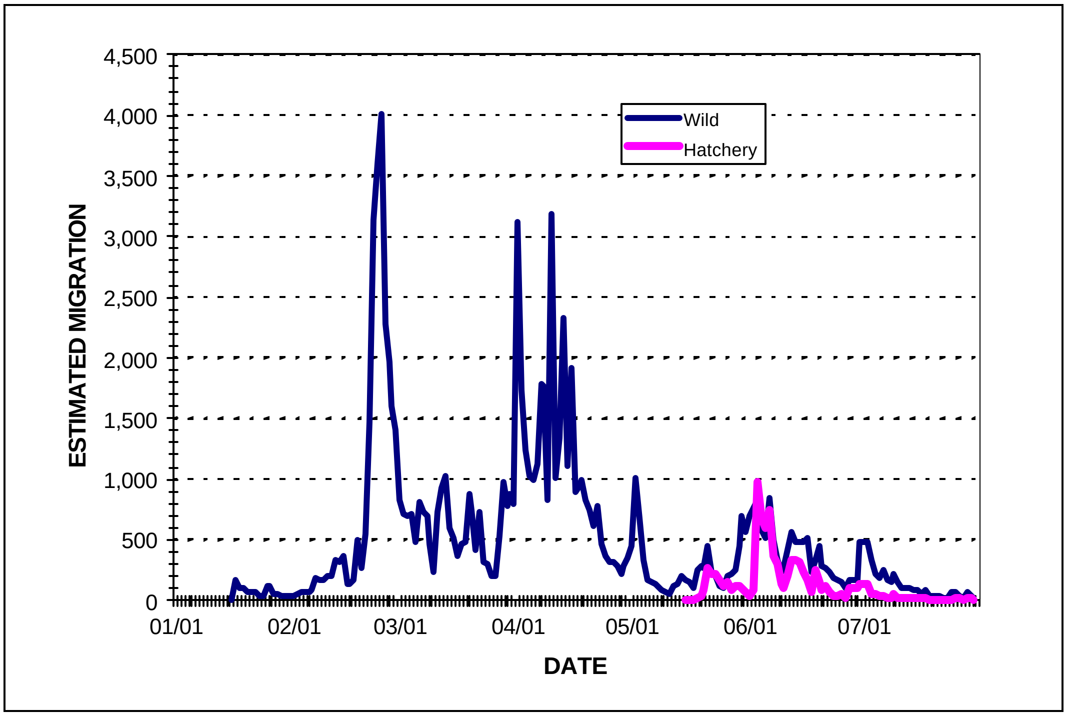


Figure 14: Estimated wild and hatchery 0+ chinook migration past the mainstem traps, Skagit River 2002.

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 30. While catch data exhibited considerable day-to-day variation, the months of February, March, and April accounted for 75% of the season total migration (Figure 15). By April 3, we estimate that 50% of the migration had passed the mainstem traps. Over the six years we have trapped throughout the entire migration (1997 through 2002), the median migration date has ranged from March 10 (1999) to May 2 (1998) (Figure 16).

Ad-marked hatchery 0+ spring, summer and fall chinook were released from three sites in the Skagit River basin: Skagit Hatchery, Countyline acclimation ponds, and Baker River, respectively (Table 13, Figure 1). Hatchery migrants entered catches two to nine days prior to the documented release dates (Table 14, Figure 17). Baker River fall chinook, which were released lowest in the watershed (R.M. 57), had a median migration timing past the traps of 12 days, and took 56 days to migrate past the traps. Skagit Hatchery spring chinook, which were released higher in the river (R.M. 78) at about the same time, had a mean migration timing to the trap of 4 days, and took 52 days to migrate. Countyline summer chinook, released earliest and highest in the watershed (R.M. 89), also had a median migration timing of 12 days, and took the longest to migrate past the traps, 76 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.

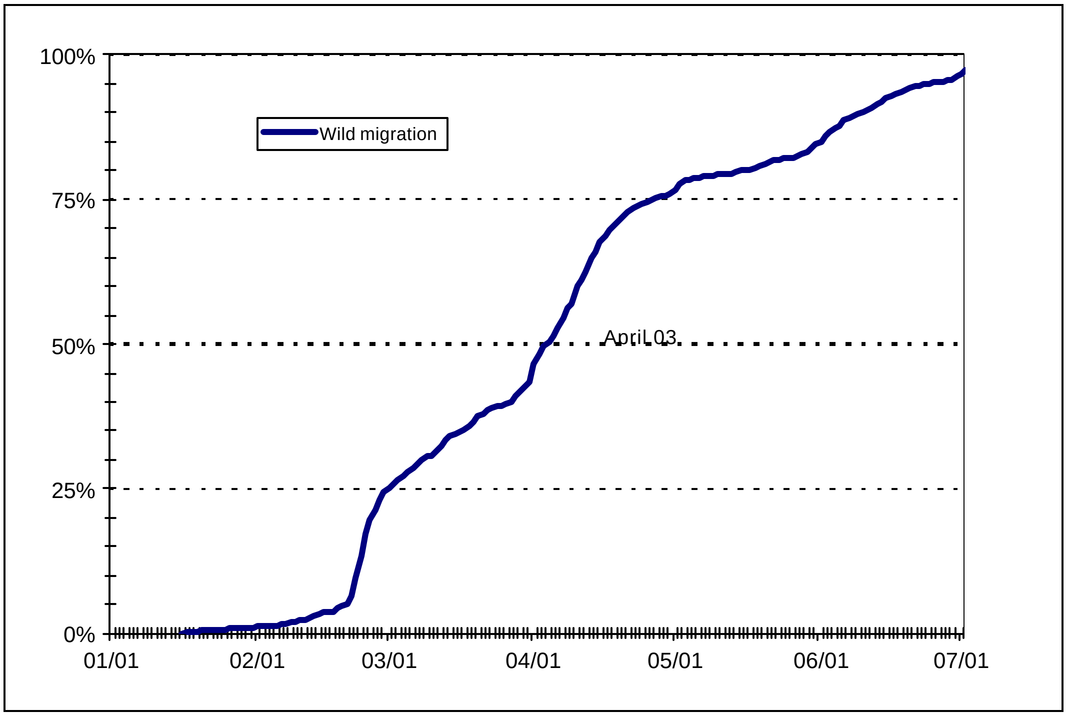


Figure 15: Migration timing of wild 0+ chinook past the Skagit River mainstem traps, 2002.

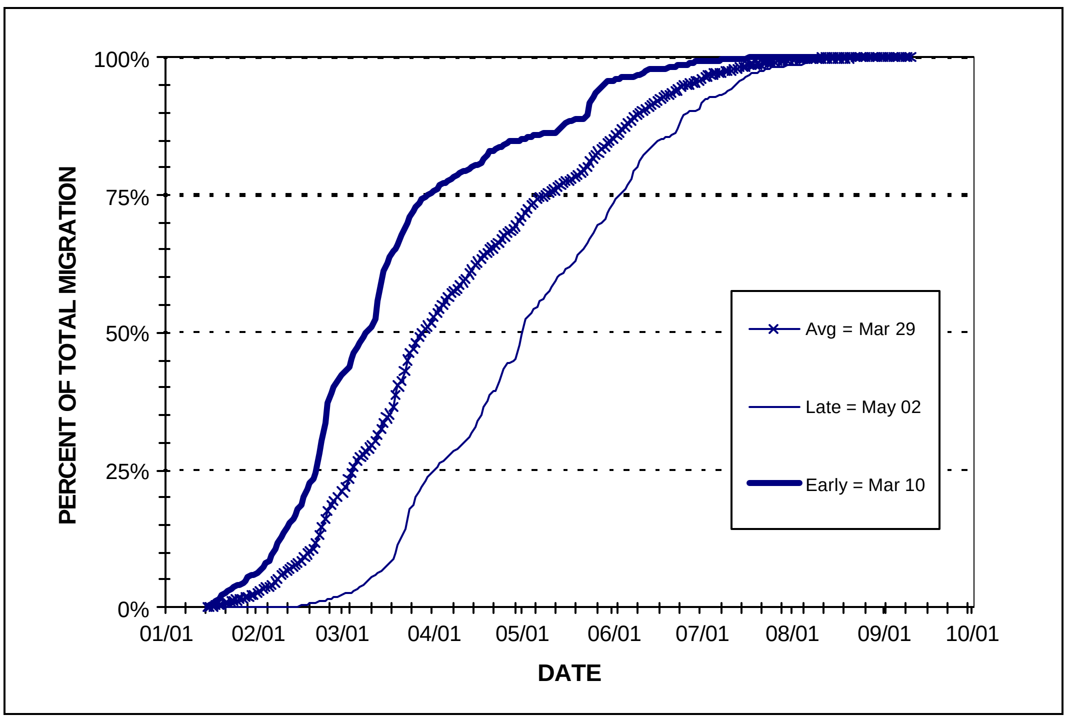


Figure 16: Mean, early, and late migration timing of wild 0+ chinook past the Skagit River mainstem traps, 1997-2002.

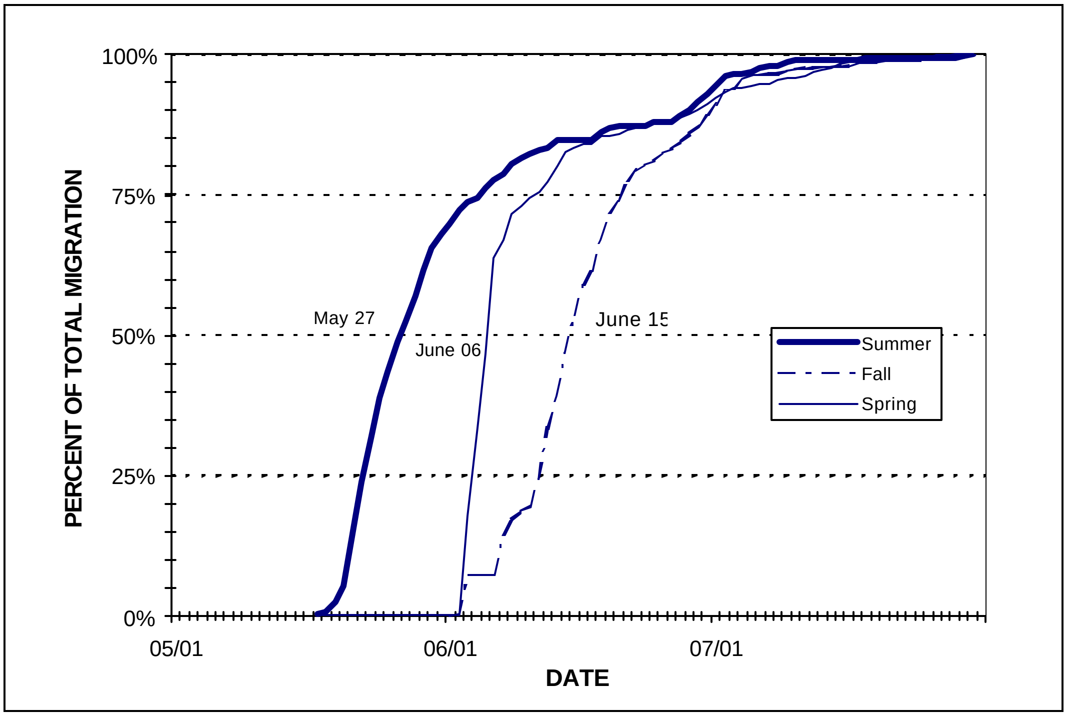


Figure 17: Estimated migration timing of three groups of hatchery 0+ chinook past the Skagit River mainstem traps, 2002.

Wild 0+ Chinook Size

Over the season, wild 0+ chinook captured in the traps increased in size from less than 40 mm through the end of February, to around 80 mm by mid-July (Table 17, Figure 18). The lower end of the weekly size range did not exceed 40 mm until early-May, indicating protracted emergence and/or slow growth for a component of the population. Comparing mean chinook fork lengths between the scoop and screw trap catches by statistical week showed no significant difference (Figure 19).

Length Analysis and Size Selectivity

High river flows dominated the Spring 2002 season, resulting in increased 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 size (fork length) of RV-marked coho smolts captured in the scoop and screw traps with that of the RV-marked smolts released from the Mannser Creek trap. The length distributions of marked smolts recaptured showed no statistical difference between the scoop and screw traps. The mean size of RV-marked smolts captured in the scoop trap was slightly less than the mean size of RV marked smolts released from Mannser Creek (91.9 mm and 93.7 mm), but no significant differences were found (KS test, " = 0.05).

Table 17: Mean fork length (mm), standard deviation, range, sample size, and catch, by statistical week, of wild 0+ chinook in the Skagit River mainstem traps, 2002.

STAT WEEK			SCOOP TRAP						SCREW TRAP					
			Avg	s.d.	Range		n	Catch	Avg	s.d.	Range		n	Catch
No.	Begin	End			Min	Max					Min	Max		
3	01/14	01/20	40.8	2.73	37	47	18	290	39.3	2.96	32	45	16	129
4	01/21	01/27	40.0	2.24	36	44	20	278	39.8	2.00	36	43	21	142
5	01/28	02/03	40.3	2.07	34	45	49	158	40.5	1.78	36	44	38	135
6	02/04	02/10	39.9	2.05	35	43	22	445	40.4	1.78	37	44	21	403
7	02/11	02/17	41.5	2.09	37	47	53	789	41.3	2.04	36	45	30	623
8	02/18	02/24	40.5	2.07	37	44	13	1,765	40.6	3.30	35	55	32	1,633
9	02/25	03/03	41.0	2.04	37	45	13	3,059	41.3	2.17	36	46	43	2,276
10	03/04	03/10	41.6	1.43	39	44	29	1,916	41.7	2.06	38	46	34	1,391
11	03/11	03/17	40.9	1.70	37	45	23	2,085	41.3	2.24	38	46	30	1,051
12	03/18	03/24	41.6	1.94	38	47	57	1,722	42.2	1.89	39	46	39	1,335
13	03/25	03/31	42.5	2.23	39	48	18	1,845	41.9	2.19	39	46	12	1,653
14	04/01	04/07	41.6	2.38	39	53	34	5,209	42.9	3.88	38	55	27	3,834
15	04/08	04/14	42.9	2.85	38	49	20	3,652	42.7	3.51	38	55	56	3,248
16	04/15	04/21	44.1	4.92	37	60	31	2,288	49.1	7.36	40	61	8	1,612
17	04/22	04/28	49.2	8.54	40	71	18	1,181	48.9	7.63	39	64	35	640
18	04/29	05/05	49.7	8.69	40	75	31	1,693	54.1	8.53	40	64	19	527
19	05/06	05/12	46.5	8.99	38	69	34	328	56.1	10.38	39	78	30	172
20	05/13	05/19	47.8	7.79	37	66	75	684	55.3	9.67	40	75	41	206
21	05/20	05/26	49.6	7.37	40	70	46	732	54.5	6.10	42	65	30	277
22	05/27	06/02	52.0	6.80	40	69	69	1,213	56.3	9.03	40	88	73	743
23	06/03	06/09	51.8	5.95	38	68	85	1,379	57.3	7.51	48	78	20	949
24	06/10	06/16	54.2	5.97	44	67	25	663	57.2	7.33	47	74	40	405
25	06/17	06/23	57.0	7.26	42	91	75	713	61.1	7.78	49	81	32	351
26	06/24	06/30	61.6	7.26	49	76	32	208	62.8	8.82	44	81	47	186
27	07/01	07/07	62.2	8.28	52	86	26	600	63.7	6.32	54	72	15	568
28	07/08	07/14	62.9	5.12	54	74	15	180	71.0	9.76	56	83	7	201
29	07/15	07/21	75.4	10.72	62	88	7	127	71.9	9.14	59	91	21	106
30	07/22	07/28	74.4	7.75	64	94	17	108			54	72	15	92
					34	94	955	35,310			32	91	832	24,888

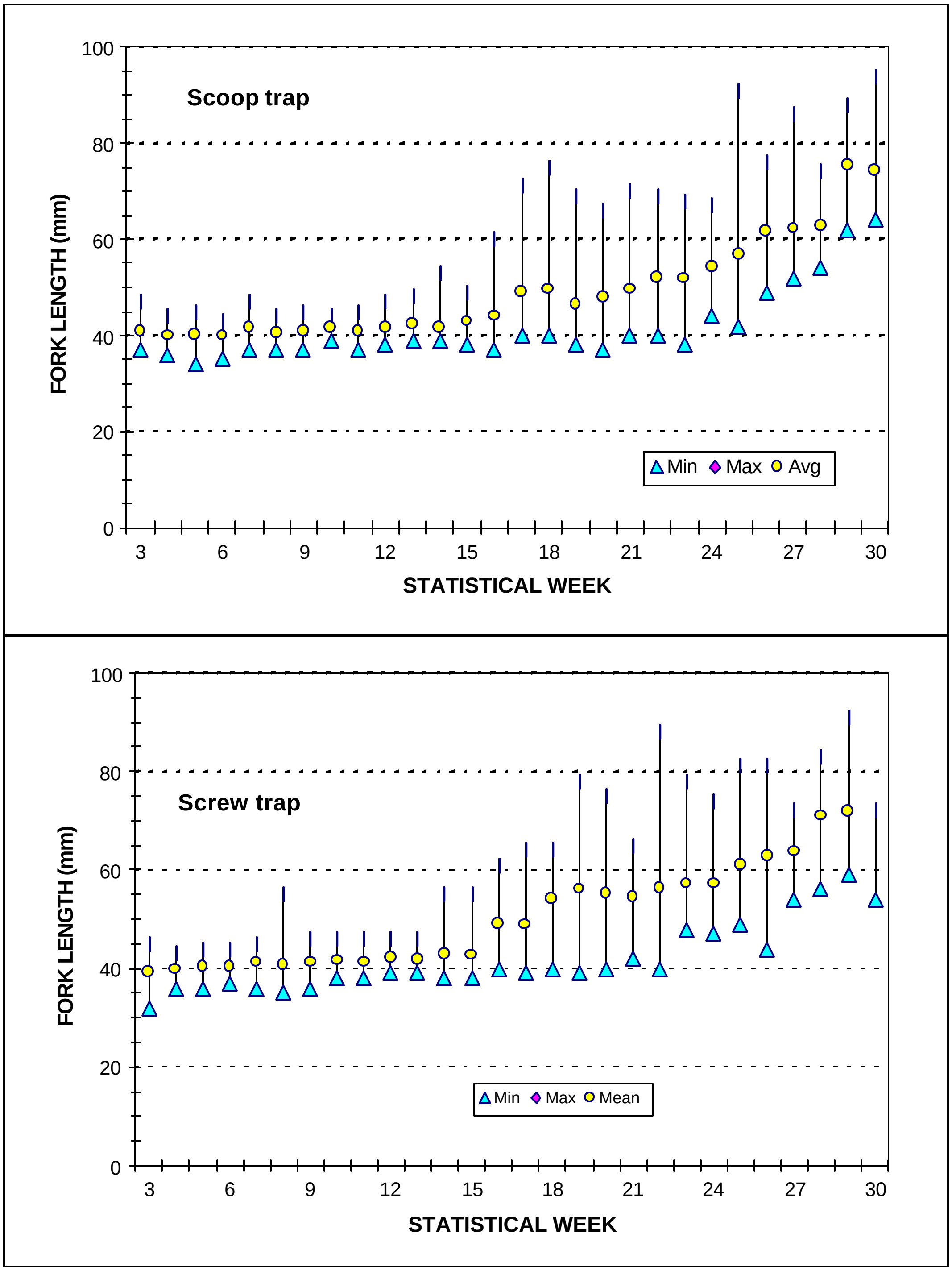


Figure 18: Weekly range and mean fork lengths of wild 0+ chinook measured at the Skagit River mainstem traps, 2002.

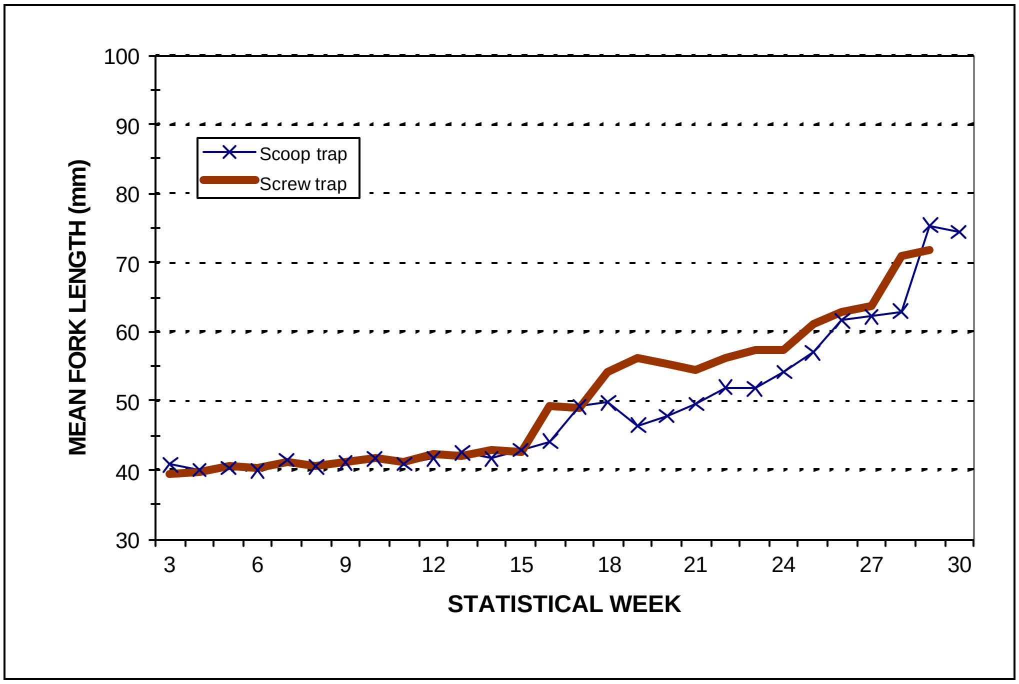


Figure 19: Comparison of mean size of chinook 0+ in the scoop and screw traps, by statistical week, Skagit River 2002.

Egg-to-Migrant Survival

Relating our estimate of 5 million downstream-migrant chinook to a potential deposition of 39 million eggs, results in an average survival-to-migration of 12.9%. This estimate of potential egg deposition (P.E.D.) is the product of 7,042 females and a fecundity of 5,500 eggs/female (Table 18).

Table 18: Estimated freshwater survival (egg deposition to migration), by brood year, Skagit River wild 0+ chiook (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	
		Total	Females (@45%)				cfs	Date
1989	1990	8,084	3,638	20.0	1.8	8.7%	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%	32,800	12/17
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%	76,000	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

[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.

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 have no flow-based correlation model to indicate its variation. Therefore, we selected a value based on the recapture rates of several groups of marked chinook 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 2002.

1. **Catch Expansion**. Moderate high flows dominated the trapping season in 2002. We did not operate the scoop trap on 15 nights and the screw trap on 19 nights due to mechanical reasons, heavy debris loads, and high flows. 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 0+ 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 0+ 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: 1.4% for Countyline Ponds summers; 1.7% for Skagit Hatchery springs; and 1.6% 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 2002 trap crew was comprised of trained scientific technicians. 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 (Figure 12) 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 higher or lower 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. 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). Therefore, based on this assumption, we believe that the estimate of trap efficiency obtained over all years that we released calibration groups is the best approximation of season trap efficiency in 2002. Application of this rate (2.0%) estimates that around five million wild 0+ chinook passed the traps in the Skagit River in 2002. If this estimate is biased, we believe that it is high, because it is unlikely that all marked chinook survived to pass the trap. Therefore, actual capture rate may be somewhat higher than indicated by the calibration groups released over the six-year period.

Discussion

Relatively moderate flows throughout the four seasons following 1997 have allowed almost continuous trapping. However, in this sixth year of extended trapping, high flows predominated the chinook 0+ migration period, providing another measure of the "shape" of the 0+ chinook migration from the Skagit River. Median migration in 2002, April 3, falls within the dates previously measured. 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 each season's estimate 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 twenty calibration groups we have released over the years ranged from 0.7% to 3.5%, 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 other 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 every year except 2002, average recovery rates of the calibration groups released approximately one mile upstream of the traps has exceeded that of the hatchery production groups released further upstream. In 2002, we believe high flows increased survival of the hatchery chinook groups to the traps. Therefore, release location and flow are important sources of bias in using such 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 eleven seasons, flow during egg incubation has explained most of the inter-annual variation in our estimates of egg-to-migrant survival rates (Figure 20). While the production in 2002 is slightly higher than predicted by this relationship, we have lower confidence in the production estimated for the first seven broods. Estimates for these broods

(1989 through 1995) were based on expanding estimated chinook migration during the coho trapping-interval (April through June). To assess the veracity of these estimates, we will analyze migration timing relative to flow patterns and parent spawner densities.

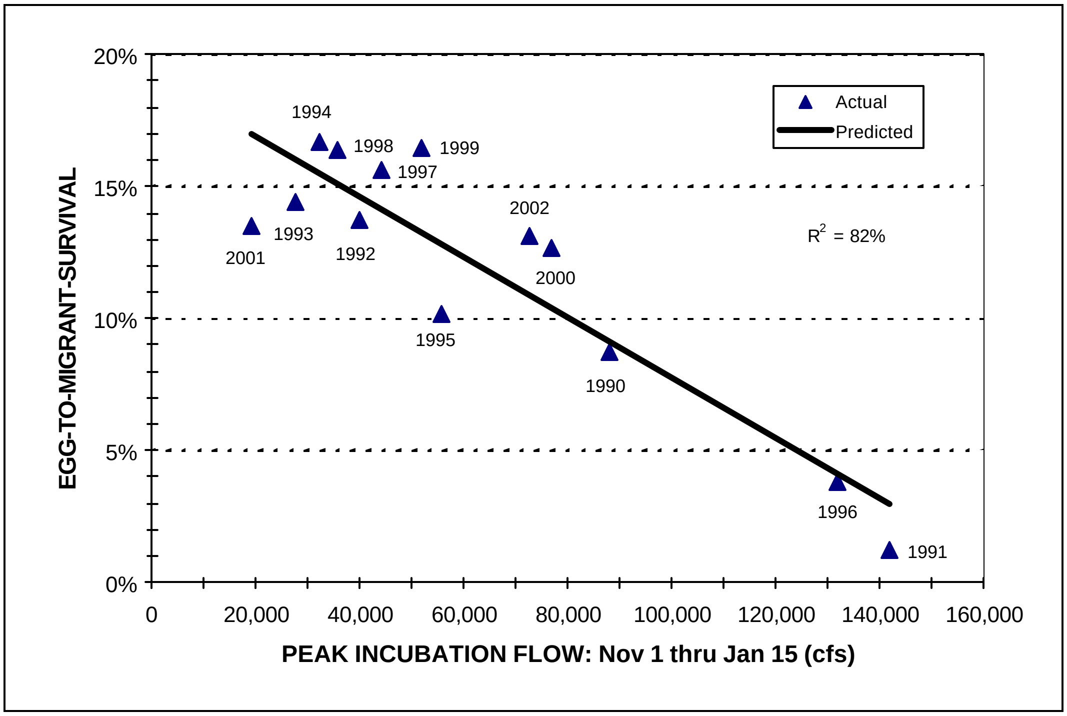


Figure 20: Wild 0+ chinook egg-to-migrant survival and peak incubation flow, migration years 1990-2002, Skagit River.

Recommendations

The following recommendations, compiled from the past five years' work, are listed so that we can assess the progress we made during the 2002 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 hatchery 0+ chinook and continue to assess the feasibility of using these fish to calibrate the traps.

Progress

1. **Accomplished**. We trapped each night with the exception of 16 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 2002 season.

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

5. **Accomplished**. With funding from Seattle City Light, WDFW contracted a biometrician in 2002 to review the data collected in 2001 and test the associated production estimation methods.

Recommendations for 2003

Our study plan for the 2003 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 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.

References

Cases

Busack, C., C. Knudsen, A. Marshall, S. Phelps, and D. Seiler. 1991. Yakima Hatchery experimental design. WA Dept of Fish Ann Prog Rpt prepared for BPA Div of Fish & Wildl. Olympia, Washington. 266pp. 7

Castle, Pete. WDFW Region 4. September 20, 2001. Telephone conversation. 2

Conrad, R.H., R.A. Hayman, E. Beamer, and P.J. Goddard. 1997. Coho Salmon Escapement to the Skagit River Estimated Using a Mark-Recapture Method: 1986. Northwest Fishery Resource Bulletin. Proj Rep Series No. 6. NWIFC. Olympia, Washington............................ 1

Puget Sound Salmon Stock Review Group. 1992. Assessment of the Status of Five Stocks of Puget Sound Chinook and Coho: As Required Under the PFMC Definition of Overfishing. Tech Rpt for the Pacific Fisheries Management Council. Portland, Oregon. 113 pp.............. 1

Puget Sound Salmon Stock Review Group. 1997. An Assessment Of The Status Of Puget Sound Chinook And Strait Of Juan De Fuca Coho Stocks: As Required Under The Salmon Fishery Management Plan. Tech Rpt for the Pacific Fisheries Management Council. Portland, Oregon. 78pp.. 1

Seber, G.A.F. 1982. *The Estimation of Animal Abundance and Related Parameters*. Charles Griffin & Co Ltd. High Wycombe, England. 3

Seiler, D., P. Hanratty, S. Neuhauser, and M. Ackley. 1984. Upstream/Downstream Salmonid Trapping Project 1980-1982. WA Dept of Fish Prog Rpt No. 200. Olympia, Washington. 1

Seiler, D., P. Hanratty, S. Neuhauser, P. Topping, M. Ackley, and L.E. Kishimoto. 1995. Wild Salmon Production and Survival Evaluation Annual Performance Report: October 1993 - September 1994. WA Dept Fish & Wildl Prog Rpt. Olympia, Washington. 113 pp. 2

Seiler, D., S. Neuhauser and L. Kishimoto. 2002. 2001 Skagit River Wild 0+ Chinook Production Evaluation. WA Dept Fish Ann Rpt. Olympia, Washington. 47 pp. 46, 47

Seiler, D., S. Neuhauser, and M. Ackley. 1981. Upstream/Downstream Salmonid Trapping Project 1977-1980. WA Dept of Fish Prog Rpt No. 144. Olympia, Washington. 195 pp... 1, 7