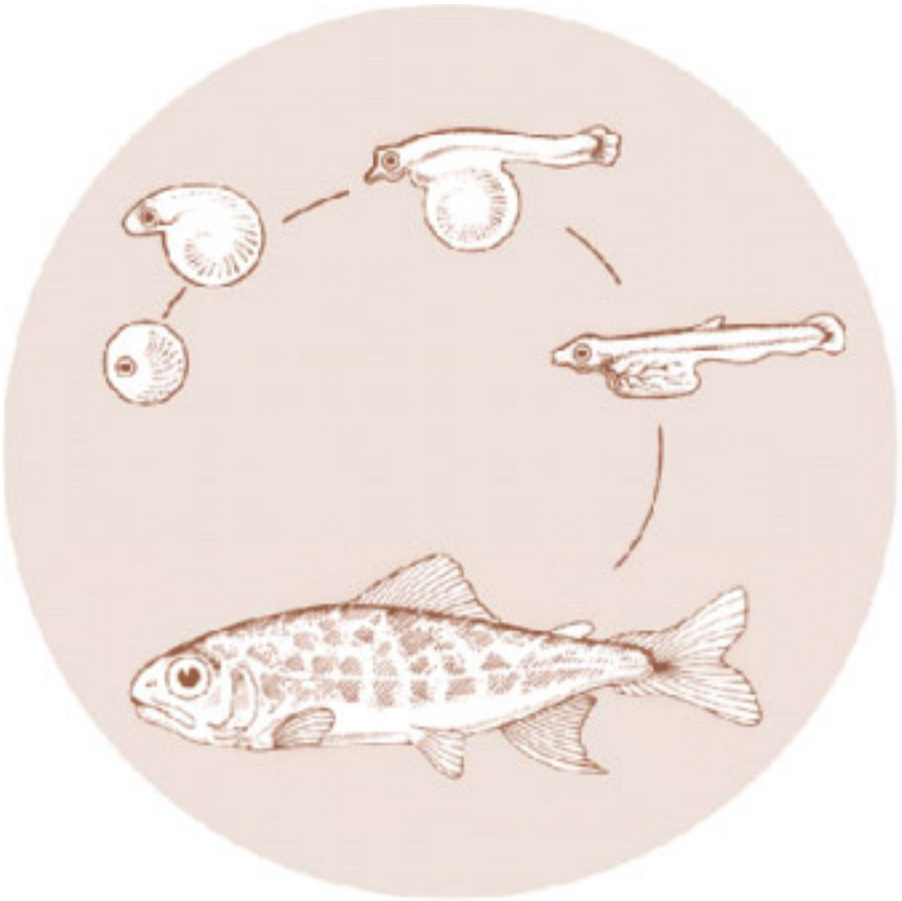
Mid-Columbia Coho Reintroduction Feasibility Study

Broodstock Development

Annual Report
2002



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MID-COLUMBIA COHO REINTRODUCTION FEASIBILITY STUDY:

2002 Annual Broodstock Development Report

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Chapter 1 2002 Pre-Smolt Acclimation

Introduction

Wild stocks of coho salmon *Oncorhynchus kisutch* were once widely distributed within the Columbia River Basin (Fulton 1970; Chapman 1986). Since the early 1900s, the native stock of coho has been decimated in the tributaries of the middle reach of the Columbia River (the Wenatchee, Entiat, Methow, and Okanogan rivers) (Mullan 1983). Efforts to restore coho within the mid- and upper Columbia Basin rely upon large releases of hatchery coho. The feasibility of re-establishing coho in the tributaries of the mid-Columbia Basin may initially depend upon the resolution of two central issues: the adaptability of domesticated lower river coho stocks used in the re-introduction efforts and associated survival rates; and the ecological risk to listed and sensitive species.

The Yakama Nation (YN), as the lead agency, began research to evaluate the feasibility of re-introducing coho salmon to mid-Columbia tributaries in 1996. The long term goal of the Mid-Columbia Coho Reintroduction Project is to re-establish naturally reproducing coho salmon populations in mid-Columbia River basins, with number at or near carrying capacity. In the short term, the feasibility study seeks to determine whether a localized broodstock can be developed from lower Columbia River coho stocks and to initiate natural production in areas of low risk to sensitive species (HGMP 2002).

Acclimation of juvenile coho reprogrammed from lower Columbia River hatcheries and development of a local broodstock are required to achieve the goals of the feasibility study. Acclimation may reduce residualism; increase smolt-to-adult survival rates, yield returning adults capable of producing naturally spawned progeny, and minimize adult straying into other watersheds.

This document reports the numbers, locations, size, and marking of reprogrammed lower Columbia River coho salmon and the developing mid-Columbia broodstock that were transported to acclimation sites in the mid-Columbia River tributaries.

Wenatchee River Basin Acclimation Sites

Icicle Creek

The Icicle Creek coho acclimation site is located at river mile (RM) 2.8 on a side channel to Icicle Creek adjacent to the Leavenworth National Fish Hatchery (LNFH) (HGMP 2002). The acclimation site is located behind a historic dam built between 1939 and 1941, originally designed to hold adult salmonids returning to the LNFH prior to spawning. Icicle Creek is our focal watershed for broodstock development.

Transportation

Oregon Department of Fish and Wildlife (ODFW) transported approximately 768,802 hatchery coho pre-smolts to the Icicle Creek acclimation site on March 19-21, 2002. Of these hatchery pre-smolts, 349,221 originated from ODFW's Cascade Fish Hatchery. The smolts transported from Cascade FH were mid-Columbia brood coho, the progeny of the first adult return to the Wenatchee River. ODFW transported an additional 419,581 hatchery coho from Eagle Creek National Fish Hatchery on March 25-29. All coho transported to the Icicle Creek acclimation site from Eagle Creek NFH were reprogrammed lower Columbia River coho.

Mortality

During the five-week acclimation period, 735 known coho pre-smolt mortalities were recovered off the outlet screens and floating structures (Figure 1). Nine percent of these mortalities (*n=68*) displayed signs of mammalian/aviary predation such as missing appendages, open wounds on the dorsal surface, puncture wounds, and scarring. The mortality rate was relatively constant throughout acclimation. The total loss during acclimation is difficult to enumerate because of unobserved mortality (buried in sediment, predation, etc.). For this reason, an estimated mortality rate was calculating using known loss plus an estimation of predator consumption. This estimate was determined using the following equation:

$$E_c = C_t * FPP * N_i * C_d$$

E_c *= Estimated consumption for an individual predator*
C_t *= Consumption total per day in kilograms for an individual predator*
FPP *= Fish per pound*
N_i *= Number of same species predators observed during time interval i*
C_d *= Duration of same species predators observed*

The target predators in determining fish loss were the North American river otter (*Lutra canadensis*) and the common merganser (*Mergus merganser*). During acclimation, four otters were observed; two adults and two kits. Adult river otters can consume as much as 20% their body weight in the natural environment (Beckel 1982). Average weights for male and female river otters were 25 and 19 pounds, respectively. Mergansers can consume upwards of one pound of fish per day. Estimated loss due to otters and mergansers was 4,274 coho. The estimated mortality rate for the Icicle Creek acclimation site in 2002 was approximately 0.65% (*n=5,009*).

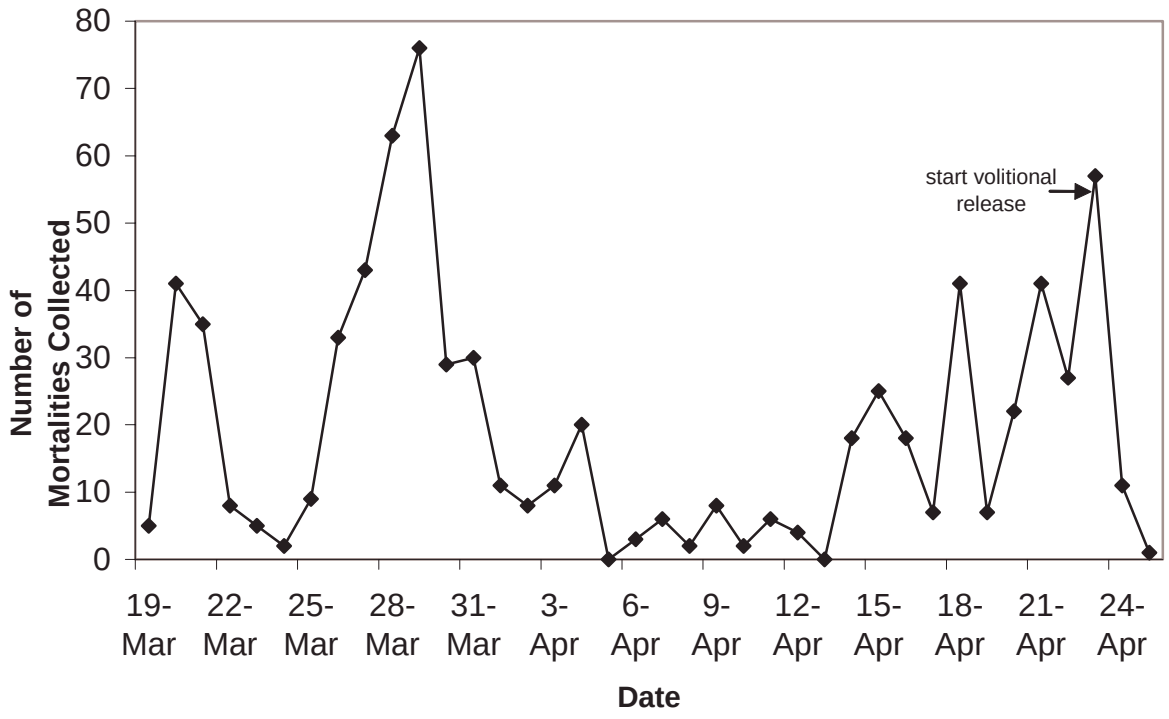

Figure 1. The number of known mortalities collected from the Icicle Creek coho acclimation site, 2002.

Marks and Tags

Coho transported from Cascade FH and Eagle Creek NFH were coded wire tagged (CWT'ed) with no external mark (Cascade FH CWT codes: 050577 and 050581; Eagle Creek CWT codes: 054532 and 055012). Accounting for pre-transfer mortality, in-pond acclimation mortality (0.75%), and estimated tag loss, the number of CWT juveniles released from the Icicle Creek acclimation site can be found in Table 1. The total number of juvenile coho released from the acclimation site was 763,793.

In addition to the CWTs, 16,888 coho smolts tagged with passive integrated transponder (PIT) tags were released. Coho reared at Eagle Creek NFH were CWT'ed and PIT tagged the summer/fall prior to transport while coho transferred from Cascade FH were CWT'ed the summer before transport and PIT tagged a couple months prior to transport.

Table 1. CWT tagged coho released from Icicle Creek acclimation pond, 2002.

Hatchery	Number of fish tagged	Mark	Tag Retention (%)	Tag Code	Tag loss and mortality	Number CWT released
Cascade FH	297,424	CWT only	98.1	050577	11,510	285,914
Cascade FH	55,944	CWT only	98.3	050581	1,726	54,218
Eagle Creek NFH	217,793	CWT only	99.9	054532	5,653	212,140
Eagle Creek NFH	206,820	CWT only	99.8	055012	3,130	203,690

Size and Growth

Juvenile coho transported from Cascade FH and Eagle Creek NFH to the Icicle Creek acclimation site averaged 20.1 and 20.3 fish per pound (FPP), respectively. In-pond sampling was performed once a week from April 3-24, 2002. Five independent samples were collected within the acclimation pond and pooled together to provide a weekly size estimate (*n=100*). The mean length, weight, condition factor and FPP for the four weekly samples are noted in Table 2. The final sample occurred on April 24, the start of the volitional release.

Table 2. Coho growth during acclimation, Icicle Creek, 2002.

Date	Mean Fork Length(mm)	Mean Weight (g)	K-factor	Fish per pound (FPP)
April 3	119.8	22.2	1.28	20.4
April 10	124.2	23.1	1.18	19.7
April 16	126.4	24.7	1.21	18.3
April 24	132.8	26.9	1.13	16.9

Juvenile Morphology and Development

Coho juveniles were identified by developmental and morphological differences seen during growth sampling. The three classification stages were parr, transitional, and smolt. Parr expressed obvious vertical markings along the lateral body (usually between 8-12 parr marks) with a noticeable sickle-shaped anal fin. The orange pigment in the anal, caudal, and dorsal fins was expressed in a variety of tones, usually very faint. The first three anal fin rays contained white coloration followed by a fourth black fin ray. Observed coloration of the dorsal body varied from a light to medium brown. Smolts were easily identified by their silvery appearance and displayed a blue-green coloration along the dorsal surface. Parr marks were faint or absent. Anal, caudal, and dorsal fins appeared transparent. Transitional juveniles displayed both parr and smolt characteristics. Fin coloration seemed to fade but parr marks were still obvious. A

silvery color was observed throughout the body. Physiological changes that occur during these developmental transformations include elevated plasma levels of cortisol and thyroid hormones as well as increased gill Na^+, K-ATPase activity (Patino et. al. 1986). Overall, the proportion of smolt and transitional coho increased throughout acclimation while parr decreased (Figure 2).

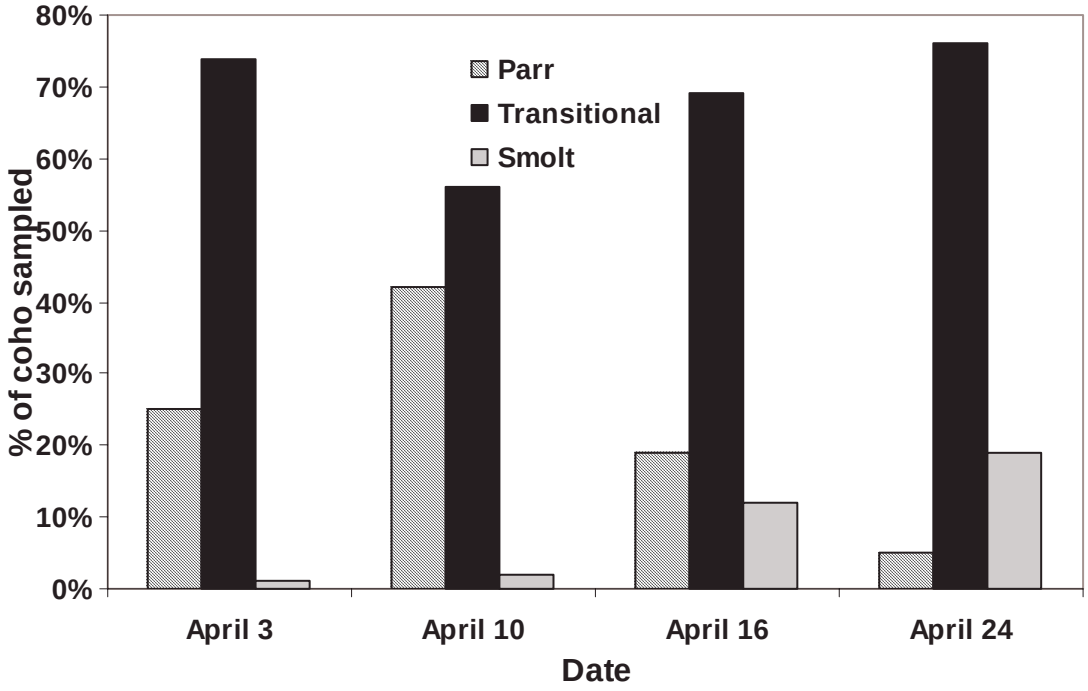

Figure 2. Proportion of coho parr, transitional, and smolts during acclimation, Icicle Creek, 2002.

Fish Health/Condition Assessment

We performed a pre-release fish condition assessment (*n=20*) to examine overall health by evaluating the normality of external features (eyes, fins, opercules, etc.) as well as internal organs and blood components. These procedures are done to note abnormalities, not to diagnose the causes of certain conditions. Results from the condition assessment concluded that individuals prior to release were in good condition with no abnormalities observed (Table 3).

Table 3. Pre-release fish health assessment for Icicle Creek juvenile coho, 2002.

Eyes[1]	Gill[1]	Psuedo-branchs[1]	Thy-mus[1]	Mes. Fat[2]	Spleen[1]	Hind[1] Gut	Kidney[1]	Liver[1]	Gender	Fin Cond.[1]	Opercle[1]
90%	95%	95%	100%	2.3	100%	100%	100%	100%	65%M 35%F	100%	100%

1- All components were based on a normality index (% norm). Variance in organ color and size was not looked at.

2- Mesenteric fat was based on a 0-3 numerical system average. An average of 2.3 equals more than 50% of the ceaca covered with fat, which is healthy.

Volitional Release

Coho smolts were volitionally released from the Icicle Creek acclimation site. The release began on April 24 at 12 p.m. and continued through May 17, when visual observation determined that all fish had exited the pond. Juvenile coho emigration was documented at the rotary smolt trap located upstream from the town of Monitor (RM 7.1) (Figure 3). The trap is operated by Washington Department of Fish and Wildlife (WDFW). YN had a cooperative agreement with WDFW to assist during the trapping period in which the majority of coho smolts would be emigrating through the system. A sub-sample (*n=1252*) of coho smolts was measured and stage of smoltification was recorded (Table 4). Developmental stages recorded at the trap were a composite of all coho release sites in the basin. A basin-wide coded-wire tag retention rate was measured at 97.5% (*n=10,379*). To determine CWT retention, each coho collected at the trapping site was scanned for CWTs and marked accordingly. After May 26, coho migration data was collected by WDFW personnel. The number of coho passing the smolt trap after May 26 did not warrant YN support. Ninety percent of the emigrating coho juveniles were trapped prior to May 22nd (Figure 3). Information regarding downstream smolt survival rates can be found in Murdoch et al. (2004). During 2002 trap operations, 72 naturally reared coho and 12,517 hatchery reared coho were captured (Murdoch et al. 2004) (Figure 3).

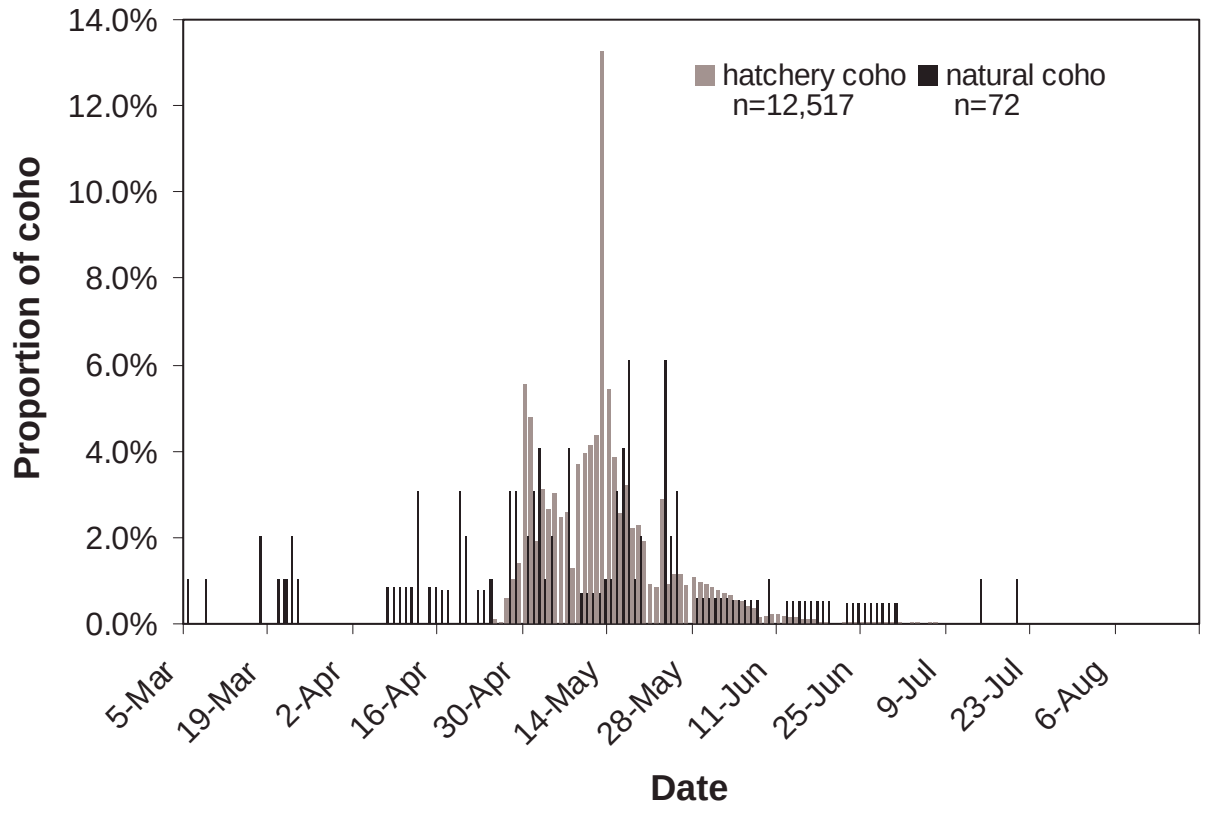

Figure 3. The proportion of natural and hatchery coho smolts captured in a rotary smolt trap located near the town of Monitor on the Wenatchee River (RM 7.1) during spring, 2002.

Table 4. Juvenile coho emigration and developmental stage information collected during rotary smolt trap operation (March 5-August 19) by WDFW and YN on the Wenatchee River, 2002.

Stage (P,T,S)	Mean Fork Length (mm)	Number	Percent of Total Collection (%)
Parr	74.0 (0)	1	0.1
Transitional	136.3 (10.8)	356	28.4
Smolt	142.1 (10.1)	895	71.5

Butcher Creek

The Butcher Creek acclimation site is located at RM 8.2 on Nason Creek (HGMP 2002). This acclimation site is a natural beaver pond located at the mouth of Butcher Creek. Coho smolts are volitionally released directly into Nason Creek from the pond. The Butcher Creek acclimation pond is a key site for initiating natural production and evaluating interactions with listed and sensitive fish species.

Transportation and Size

A total of 143,926 hatchery coho pre-smolts were transported to the Butcher Creek acclimation pond from Cascade FH on March 19, 2002. Fish transported to the acclimation pond averaged 20.5 FPP and were mid-Columbia brood origin (Appendix A). We sampled coho in the pond once a week between April 4 and 22, 2002. Random dip net samples were collected within the acclimation pond and pooled together to provide a weekly size estimate (*n=100*). The mean length, weight, condition factor and fish per pound for the three weekly samples are reported in Table 5. The final sample occurred on April 22, eight days prior to release.

Table 5. Coho growth sampling during acclimation at Butcher Creek pond, 2002.

Date	Mean Fork Length(mm)	Mean Weight (g)	K-factor	Fish per pound (fpp)
April 4	124.3	22.3	1.16	20.3
April 13	126.9	23.8	1.17	19.0
April 22	127.2	24.4	1.19	18.6

Juvenile Morphology and Development

Coho juveniles were identified by developmental and morphological differences seen during growth sampling. We classified the coho as either parr, transitional, or smolt (see "Icicle Creek"). The proportion of transitional coho increased throughout acclimation, while the proportion of parr decreased (Figure 4). Smolts were not observed during sampling at Butcher Creek. The last sample was collected eight days prior to release due to logistical constraints. We believe that coho emigrating from Butcher Creek were smolting. Nighttime captures of coho exiting the pond in May confirmed that the majority of juveniles were in the transitional and smolt developmental stages. It may be advantageous for coho emigrating from mid-Columbia basins to exit acclimation ponds as transitionals because of the extended seaward migration.

Long emigration distances may require juveniles to migrate early in the smoltification process to ensure complete transformation by the time they enter the marine environment. Similarly, most naturally produced spring chinook yearlings (76.1%) emigrating from the Chiwawa River in the Wenatchee River basin emigrate as transitionals (WDFW unpublished data).

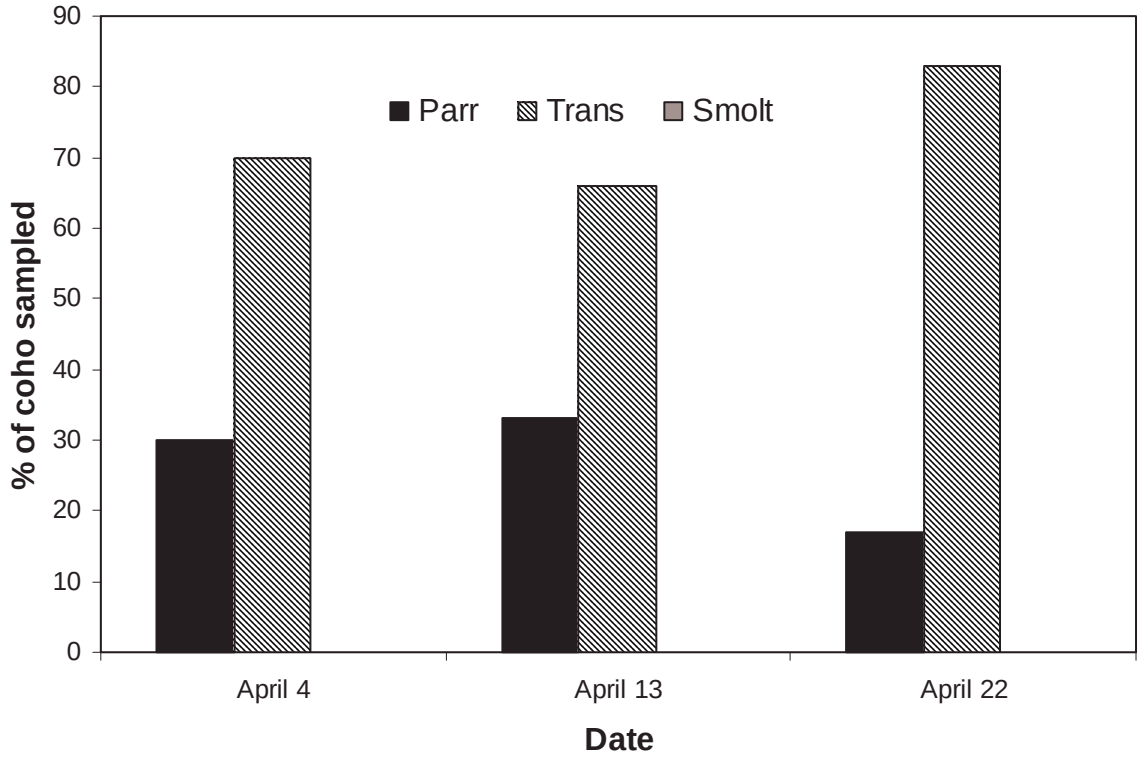

Figure 4. Proportion of coho parr, transitional, and smolts during Butcher Creek acclimation, 2002.

Mortality

Three hundred and six coho pre-smolts were known to have died and were recovered from the Butcher Creek pond during the acclimation period. The actual number of mortalities is unknown. It is difficult to estimate the number of fish that died and were not visible or were consumed by predators. Twenty-four of the mortalities (7.8%) displayed signs of predation (as described previously in the Icicle Creek section). The mortality rate was relatively constant throughout acclimation. During acclimation, four adult otters and a small number of mergansers were observed. The estimated mortality rate in Butcher Creek pond in 2002 was 3.46%. Applying the same predation estimate used on the Icicle side channel, in-pond loss was 4,986 coho.

Marks and Tags

Coho smolts released from the Butcher Creek acclimation site in 2002 were CWT'ed (CWT code: 050578 and 050579) with no external marks (adipose fin present). In addition to CWTs, 7,894 coho were PIT tagged. PIT-tagged coho allowed for analysis of survival rates from release to McNary Dam (Murdoch et al. 2004).

PIT-tag Detection System

The Butcher Creek outlet system is made of two 8-inch PVC pipes buried within a natural beaver dam at the far end of the pond. A two-antenna detection system (one on each release pipe) was constructed to monitor and record PIT-tagged juveniles exiting the pond. In order to prevent the detection fields from overlapping, one antenna was mounted on the pond side and the other on the stream side. Both transceivers were powered by deep-cell batteries and placed in a storage tote for weather protection. Cords connecting the transceiver to antenna were protected with rubber tubing and sealant. Twelve efficiency trials were performed at various water depths (Table 6). A staff gauge was placed in Nason Creek to correlate depth with detection efficiency. Each trial consisted of "wooden fish" being passed through the outlet pipes for a total sample size of 40 per release pipe. These "artificial coho" were constructed out of 5-inch pieces of dowel rod with a PIT tag inserted into a pre-drilled hole. Detection efficiencies ranged from 55-100% detection. Increased water depths in Nason Creek seemed to correlate with detection efficiencies in both outlet pipes. As Nason Creek flows increased, water levels rose submerging the release pipes resulting in decreased flow velocities within the pipes. The decrease in flow velocities within the release pipes resulted in an increased detection efficiency.

Table 6. PIT tag efficiency trials conducted at Butcher Creek acclimation pond, 2002.

Date	Staff gauge (in.)	Detection Rate		Efficiency (%)	
		Detector #1	Detector #2	Detector #1	Detector #2
May 2nd	18	40/40	40/40	100	100
May 3rd	21	40/40	40/40	100	100
May 8th	11	30/40	23/40	75	57.5
May 10th	7	29/40	22/40	72.5	55
May 13th	15	31/40	23/40	77.5	57.5
May 20th	30	40/40	40/40	100	100
May 21st	27	40/40	40/40	100	100
May 22nd	24	40/40	40/40	100	100
May 23rd	18	40/40	40/40	100	100
May 28th	36	40/40	40/40	100	100
May 29th	39	40/40	40/40	100	100
May 30th	36	40/40	40/40	100	100

Volitional Release

Coho smolts were volitionally released from the Butcher Creek acclimation site beginning on May 1, 2002. Peak emigration occurred from May 16th through the 31st. During this period, 5,787 tags were detected (79.2%). We expanded the known detections with the detection efficiency of each release pipe. Based on expanded detections, we estimate that 7,304 (+/- 522) tagged fish left the pond. Applying the proportion of the population that was PIT tagged (5.5%), an estimated 133,159 total coho (+/- 9,524) exited Butcher Creek acclimation site in 2002 (Figure 5). In-pond survival was estimated at 92.5% (+/-7.15%). The release continued through June 12 when we no longer detected any PIT-tagged fish.

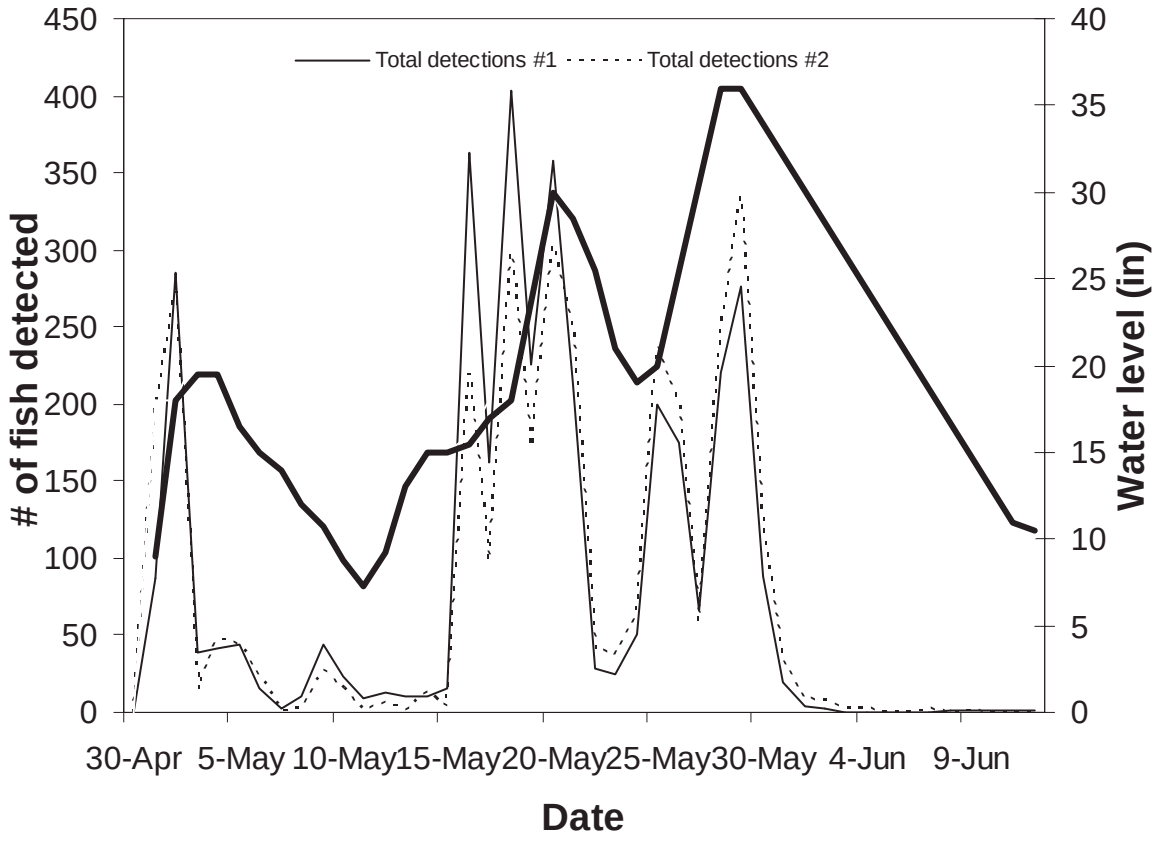

Figure 5. PIT tags detected during emigration at Butcher Creek acclimation site, 2002.

Beaver Creek

The Beaver Creek acclimation site is located at RM 1.5 on Beaver Creek. The Beaver Creek drainage enters into the Wenatchee River near Plain, WA at RM 46.2. The Beaver Creek acclimation site was artificially constructed in the mid 1980s and is located behind Mountain Springs Lodge. Originally, the pond was stocked with Kamloops rainbow trout for aesthetic purposes. Predation on these year-round residents became too problematic and the stocking was

discontinued. Since then, the pond has not been stocked with fish until the introduction of coho juveniles this year. Containment structures were positioned at the inlet and outlet. Coho smolts were volitionally released into Beaver Creek.

Transportation and Size

A total of 72,300 hatchery coho pre-smolts were transported to the Beaver Creek acclimation site from Cascade FH on March 26, 2002. Fish transported to the Beaver Creek averaged 20.0 FPP. These juveniles were progeny of mid-Columbia adult matings.

Mortality

Two hundred and sixty-two coho pre-smolts died and were removed from the Beaver Creek pond during the acclimation period. The majority of fish loss occurred due to transport stress encountered prior to release. Because it was difficult to enumerate fish that died and were not visible or were consumed by predators, the actual number of mortalities is unknown. For this reason, we doubled the known loss to provide an estimated mortality rate in 2002 of 0.72%. Predation estimate methods used in the previously reported acclimation sites were not applied because predators were not observed at this site.

Marks and Tags

Coho smolts released from the Beaver Creek acclimation site in 2002 were CWT'ed (CWT code: 050582) with no external marks (adipose fin present).

Volitional Release

Coho were volitionally released from Beaver Creek acclimation pond beginning on April 28, 2002. On June 23, an estimated 15,000 fish were still on site. Two hypotheses were explored regarding coho residualism: 1) coho juveniles were not smolting and therefore did not possess the instinctive urge to emigrate; or 2) a possible lack of attraction flow was restricting coho emigration. On June 26 and July 11, two random dip nets samples (*n=100 and n=124*) were collected and developmental stages were documented. Ninety-five and ninety- nine percent of the samples displayed a transitional or smolt appearance, negating the first hypothesis. We then removed the outlet structure from the culvert so as not to impede emigration. We force-released approximately 5,000 – 6,000 coho smolts from the pond between June 26 and July 3. High flows continued throughout the month, allowing for adequate migration conditions. With assistance from the Colville Confederated Tribes, we electro-fished and removed an additional 5,000 - 8,000 juvenile coho from the pond. We transported the coho directly to the Columbia River near Wenatchee due to concerns regarding potential interactions with newly emerged steelhead fry.

Early Pond

The Early Pond acclimation site is located at RM 9.0 on Nason Creek. This site is a natural pond just upstream of Butcher Creek. Fish are released through a culvert positioned underneath Highway 2, connecting the pond to Nason Creek. A containment structure, similar to the one at Beaver Creek, was installed onto the culvert. Dam boards were added to provide increased water depth for the pre-smolts.

Transportation and Size

A total of 19,013 mid-Columbia brood coho pre-smolts were transported to Early Pond acclimation site from Cascade FH on March 19, 2002 (Appendix A). Fish transported to Early Pond averaged 19.5 FPP.

Mortality

Eight coho pre-smolts were known to have died and were removed from the Early Pond during the acclimation period. The actual number of mortalities is unknown because it is difficult to estimate the number of fish that died and were not visible or were consumed by predators. For this reason, we will double the known loss to provide an estimated 2002 mortality rate in Early Pond of 0.06%. Predation estimate methods used in the previously reported acclimation sites were not applied because predators were not observed at this site.

Marks and Tags

Coho smolts released from the Early Pond acclimation site in 2002 were CWT'ed (CWT code: 050581) with no external marks (adipose fin present). Due to the low number of fish acclimated in Early Pond and the number of fish per raceway at the rearing hatchery, we were unable to mark Early Pond coho with a unique tag code. The tag code used in Early Pond was shared with a code used in the Icicle Creek side-channel. As a result, smolt-to-adult survival rates specific to Early Pond will not be obtainable.

Volitional Release

Coho were volitionally released from Early Pond beginning on April 21, 2002. On June 25, 2002, a few juveniles were noticed still inhabiting the site. We removed the outlet structure from the release culvert. In September 2002, no fish were observed in the pond.

Methow River Basin

Winthrop National Fish Hatchery

Coho smolts released into the Methow River in 2002 were acclimated and released at the Winthrop National Fish Hatchery, located at RM 50.4 on the Methow River. All coho juveniles were derived from lower Columbia River (LCR) stock.

Transportation

Approximately 168,393 hatchery coho pre-smolts were transported to the Winthrop NFH from Cascade FH, Eagle Creek NFH, and Willard NFH on March 25-28, 2002. Approximately 17,114 coho were already on site. The on-station fish were derived from 207,000 LCR eyed eggs transported to Winthrop NFH from Eagle Creek NFH on February 20, 2001.

Mortality

Heavy predation and an outbreak of botulism decimated the on-site population to 17,114 by the time of release. To compensate for this loss (92%), coho pre-smolts from three lower river hatcheries (Table 7) were transported to Winthrop NFH. A total of 506 pre-smolt mortalities were removed during acclimation. To alleviate predation concerns, coho were reared on-station in 2002.

Marks and Tags

Of the 168,393 juveniles transported to Winthrop NFH, 124,259 were CWT'ed. The remaining 17,114 brood were CWT'ed at Winthrop NFH during the summer of 2001. An estimated 53,353 coho transported from Cascade FH were part of ODFW's double-index study. Of the double-index fish, 25,230 were CWT tagged (CWT code: 053326) with an external mark (adipose fin absent) while 28,123 coho were CWT tagged (CWT code: 053328) with no external marks. Eagle Creek NFH transported 52,740 CWT-tagged coho (CWT code: 054332) with no external mark. The remaining 62,300 coho from Willard NFH were 100% adipose fin clipped without CWTs (Table 7).

Table 7. LCR stock coded-wire tagged coho released from WNFH, 2002.

Hatchery	Number of fish tagged	Mark	Tag Code
Winthrop NFH	17,114	CWT only	054527
Cascade FH	25,230	CWT + ad-clip	093326
Cascade FH	28,123	CWT only	093328
Eagle Creek NFH	52,740	CWT only	054332
Willard NFH	62,300	100% ad-clip	None

Volitional Release and Size

The USFWS volitionally released 185,001 coho smolts from the Winthrop NFH between April 19 and 30, 2002. Size at release was 18.4 FPP (C. Pasley pers. comm.).

Summary

Successful acclimation from sites in the Methow and Wenatchee River basins are an integral part of the Mid-Columbia Coho Reintroduction Project. The Hatchery and Genetic Management Plan (HGMP 2002) establishes program goals for smolt releases within these basins. Smolt release goals for the Methow and Wenatchee rivers in 2002 were 250,000 and 1,000,000 fish, respectively. Coho within the Methow program, were released solely from Winthrop NFH, and achieved a 99.7% transport-to-release survival. In the Wenatchee basin, overall survival was 99.0% from transport to release. In-pond survival at Butcher Creek in 2002 (96.5%) was lower than estimated in 2001 (99.9%). This comparison may be misleading due to the new approaches taken in 2002 to determine survival and mortality. A total of 993,776 coho were released in the Wenatchee basin, and 185,001 coho were released into the Methow River in 2002. Additional acclimation sites in the Wenatchee basin were proposed for 2003 and can be found in the HGMP (2002).

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Chapter 2 2002 Broodstock Development: Collection, Spawning, Incubation and Transportation

Introduction

Inter-basin coho salmon transfers throughout this century were common for most hatcheries in the lower Columbia River. Many of these lower Columbia River coho hatcheries have been in operation since the early 1900s. Given the lengthy culture history of these stocks, it is likely many have been subjected to intensive domestication selection for generations. Domestication is usually attributed to the effects of genetic drift which may result from low founding broodstock numbers and selection pressures from rearing fish in the hatchery environment (Calaprice 1969; Cross and King 1983; Allendorf and Phelps 1980). Fish populations which have been subjected to artificial selection may perform well in the hatchery, but poorly in the wild (Busack et al. 1997). The hatchery environment shifts mortality to later stages of life, and may produce opportunity for genetic change within the population (Waples 1991).

Success of the coho re-introduction program relies on the development of a local broodstock from the adult returns of reprogrammed coho from lower Columbia River hatcheries. Our ability to trap returning coho is essential to the broodstock development process.

Efforts to trap returning coho in the Wenatchee River basin in 2002 centered on Dryden Dam. The Dryden Dam fish traps are not designed to be 100% effective. The efficiency of Dryden Dam depends upon river flows and fish migration patterns (K. Petersen pers. comm.). Although not used in 2002 for broodstock collection, other potential trapping sites for the Wenatchee brood include Dam 5 behind the Leavenworth NFH, Tumwater Dam and Priest Rapids Dam.

Coho returning to the Methow River basin are trapped at Winthrop National Fish Hatchery and the Wells Dam west ladder trap. At Winthrop NFH, coho volunteer into the adult holding ponds. Trapping at Wells Dam occurred concurrently with Washington Department of Fish and Wildlife (WDFW) steelhead broodstock collection.

The discussion below describes coho trapping and spawning in the Wenatchee and Methow rivers and fundamentals of the broodstock development process.

Wenatchee River Basin

Broodstock Collection

Hatchery coho returning to the Wenatchee River in 2002 were trapped from the left and right banks at Dryden Dam (Wenatchee RM 17.5). Trapped coho were transported to Entiat National Fish Hatchery (USFWS) for holding and spawning.

A total of 213 adult coho were trapped at Dryden Dam between September 10 and December 6. In previous years, trapping at Dryden Dam concluded on November 14. Beginning in 2002, modification to WDFW's section 10 permit # 1094 extended the trapping period through December 7. Thirty-five percent of the coho collected at Dryden Dam were collected during the extension. Due to the longer trapping period, we were able to accurately collect from the entire run. Between October 22 and November 22, we collected 77.0% of the broodstock, with peak collection on November 14 (28 coho; Figure 1).

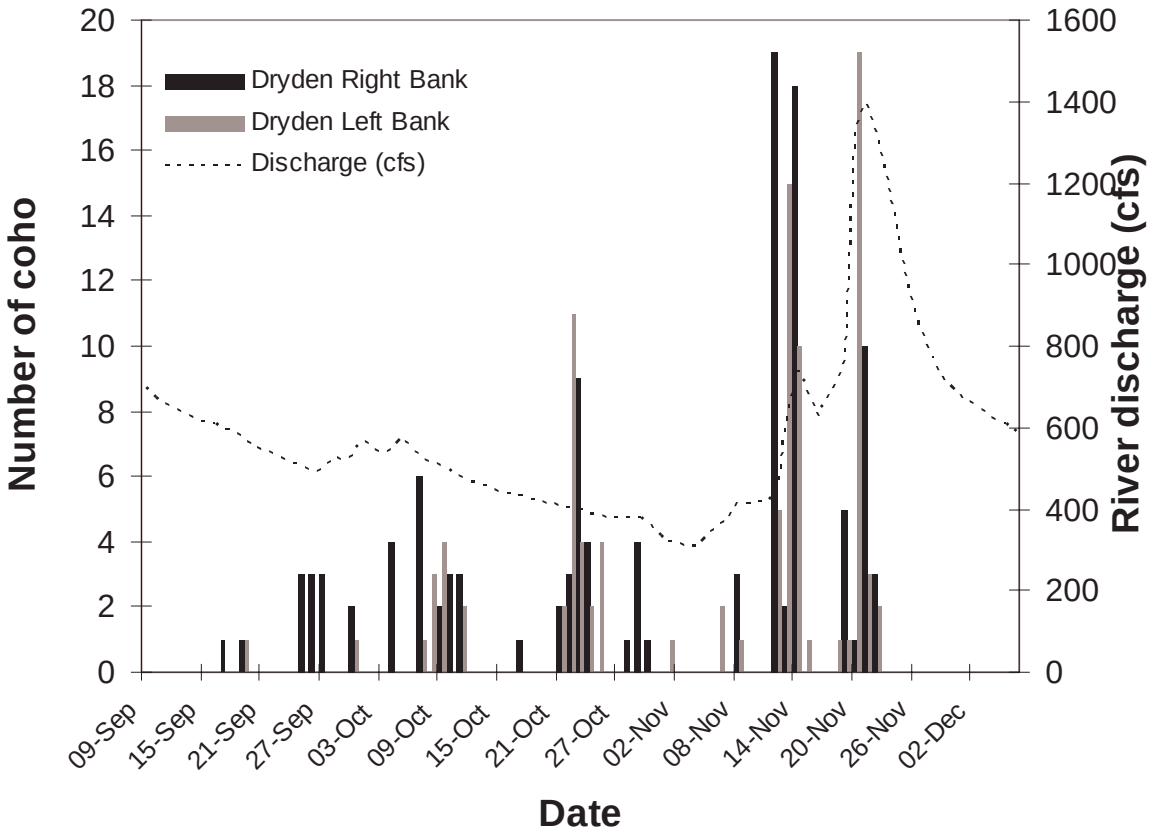

Figure 1. Distribution of coho salmon trapped at Dryden Dam in the right and left bank traps in relation to discharge (cfs), 2002.

Dryden Dam appeared to be an effective trapping site for coho in 2002. The dam's fish trapping efficiency varied depending on river flow and fish migration patterns. As river flow increased, trapping efficiency decreased (K. Petersen pers. comm.). Typically, the Wenatchee River is low during the months that coho were returning. Wenatchee River flows during September, October, and November 2002 were extremely low, likely increasing trap efficiency. Dryden Dam will remain the primary trapping site in the basin. We believe that the below-goal broodstock collection in 2002 was the result of low smolt-to-adult survival rates rather than poor trap efficiencies (Murdoch and Kamphaus 2003).

Spawning

Of the 213 coho collected, 32.9% were females (n=*70*) and 67.1% were males (n=*143).* While in the holding pond, the pre-spawn mortality rate was 2.3% (n=*5*). A total of 153 coho adults (69 females; 84 males and jacks) were spawned between October 28 and December 10, 2002. Three of these females were deemed non-viable because of poor egg quality or unripe. The spawning distribution was delayed two weeks compared to the previous year, possibly due to the low number of adults collected and/or to extreme river conditions during adult migration. Peak spawn occurred on November 19 with eighteen ripe females (Figure 2).

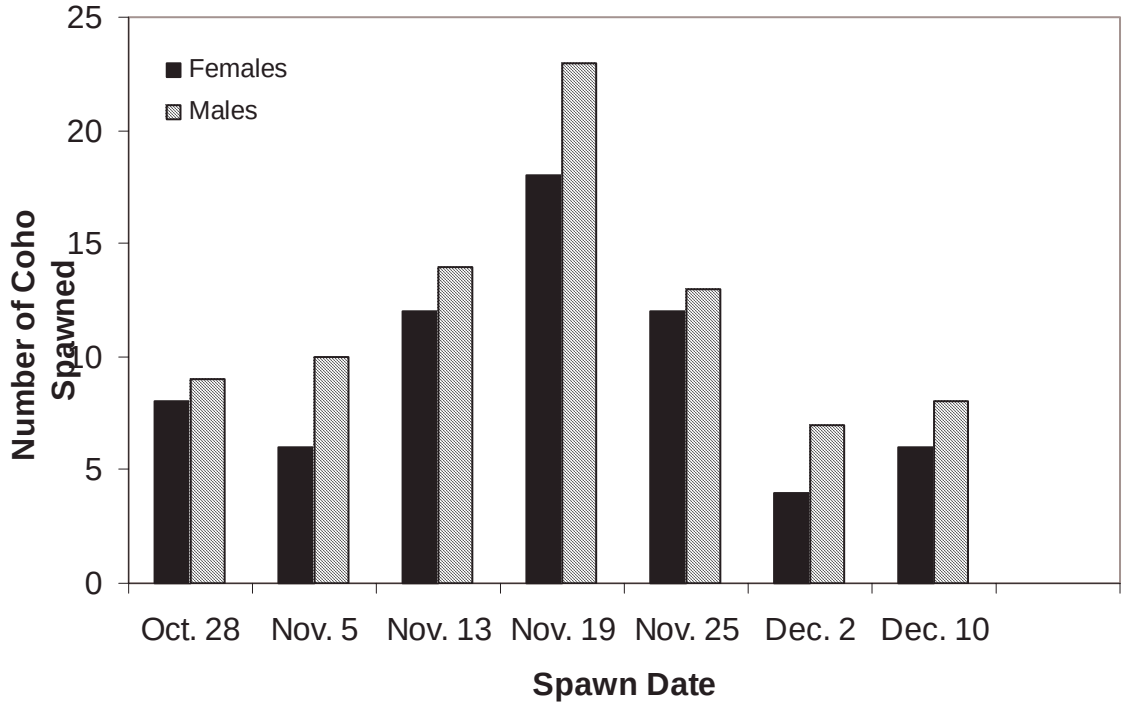

Figure 2. Number of coho spawned at Entiat National Fish Hatchery (ENFH), 2002.

In addition to on-station mating, 41 males were spawned and transported to a cryopreservation facility in Pullman, WA. This procedure is intended to evaluate the broodstock development process and resulting phenotypic and/or genetic divergence from the founding stock in the future (5-10 years). Thirty five Excess males were spawned and the milt transported to Willard FH for

mating with lower river females. By infusing the gametes, we hope to successfully pass inherited traits from mid-Columbia returning adults to some of the future progeny.

Broodstock Composition

The mean fork length (FL) of the females in the broodstock was 63.2 cm (SD = 8.7; Figure 3). The mean FL of the males measured 58.4 cm (SD=9.8). The mean FL of the jacks was 38.1 (SD=3.3; Figure 3). Age composition of Wenatchee brood coho in 2002 was determined from scale samples collected at spawning (*n=203*; Table 1). The broodstock consisted of 79.3% three-year-old coho. We observed a notable difference in age structure compared to coho broodstock collected in 2000 and 2001. Based on scale analysis, 49% of the returning three-year-old adults emigrated as two-year-old fish (J. Sneva, WDFW, pers. comm.). These fish displayed little or no saltwater residence. The delay in migration timing and reduction in migration rate may have been the result of decreased river velocities through Columbia River reservoirs during the 2001 drought (Raymond 1969, 1979; Venditti 2000). Migratory behavior and seawater tolerance develop concurrently and increase over the migration (Berggren 1993). Delays to that emigration, incurred by dam impoundments, could be detrimental behaviorally, physiologically, and physically to emigrating juveniles (Zaugg 1985). These hardships can be costly, restricting fish growth and exposing them to prolonged predation within the reservoirs.

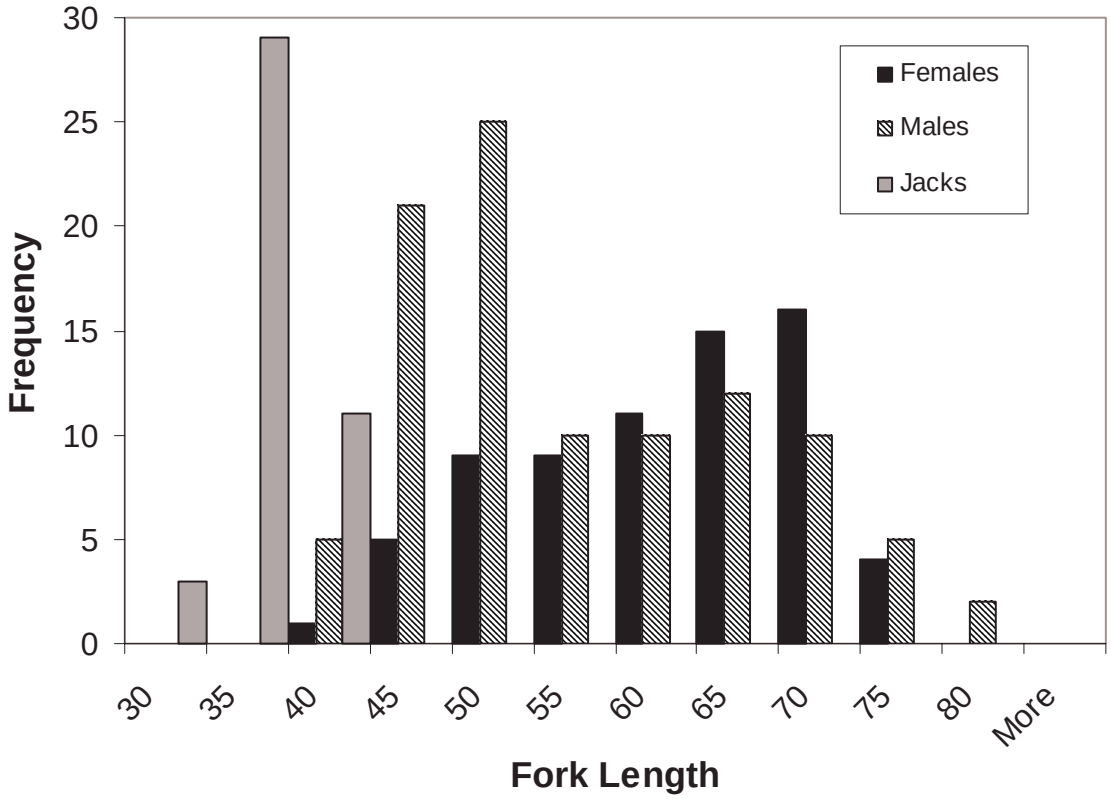

Figure 3. Length-frequency distribution of coho spawned in the Wenatchee River basin, 2002.

Table 1. Mean fork length and POH by sex and age of 2002 Wenatchee brood coho.

	Mean length at age- cm (SD,*N*)		
	1.0	1.1	2.0
	Males		
Fork	37.3	66.4	51.1
	(2.83,*42*)	(8.57,*40*)	(5.44,*53*)
POH	29.8	50.9	39.9
	(2.17,*42*)	(6.11,*40*)	(4.12,*53*)
	Females		
Fork	0.0	68.5	54.7
	(0.0,*0*)	(5.68,*42*)	(5.98,*26*)
POH	0.0	55.1	44.0
	(0.0,*0*)	(4.99,*42*)	(5.20,*26*)

Coded Wire Tag (CWT) Recovery

Snouts were removed and CWTs extracted from broodstock adults and pre-spawn mortalities. A total of 110 snouts were collected and 107 CWTs recovered. After further examination, the remaining 3 snouts did not contain tags. Eighty (74.7%) of the coho snouts recovered had been acclimated at the Icicle Creek acclimation site. Of the 80 returns of Icicle Creek acclimated coho, thirty-seven coho (46.3%) originated from 2002 releases returning as two-year-old jacks. Eight adults were released as smolts from Icicle Creek acclimation site as a part of ODFW's double-index study. Of the eight double-index fish, five (6.3%) were CWT tagged and adipose fin clipped, while the other three (3.8%) were CWT tagged only. Twenty-seven (25.3%) coho snouts recovered had been released as smolts from the Butcher Creek acclimation pond (Table 2). In 2003, all returning hatchery coho will be CWT tagged (based on 100% tagging of 2002 releases). This will allow us to make comparisons on smolt-to-adult survival rates (SARs) and observe stray rates to natal hatcheries. Smolt-to-adult survival rates for 2002 can be found in Murdoch and Kamphaus (2003).

Table 2. Coded wire tag codes and origin of Wenatchee brood coho spawned at Entiat National Fish Hatchery, 2002.

Tag code	N	Release Year	Release Location
055012	11	2002	Icicle Creek
054532	23	2002	Icicle Creek
050577	3	2002	Icicle Creek
054432	9	2001	Icicle Creek
054433	8	2001	Icicle Creek
054524	18	2001	Icicle Creek
054529	27	2001	Butcher Creek
093011	5	2001	Icicle Creek
093202	3	2001	Icicle Creek
Total	107		

Egg Fertilization and Incubation

Coho trapped in the Wenatchee River were transported to the ENFH for holding and spawning. The gametes were either incubated on-station or transported to the YN's Peshastin incubation facility. Coho eggs were incubated in deep troughs at both facilities. The deep troughs were supplied with 4-6 gal/min chilled water from the domestic water supply at Peshastin and from well water at ENFH.

In 2002, a 1% saline solution was used during fertilization to increase sperm motility. Eggs from each female were mated with one primary and one back-up male. After fertilization, all excess water was strained from the eggs. The eggs were then soaked in 75 ppm iodine treatment for 30 minutes prior to being placed in the incubator.

We incubated a total of 78,073 green eggs from three spawn dates in the Peshastin deep troughs, and 97,660 green eggs from four egg takes in the ENFH deep troughs (Table 3). Egg takes were alternated between Peshastin and Entiat throughout the duration of spawning (Table 3). Average fecundity for the 2002 brood was 2,683 eggs per female (Table 3).

Table 3. Spawn dates, number of eggs collected and eye-up rate at ENFH and Peshastin incubation sites, 2002.

Incubation Location	Spawn Date	Transport Date	Number of Females	Number eyed eggs	Number dead eggs	Total eggs	Eggs per Female	Eyed eggs per female	Percent Eye-up	Receiving /Rearing Hatchery
ENFH 1	28-Oct	20-Dec	8	17403	1922	19325	2577	2320	90.1	Willard
Peshastin 1	5-Nov	20-Dec	6	15545	572	16117	2686	2591	96.5	Willard
ENFH 2	13-Nov	20-Dec	12	32934	2225	35159	2930	2745	93.7	Willard
Peshastin 2	19-Nov	3-Jan	18	43364	7632	50995	2833	2409	85.0	Willard
ENFH 3	25-Nov	3-Jan	12	23788	9332	33120	2760	1982	71.8	Willard
Peshastin 3	2-Dec	17-Jan	4	9808	1152	10960	2740	2452	89.5	Willard
ENFH 4	10-Dec	17-Jan	6	7805	2251	10056	1676	1301	77.6	Willard

In the Peshastin deep troughs, we calculated an eye-up rate of 88.0% (range: 85.0-96.5; Table 3). In the ENFH deep troughs we estimated an eye-up rate of 83.9% (range: 71.8 – 93.7; Table 3). The coho eggs incubated at ENFH became "soft-shelled" during incubation, making sorting and accurate enumeration of eggs difficult. It is impossible to determine how many eggs broke during the sorting process. The majority of the dead eggs picked post-shocking were developing embryos that died. Soft-shell is primarily caused by bacteria that attaches to the egg's clorion, causing areas of erosion and pitting (Sauter 1985). At the Peshastin facility, moribund eggs were typically unfertilized or underdeveloped. We compared incubation conditions at both facilities to examine the occurrence of soft-shell at ENFH. Two variables became readily apparent and were considered: water hardness and formalin treatments. Water hardness ranges were comparable for Peshastin and Entiat at 55-75 ppm and 60-80 ppm, respectively. Eggs were treated with formalin at different frequencies and concentrations. At the Peshastin facility, we treated the eggs with formalin daily at 1500 ppm for 15 minutes while the eggs at ENFH were treated every other day at 750 ppm. The lower concentrations and frequencies of formalin treatments may account for the occurrence of soft-shell seen at Entiat. Research has shown that formalin is effective for combating external bacterial growth (Bowser 1999). Jensen (1996)

reported that iodine treatments can provide additional hardness to developing salmonid eggs while acting as a disinfectant. In 2003, coho eggs incubated at ENFH will be treated daily with formalin and an iodine drip will be applied weekly in hopes of preventing the reoccurrence of soft-shell.

Upon reaching between 500 and 600 temperature units, the eyed eggs at both facilities were shocked, sorted, and then transported to Willard National Fish Hatchery for rearing.

Methow River Basin

Broodstock Collection

Coho destined for the Methow River basin in 2002 were collected at Winthrop National Fish Hatchery (WNFH; Methow River RM 50.4) and the Wells Dam west ladder fish trap. At Wells Dam, coho collection occurred concurrently with ongoing steelhead broodstock collection. A total of nine coho (6 females and 3 males) were trapped between October 3-18, 2002 at Wells Dam. Forty-six percent of the female coho spawned at Winthrop NFH were collected from Wells Dam. A total of 43 coho returned to the Winthrop NFH between October 15 and December 10, 2002. Coho entered the hatchery volitionally and were counted weekly during spawning. The peak spawn occurred on November 19; peak collection occurred the same week as determined by the number of adults remaining post spawn. Low smolt-to-adult survival rates (Murdoch and Kamphaus 2003), and a high proportion of males within the broodstock accounted for the below-goal collection. Winthrop NFH and Wells Dam will remain important collection sites for coho adults returning to the Methow basin.

Spawning

Of the 52 coho collected, 25.0% were females (*n=13*) and 75.0% were males (*n=39*). Jacks were not differentiated due to the unusually small size of the 2002 brood (Figure 4). While in the holding pond, the pre-spawn mortality rate was 11.4% (*n=8*). Forty-four coho were spawned (11 females; 33 males and jacks) between November 19 and December 17. The peak spawn occurred on November 25 with four females (Figure 5).

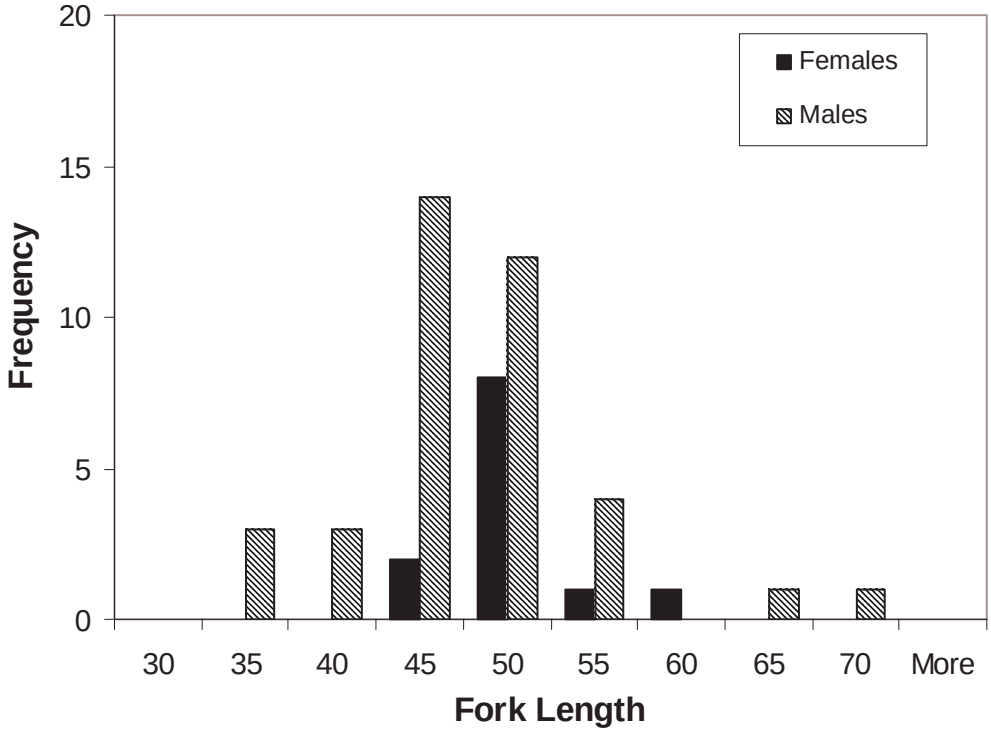

Figure 4. Length-frequency distribution of coho spawned in the Methow River basin, 2002.

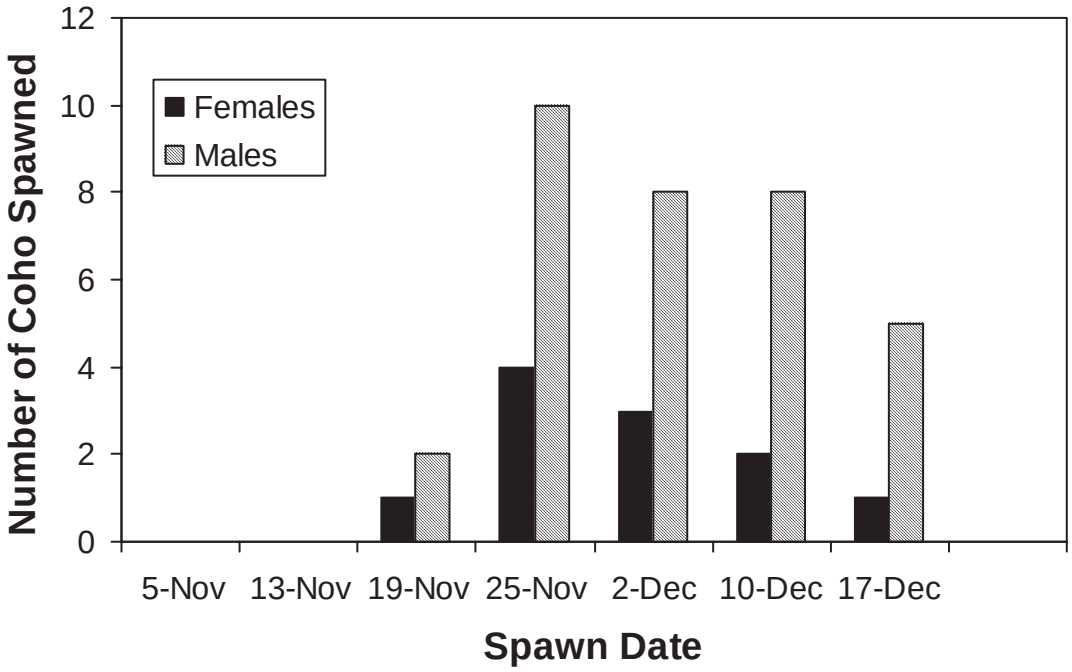

Figure 5. Number of coho spawned at Winthrop National Fish Hatchery, 2002.

The male-to-female ratio for the 2002 brood was 3:1. The male-to-female ratio for coho retuning to the WNFH may not be representative of the run at large. More females were collected than males at Wells Dam. The low female-to-male ratio may be the result of female dropouts, both as pre-spawn mortalities and as contributors to the natural spawning recruitment.

Spawning ground surveys on the Methow River occurred after peak spawn and did not demonstrate specific spawn timing (Murdoch et al. 2004). Winthrop NFH spawning was delayed two weeks compared to the Wenatchee brood held at Entiat NFH. Of the fish spawned, the mean fork length (FL) of the females was 52.2 cm (SD = 4.4; Figure 4). The mean FL of the males measured 49.5 cm (SD=6.8). The 2002 brood males and females were significantly shorter ($p<.01$) than the 2001 brood males and females. There was no significant difference between the length of males and females ($p=.21$) at Winthrop NFH within the 2002 brood. No distinction was made between mature males and jacks due to the decreased overall size of the 2002 brood. The 2002 Methow brood was significantly smaller (FL) than the 2002 Wenatchee brood ($p<.01$).

Egg Fertilization and Incubation

During spawning, gametes were brought into the hatchery building for fertilization. Eggs from each female were mated with one primary and one back-up male. After fertilization, the eggs were rinsed and placed in isolation buckets containing 75 ppm iodine treatment and soaked for 30 minutes prior to rinsing. Coho eggs were initially incubated in isolation buckets until fish

health results were confirmed and the eyed-egg stage was reached. The isolation buckets were supplied with 1 - 2 gallons/minute of well water per bucket. After eye up, eggs were enumerated and moved into the vertical stack incubators located within the WNFH. Each vertical stack was supplied with approximately 2 - 4 gallons/minute of mixed ground and river water. Since fungus had not been a problem in the incubation of salmon eggs at WNFH, formalin treatments were not required.

Winthrop National Fish Hatchery incubated 21,701 green eggs from the five spawn dates (Table 4). The overall eye-up rate for 2002 brood was 82.1% (range: 75.2-88.1), leaving 17,806 eyed eggs. After post-hatch mortalities had been eliminated, 16,668 alevin remained. Ponding began by the end of February and early March, 2003. YN transported an estimated 220,000 eggs to WNFH from Willard NFH to supplement the 2002 brood spawned on-station.

Table 4. Spawn dates, number of eggs collected and eye-up rate at Winthrop National Fish Hatchery, 2002.

Incubation Location	Spawn Date	Number of Females	Number eyed eggs	Number dead eggs	Total eggs	Eggs per Female	Eyed eggs per female	Percent Eye-up	Rearing Hatchery
Winthrop NFH	19-Nov	1	1521	301	1822	1822	1521	83.4	Winthrop NFH
Winthrop NFH	25-Nov	4	6643	2187	8830	2208	1661	75.2	Winthrop NFH
Winthrop NFH	2-Dec	3	5041	676	5717	1906	1680	88.1	Winthrop NFH
Winthrop NFH	10-Dec	2	2911	482	3393	1696	1456	85.7	Winthrop NFH
Winthrop NFH	17-Dec	1	1690	249	1939	1939	1690	87.1	Winthrop NFH

Summary

Development of a local broodstock from lower Columbia River coho stocks is a goal of the Mid-Columbia Coho Reintroduction Project. In-basin trapping locations that can effectively collect broodstock are essential for program success. We collected 213 coho between October 10 and December 6 at Dryden Dam on the Wenatchee River. At WNFH and Wells Dam, we collected 52 coho for the Methow River program. Our broodstock goals for both basins were to collect enough females to fulfill future acclimation release needs of 250,000 juveniles in the Methow River and 1,000,000 juveniles in the Wenatchee River while reducing the influence of lower Columbia River genetics within the brood. Collection goals for the Wenatchee and Methow are 1,464 and 497 adults, respectively. Collection goals were not met, presumably due to low survival rates (Murdoch et al. 2004). We spawned 66 coho salmon at ENFH and 11 at Winthrop NFH. We calculated an eye-up rate of 85.7% for the Wenatchee program and 82.1% for the Methow program. We saw an improved eye-up rate for the Wenatchee program in 2002 over eye-up rates reported in 2000 and 2001. This increase in eye-up results in fewer females needed to meet program goals, allowing for increased natural production.

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APPENDIX A

Program progress report for mid-Columbia broodstock development from 1996 to present

Brood year	Release year	Location	Brood source	Adult return year	MCR Adult brood-to-Hatchery Smolt Production
1996	1998	Methow	LCR (341K)	1999	***143,000 MCR A***
1997	1999	LNFH	LCR (450K)	2000	***585,000 MCR B***
		Swamp Creek	LCR (50K)		
1998	2000	Methow	LCR (200K)	2001	***162,800 MCR C_m***
		Dam 5	LCR (890K)		***738,900 MCR C_w***
		Butcher Creek	LCR (77K)		
1999	2001	Methow	LCR (260K)	2002	***22,000 MCR D_m***
		Dam 5	LCR (855K)		***133,000 MCR D_w***
		Butcher Creek	***MCR A (142K)***		
2000	2002	Methow	LCR (186K)	2003	NA
		Dam 5	***MCR B (350K)*** LCR (450K)		
		Butcher Creek	***MCR B (146K)***		NA
		Early Pond	***MCR B (17K)***		
		Beaver Pond	***MCR B (73K)***		
2001	2003	Methow	LCR (244K)	2004	NA
		Dam 5	LCR (37K) ***MCR C_w (290K) MCR C_m (163K)***		NA
		Butcher Creek	***MCR C_w (150K)***		

		Coulter Creek	***MCR C_w (88K)***		
2001	2003	Mahar Pond	***MCR C_w (35K)***	2004	NA
		Two Rivers	***MCR C_w (100K)***		
		Beaver Creek	***MCR C_w (75K)***		

LCR*- Lower Columbia River brood*
MCR*- Mid-Columbia River brood*
MCR A*- Methow River origin mid-Columbia brood released in the Wenatchee basin in 2001.*
MCR B*- Wenatchee River origin mid-Columbia brood released in the Wenatchee basin in 2002*
MCR C_m*- Methow River origin mid-Columbia brood released in the Wenatchee basin in 2003*
MCR C_w*- Wenatchee River origin mid-Columbia brood released in the Wenatchee basin in 2003*
MCR D_m*- Methow River origin mid-Columbia brood released in the Methow basin in 2004*
MCR D_w*- Wenatchee River origin mid-Columbia brood released in the Wenatchee basin in 2004*