CRITFC

TECHNICAL REPORT 06-5

Summer Chinook Juvenile Sampling and Adult Monitoring in the Mid-Columbia

2005 Progress and Final Report to Southeast Sustainable Salmon Fund Projects No. 45060 and 45289: A Stock Assessment and Research Plan For Mid-Columbia River Summer Chinook, Parts I and II

Peter F. Galbreath, Peter E. Barber, Shawn R. Narum, Dani Evenson, and Saang-Yoon Hyun

October 24, 2006

Columbia River Inter-Tribal Fish Commission
729 NE Oregon, Suite 200
Portland, OR 97232
503.238.0667
www.critfc.org

Summer Chinook Juvenile Sampling and Adult Monitoring in the Mid-Columbia

2005 Progress and Final Report to Southeast
Sustainable Salmon Fund Projects No. 45060 and 45289:
A Stock Assessment and Research Plan For Mid-Columbia
River Summer Chinook, Parts I and II

Columbia River Inter-Tribal Fish Commission Technical Report 06-5

Peter F. Galbreath[1], Peter E. Barber[2], Shawn R. Narum[3], Dani Evenson[1]
and Saang-Yoon Hyun[1]

[1] Columbia River Inter-Tribal Fish Commission
729 NE Oregon, Portland OR 97232

[2] Yakama Nation Fisheries, Methow Field Office, Twisp WA 98856

[3] Collaborative Center for Applied Fish Science
3059-F National Fish Hatchery Road, Hagerman ID 83332

October 24, 2006

Please cite as:

Galbreath, P. F., P. E. Barber, S. R. Narum, D. Evenson and S.-Y. Hyun. 2006. Summer Chinook Juvenile Sampling and Adult Monitoring in the Mid-Columbia. Southeast Sustainable Salmon Fund Project Numbers: 45060 and 45289, Columbia River Inter-Tribal Fish Commission Technical Report 06-4, Portland, Oregon (http://www.critfc.org/tech/tech_rep.html).

ACKNOWLEDGEMENTS

We gratefully acknowledge the following individuals for their assistance in this project: Rick Alford, John Jorgenson, Ralph Kiona and Tom Scribner of the Yakama Nation; Jeff Fryer, Doug Hatch, Phil Roger, André Talbot and John Whiteaker of the Columbia River Inter-Tribal Fish Commission; John Clark, Dave Gaudet, James McDermott and Gordon Williams of the Alaska Department of Fish and Game; Charmane Ashbrook, Todd Miller, Andrew Murdoch, Erik Schwartz and Chris Waldbillig of the Washington Department of Fish and Wildlife; and Shane Bickford of Douglas County Public Utility District.

This research was funded by a grant from the Southeast Sustainable Salmon Fund; contract number COOP-02-056, as a cooperative agreement between Alaska Department of Fish and Game and the Columbia River Inter-Tribal Fish Commission.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This report presents a summarization of results for the project “A Stock Assessment and Research Plan For Mid-Columbia River Summer Chinook, Parts I and II”, Southeast Sustainable Salmon Fund Project No.s 45060 and 45289. The project was executed by researchers with the Columbia River Inter-Tribal Fish Commission (CRITFC), and the Yakama Nation (YN) Department of Fisheries. Information gathered during project activities in 2005 is presented in conjunction with data for 2004 (some of it rectified and updated from the 2004 Progress Report). Project activities were designed to describe characteristics of adult escapement, juvenile production and out-migration, and ocean migration of Mid-Columbia summer (summer/fall ocean-type) Chinook salmon *Oncorhynchus tshawytscha* in the Methow River, Okanogan County, Washington.

In 2004, an effort was made to acquire visual counts of in-migrating adult summer Chinook salmon from a counting tower located in the lower Methow River, near its confluence with the Columbia River. Counts were to have been expanded to provide an estimate of total adult escapement to the Methow. However, poor water visibility associated with rain events and windy weather precluded obtaining reliable counts except for a limited number of counting periods late in the season. Tower counting was deemed unreliable as a method for obtaining escapement estimates in this river, and the technique was abandoned.

In 2005, project researchers collaborated with personnel from the Washington Department of Fish and Wildlife (WDFW) on a radio telemetry study to describe migration patterns of summer Chinook upstream of Wells Dam. In this project, 291 adult summer Chinook salmon were intercepted and radio tagged at Wells Dam (12 km downstream of the confluence with the Methow River), of which 280 were successfully detected upstream. Of the latter, 35 (12.5%) were identified as having returned to the Methow River. Based on a total count of 34,075 adult summer/fall Chinook passing Wells dam in 2005, total escapement of adult summer Chinook to the Methow River is estimated to have been 4,259 ± 1,320. This estimate of tributary escapement is significantly larger than the corresponding estimate for spawning escapement of 2,561, produced by the Washington Department of Fish and Wildlife from expanded redd counts. Results for the overall radio telemetry project can be found in the project final report (Ashbrook et al. 2006).

CRITFC and YN researchers also collaborated on a Pacific Salmon Commission Southern Boundary Fund Project to test the capabilities of a long range model of a Dual Identification Sonar (DIDSON-LR) to provide escapement counts of returning adult salmon in an open river. Results indicated that properly positioned, the instrument can yield accurate counts of migrating fish at a distance of 42m and more. Beyond counts of passing fish, however, resolution of the images was insufficient to make more than qualitative estimates of fish size. Observation of characters by which to differentiate between species was not possible. The final report for this project (Galbreath and Barber 2005) is available at: www.critfc.org/didson-lr.

In both 2004 and 2005, a rotary screw trap was installed in the Methow River at river km 15.6, and operated nightly during the months of May to July. A total of 40,783 and 16,230 juvenile Chinook salmon, presumed to be out-migrating smolts, were captured in each year, respectively. Mark-recapture trials were conducted multiple times through the sampling period in both years to obtain estimates of trap efficiency. In 2004, these estimates ranged from 3% to 15%, with no apparent correlation to time nor river flow. In 2005, these estimates ranged from 1% to 10%, with a significant increase in value over time, which also corresponded to a significant decrease in flow rate. The trap efficiency estimates were used to expand the capture numbers to produce estimates for total Chinook smolt out-migration of 526,385 in 2004 and 504,908 in 2005. Peak out-migration occurred during the first week of June in 2004, and during the second week of June in 2005.

During smolt-trapping, tissue samples were non-lethally collected from juvenile Chinook salmon for genetic stock identification. The tissue was analyzed for a suite of 13 microsatellite DNA loci, to distinguish summer versus spring stock. Summer Chinook typically begin smoltification and out-migrate as age 0+ juveniles (ocean-type), whereas spring Chinook out-migrate as age 1+ juveniles (stream-type). Results were similar among years. In 2004, 85% (515 of 609) of the smolts were determined to be summer Chinook; in 2005, this proportion was 86% (235 of 273). In both years, greater than 90% of smolts under 70 mm standard length were summer Chinook, and smolts in this size range represented 67% (2004) and 53% (2005) of the smolts sampled for stock identification. At larger sizes, the proportion determined to be summer Chinook progressively decreased, with the summer:spring ratio being approximately 1:1 for smolts of 100 mm. As the 2004 sampling season progressed, the summer:spring ratio remained relatively constant, however, in 2005 the proportion of spring Chinook decreased significantly over time. Reducing the total smolt abundance estimates cited above to discount for the proportion of spring Chinook provided estimates for total out-migration of summer Chinook smolts of 444,269 for 2004, and 433,312 in 2005.

During both years of smolt trapping, sub-samples of fish collected across the run were tagged with passive integrated transponder (PIT) tags. Some of these fish were detected downstream at Columbia River mainstem dams, and these data were used to estimate out-migration survival and travel time. In 2004, 2,825 smolts were PIT tagged, of which 65 were detected at McNary Dam, 7 at John Day Dam, and none at Bonneville Dam. In 2005, 3,117 smolts were tagged, of which 32 were detected at McNary Dam, 14 at John Day dam, and 2 at Bonneville Dam. The geometric mean travel time to McNary Dam was similar between years – 31.1 days in 2004, and 30.9 days in 2005. Survival and abundance estimates of the Methow River Chinook smolts at McNary Dam were also similar between years. In 2004, survival was estimated as 8.08% and abundance as 35,881, respectively. In 2005, these estimates were 7.17% and 31,139.

In 2004, 1,132 out-migrating wild juvenile Chinook were coded-wire tagged (CWT) for eventual identification in ocean and lower Columbia River fisheries. However, collection of CWT data will not be finalized until following submission of this report, and data analysis will have to be accomplished in a future project.

INTRODUCTION

Populations of ocean-type summer/fall (hereafter, referred to simply as summer) Chinook salmon *Oncorhynchus tshawytscha* destined for the Mid-Columbia River have declined dramatically from historic levels (Nehlsen et al. 1991, WDF et al. 1993). Mid-Columbia summer Chinook salmon were important to the culture of Indian tribes in the Columbia River basin for subsistence, spiritual, and socio-economic reasons. Following the arrival of European settlers, summer Chinook (once termed "June hogs" for their large size) were the most robust and heavily fished of the Columbia River Chinook stocks during the late 1800's and early 1900's (Thompson 1951, Chapman 1986). Causes for their subsequent decline include overfishing in the lower Columbia, and loss of habitat and increased migration mortality associated primarily with construction of hydropower and storage dams, and irrigation canals (Mullan 1987, Chapman et al. 1994).

The Southeast Alaska salmon fisheries harvest a mixture of Chinook salmon stocks including far-northern migrating Mid-Columbia River summer Chinook salmon. The Pacific Salmon Commission (PSC) considers Mid-Columbia summer Chinook an exploitation rate indicator stock for harvest evaluation, and poor stock performance can constrain ocean and terminal fisheries (PSC 2000). Ocean harvest is now regulated by an abundance based management approach that uses an index of abundance (current versus an historical base period) of stock aggregates for this purpose. The Columbia River summer Chinook stock is comprised of the single stock aggregate of Mid-Columbia summer Chinook which return as adults upstream of Priest Rapids Dam during their spawning migration. These fish return for spawning to the Wenatchee, Entiat, Chelan, Methow and Okanogan River systems, plus a proportion which remains to spawn within the mainstem Columbia itself. Mid-Columbia summer Chinook is the only single stock aggregate recognized by the U.S. and Canada in this new management framework.

Despite its importance, data on natural escapement and recruitment to the spawning grounds of the component (sub)populations which comprise this aggregate stock is limited in amount and reliability. Almost no data exists on natural smolt productivity. Adult escapement information is based on annual redd counts and carcass surveys, though the reliability of escapement estimates calculated in this manner is highly variable (Mosey and Truscott 1999, Murdoch and Miller 1999, Dunham et al. 2001, Faurot and Kucera 2005). Factors affecting this ratio include the age composition of the run, sex ratios, abundance, environmental factors, and variance among technicians performing the counts. Because of variability in these factors among populations, calculation of escapement through expansion of redd count data requires independent validation. A primary goal of this study was to test the use of other techniques for escapement estimation of natural-origin Mid-Columbia summer Chinook, which might be both more accurate and precise. For these tests we chose to study one of the component (sub)populations within the Mid-Columbia stock – the Methow River population.

The region is currently developing monitoring and evaluation standards for salmon recovery, and several review bodies have called for enhanced monitoring of natural populations (e.g. the Biological Opinion on the Federal Columbia River Power System, or BiOp). Among other initiatives, the ability to separately distinguish life history parameters (productivity and survival) during the freshwater and migration corridor/ocean phases is considered critical to identifying limiting factors to population viability. The various reports on monitoring also emphasize the need to estimate with precision the natural productivity of stocks independently of hatchery or supplementation influences. The present study was a pilot project to determine the level of effort required to implement such an approach. The Methow River population within the Mid-Columbia summer Chinook aggregate stock is ideal for several reasons: 1) it is relatively well confined and defined, so that productivity estimates (e.g. recruits per spawner) are possible, 2) the river size, morphology, and discharge are favorable for monitoring with standard methods, 3) it is not an ESA listed stock/ESU, 4) it is a far-northern migrating stock with potential to be heavily impacted by fisheries in Southeast Alaska and northern British Columbia, and 5) it is an exploitation rate indicator stock for the PSC.

Estimation of ocean distribution, ocean and in-river harvest rates, and escapement of naturally produced Mid-Columbia summer Chinook have been dependent on corresponding estimates for coded-wire tagged (CWT) fish produced by the Wells Dam hatchery program (river km 830 on the Columbia River). However, this approach has several shortcomings. The hatchery-reared fish are released at a larger size and with a higher condition factor and fat content than their naturally produced counterparts. These differences generally result in increased post-release survival through the hydro-system relative to naturally produced fish. Also, analysis of CWT recoveries indicates that hatchery-reared fish do not migrate as far and that they mature earlier than naturally-produced fish. As such, the presumption that data for Wells program fish is representative of that for naturally produced Mid-Columbia summer Chinook juveniles is questionable.

Baseline information on productivity of wild Mid-Columbia summer Chinook is limited (Matthews and Waples 1991). Data are needed to evaluate separately freshwater and ocean life history parameters, and to assess the status (abundance and productivity) of naturally-spawning summer Chinook. These data include smolt abundance, growth and migration timing, spawner abundance, size, distribution and timing of spawning, habitat quality, quantity and distribution, and age/sex structure. Lichatowich and Cramer (1979) demonstrated that parameters such as adult migration and spawn timing, and distribution, size and out-migration timing of juveniles have a strong influence on survival. If acquired, these data could be used to assess the condition of Mid-Columbia River summer Chinook salmon, and to guide restoration strategies, and harvest and escapement goal management.

The present project was funded through an award to the Fish Science Department of the Columbia River Inter-Tribal Fish Commission (CRITFC), with sub-contracts to Yakama Nation Fisheries (YN Fisheries), and was designed to procure some of this

needed baseline data for Mid-Columbia summer Chinook. Estimates were obtained for various factors affecting freshwater life history and overall stock productivity of summer Chinook in the Methow River (Figure 1) – measures which can be used to assess the reliability of current methods used for escapement estimation, and to address uncertainties regarding population trends, and factors limiting abundance and productivity of the stock.

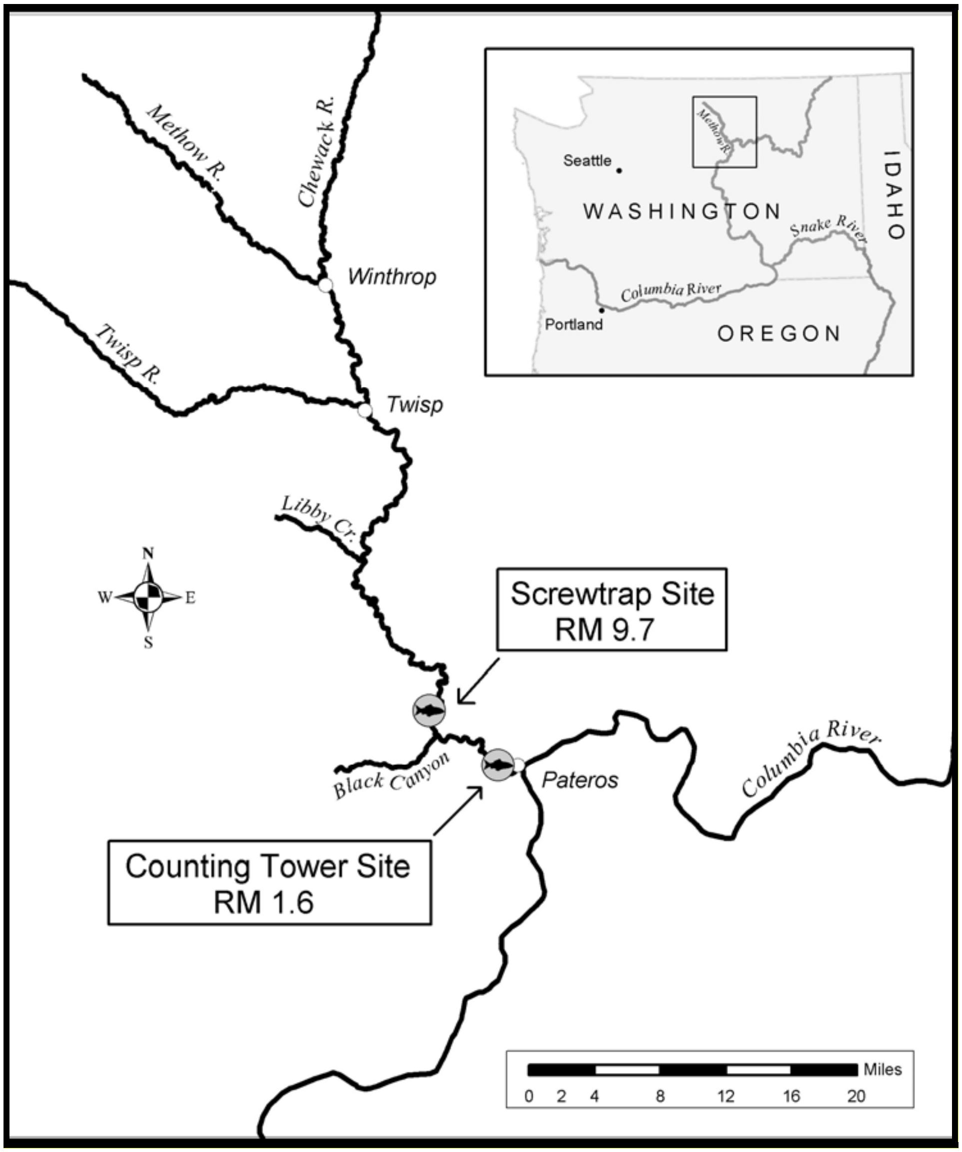


Figure 1. Map of the Methow River Basin depicting summer Chinook salmon sampling sites. (note: Chewuch River is misspelled on the map.)

The research objectives of this project, as originally proposed in 2003, were to:

1. Estimate the total escapement of adult Chinook salmon into the Methow River using tower counting techniques, and compare these estimates with past and current methods of estimating escapement and spawner/recruit modeling.

2. Estimate abundance of naturally produced juvenile summer Chinook salmon emigrating from the Methow River through use of a rotating screw-trap.
3. Identify the genetic stock composition of subyearling Chinook (summer Chinook versus spring Chinook) collected over the duration of the juvenile migration.
4. Determine the migration rate and survival of subyearling summer Chinook from the Methow River to lower Columbia River mainstem dams.

Results for the first year of field work were reported in Evenson and Narum (2005). The present report, which serves as the project final report, recapitulates and rectifies some of the analyses from the 2004 report, and presents a summary of results from the 2005 field season.

STUDY DESIGN

Adult Escapement Estimation

Tower Counting – During the summer and fall of 2004, counts of returning adult summer Chinook were made from an elevated vantage point above the Methow River, at a location 2.5 km upstream of its confluence with the Columbia River [Latitude 048° 03' 15" N and Longitude 119° 55' 36" W (NAD 27), Figure 1]. The "tower" was a rock outcrop located on the steeply sloped north bank. Below this observation point, a line of light-colored vinyl panels (each 2.4 m x 6.1 m) which traversed the river were anchored along the river bottom. The panels provided for improved visibility of the fish as they swam above the panels (Figure 2). Lights were suspended 2-3 m above the water surface over the line of panels, to provide illumination during evening/night hours. Total summer Chinook escapement to the Methow was to have been estimated according to the following sampling design. Visual counts of escapement were to be made over fourteen 8-hour counting shifts per week. Each day was sub-divided into three 8-hour shifts: Shift I from 01:00 h to 09:00 h, Shift II from 09:00 h to 17:00 h, and Shift III from 17:00 h to 01:00 h. Each week, 14 of these shifts were systematically selected for sampling. Artificial lighting has been observed to affect fish migration (Hetrick et al. 2004) and Shift I and Shift III counts are both dependent on artificial lighting, therefore, these shifts were linked in the sampling strata, i.e., both were to be sampled in the same day. This sampling scheme avoids the potential for biased counts due to fish holding up below the illuminated tarps until the lights are turned off and then migrating upstream without being counted. Also, preliminary observations performed in 2003 suggested that very few fish migrate during the day (less than 10%). Therefore, Shift II was to be sampled only twice per statistical week. A field biologist and three technicians were assigned to the project. Each technician was to work four 8-hour shifts per week; the field biologist was assigned to two shifts per week and also participated in independent counts with all technicians to validate consistency between counters. Personnel were to record the number of summer Chinook, spring Chinook, and steelhead *Oncorhynchus mykiss* moving upstream and downstream for a 10-minute period every half hour. Data to be recorded during visual counting included: name of observer, date and time of the counting shift, weather conditions, and numbers of summer Chinook, spring Chinook, and steelhead counted during the 10-minute counting

periods. Count data were then to be expanded to provide an estimate for total adult escapement, with calculation of associated estimates of error around that estimate (Evenson and Narum 2005).

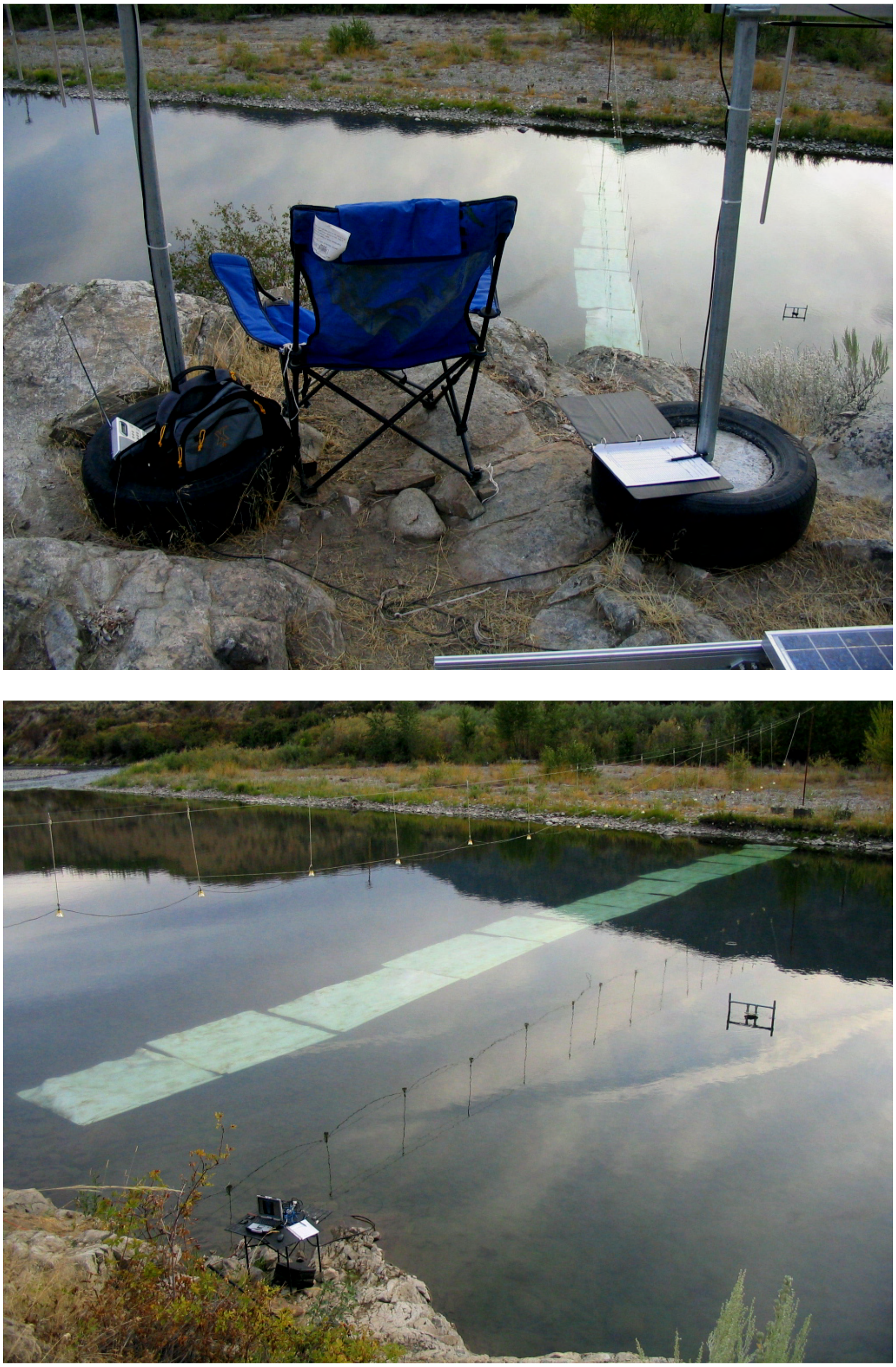


Figure 2. Photographs showing the site of the Methow River counting tower (note: light colored panels and lights), radio receiver antennae, and the DIDSON-LR and associated computer.

Radio Telemetry – In lieu of tower counting as performed in 2004, in 2005 project researchers cooperated with personnel from the Washington Department of Fish and Wildlife (WDFW) on a radio telemetry project to track movement of naturally-spawned returning adult summer Chinook, and to obtain an estimate of escapement to the Methow River. Cooperation in this project involved help in tagging of returning adult Chinook salmon at Wells Dam, and in mobile tracking along the Methow River and the Columbia mainstem.

Over the period July 6 to November 9, 2005, a total of 291 Chinook salmon were captured in the broodstock collection facilities within the east and west fish ladders of Wells Dam. Following capture, the fish were anesthetized in a solution of carbon dioxide (CO_2) buffered with baking soda ($NaHCO_3$). The anesthetic bath was prepared by adding CO_2 gas through a high flow air stone until the pH dropped to approximately 5.7, at which point the CO_2 gas was turned off and baking soda added until pH returned to neutral. Oxygen (O_2) gas was then added at a rate of 2.1 kg/cm^2 and left on until the dissolved O_2 concentration reached saturation. After the fish became quiescent, data on size (fork length), hatchery or natural origin, and sex were recorded, and scale and tissue samples were collected from each. Sex was estimated based on secondary sexual characteristics, although these characteristics were still not well developed, particularly early in the tagging period, lending some uncertainty to these data. A digitally encoded Lotek™ radio transmitter model MCFT-7F (Lotek Wireless Inc., Newmarket, ON, Canada) was tested for functionality and gastrically implanted into the fish using a PVC pipe as a trochar. The radio tagged Chinook were then held for recovery (approximately 2 hours) in an oxygenated transport tank until release at the Starr boat launch, located 4.4 km upstream of Wells Dam on the west side of the Columbia River. Date and approximate time of release were recorded.

In all, 54% of the tagged summer Chinook were captured in the east side ladder of Wells Dam, and 46% in the west side fish ladder. Sex-ratio of the tagged fish was 50.2% female to 49.8% male. In most weeks only wild (adipose fin present) summer Chinook were selected for radio tagging. However, when tagging goals were not being met, the deficit was made up by tagging hatchery-origin (adipose-clipped) fish. In total, 21 (7.5%) of the 291 fish receiving transmitters were hatchery-origin.

Prior to initiating tagging of the fish, a fixed-site Lotek™ SRX receiver was installed at the counting tower site in the lower Methow River, and at seven other locations along the Columbia and Okanogan Rivers (Table 1). At each fixed-telemetry site, two or three 3-element Yagi antennae were installed. Typically, one antenna was pointed downstream and the other upstream, aimed approximately 40° off the shoreline to maximize detection of tagged fish passing the location. The antenna arrays were powered by 12 V batteries linked to a solar-panel recharger.

Tracking of Methow River fish was also conducted from a vehicle while driving along Washington State Highways 153 and 20, which run parallel and in proximity to the river for much of its length. Additional mobile tracking was conducted along the Columbia and Okanogan/Similkameen Rivers from fixed-wing aircraft, boats and vehicles.

Table 1. Station number and location of fixed site receivers for the 2005 radio telemetry study of adult summer Chinook migration upstream of Wells Dam.

Station	Location
01	Chief Joseph Dam powerhouse
02	Chief Joseph Dam vicinity, south shore
03	Chief Joseph Dam vicinity, north shore
04	Colville Trout Hatchery
05	Upper Okanogan River at Riverside
06	Lower Okanogan River
07	Methow River
08	Below Wells Dam

At the end of the season, the tagged fish detected as having entered and remained in the Methow River were identified and their telemetry data assembled and evaluated. Travel time was calculated and migration pattern classified for each fish. These data were then compared for an effect of sex, size, capture location (ladder) and arrival time at Wells Dam. The data were also compared to that for those fish which migrated elsewhere in the Columbia, to look for differences in timing and migration pattern. A full report on the project, presenting additional details on methods and analyses (particularly for fish which migrated upstream in the Columbia and Okanogan/Similkameen Rivers, and for which results are not reported here) can be found in the WDFW project final report (Ashbrook et al. 2006).

DIDSON-LR – In 2005, project researchers also collaborated on a Pacific Salmon Commission – Southern Boundary Fund project, "Validation of a Long-Range Dual Frequency Identification Sonar (DIDSON-LR) for Fish Passage Enumeration in the Methow River" awarded to CRITFC. A DIDSON™ (Sound Metrics Corporation, Lake Forest Park, Washington) is a multi-beam sonar. Reflections of objects passing through the ensonified area created by the DIDSON are electronically converted to moving images within the field of view. When placed in a body of water and oriented to transmit horizontally, it produces a top-down ("bird's-eye") view of the conically-shaped ensonified field. This "underwater acoustic camera" is not constrained by conditions of darkness or turbidity as are optical video systems, and provides much higher resolution than older single or split-beam sonar systems. The standard version of a DIDSON can be operated at one of two emission frequencies, 1.8 or 1.1 MHz. The higher frequency produces images of greater resolution, but at a range limited to 10-12 m; the lower frequency extends the operating range of the instrument to over 20m. However, to view objects at an even greater distance, a long range (LR) model was recently designed, with a transducing array which can emit at either 1.2 or 0.7 MHz – the lower frequency permitting even greater penetration through the water. The primary objective of this project was to confirm efficacy of the DIDSON-LR to record countable images of passing fish, for the purpose of escapement estimation in an open river. The DIDSON-LR was installed along the near shore immediately upstream of the panels at the tower-

counting site, and oriented across the 40+ m expanse of the river. On several occasions from mid-July to mid-September 2005, the DIDSON was operated concurrently with visual counts of fish passage made from the counting tower. Time, approximate distance and direction was recorded for each passing fish observed visually. Afterwards, the same data were noted for images of migrating fish in the corresponding DIDSON files. The respective data sets were then compared for concordance. A full description of the experimental design is provided in the final report for the project (Galbreath and Barber 2005; http://www.critfc.org/didson-lr).

Juvenile Production

Smolt-Trapping - Out-migrating fish in the Methow River were captured in both 2004 and 2005 using an 2.4 m diameter rotary-screw trap (EG Solutions, Inc. Corvallis, OR). The trap was installed downstream of the Burma Road Bridge off of Washington State Highway 153, milepost 8.54, river km 15.6 [Latitude 048° 06' 02" N and Longitude 120° 01' 12" W (NAD 27), Figure 3]. This site was chosen because it provided stable anchor sites (off the Burma Road Bridge guard rails) and immediate proximity to the road allowing for ease of installation and accessing of the trap. The trap functioned daily from May 3 to August 2 in 2004, and from May 3 to July 11 in 2005, except for 2 days in 2004 and 3 days in 2005 when high water precluded operation. The trap was operated solely during evening hours (from dusk to dawn), then was winched to the shore to allow for safe river passage of recreational boats (kayaks, rafts, etc.). Daily flow data were obtained online for the USGS Pateros/Methow River flow gauge located downstream at river km 10.8 [Latitude 048° 04' 40" N and Longitude 119° 59' 05" W (NAD 27), http://waterdata.usgs.gov/wa/nwis/uv/?station=12449950].

Each morning, fish trapped during the previous night were removed from the screw trap holding box and anaesthetized in approximately 80 mg/L Finquel MS-222™ (Argent Chemical Laboratories, Inc, Redmond, WA). Individuals of species other than Chinook, coho and steelhead were immediately released downstream. The Chinook (spring and summer stock), coho and steelhead were sorted by species/stock and origin (hatchery versus wild), and counted. Hatchery-origin fish were distinguished as lacking an adipose fin, possessing a coded-wire tag (CWT) or a passive integrated transponder (PIT) tag, and/or exhibiting obvious fin or snout erosion. In the absence of these characteristics, the fish were deemed wild. From among the Chinook juveniles, a randomly chosen subset of approximately 50 individuals per week were tissue-sampled for subsequent DNA analysis and genetic stock identification (see below). Another randomly chosen group of juvenile Chinook were implanted with PIT tags for determination of smolt migration rate and survival (see below). In 2004, but not in 2005, another randomly chosen group of juveniles were implanted with CWTs for eventual identification in the ocean and lower Columbia fisheries. Tag code, and length and weight measurements for each of the tissue-sampled and PIT or CWT tagged fish were entered into a field laptop computer. The total time required to biopsy and/or tag each fish was approximately one minute. Afterwards, the fish were placed in a recovery tank and released below the trap site.

Figure 3. Methow River rotary screw trap, installed downstream of the Burma Road Bridge adjacent to Washington State Road 153 (opposite bank), river km 15.6.

Trials to produce Peterson mark-recapture estimates of capture efficiency of the smolt trap were conducted 16 times through the sampling period in 2004, and 25 times in 2005. The protocol for these trials involved immersion of between 100 and 230 fish per trial (with the exception of one trial in 2005 involving only 66 fish) in a bath of approximately 40 mg/L Bismark Brown for 15-20 minutes. The dye produced a non-permanent darkened skin coloration in the fish that usually lasted for two to three days. The treatment was applied during the evening, then the fish were transported approximately 1.3 km upstream of the trap site and immediately released in shallow water on one and/or the other side of the river. The recapture rate (trap efficiency) was calculated as the proportion of dyed-marked fish found in the smolt-trap the following morning relative to total number released.

Temporal trends in the individual trap efficiency estimates were examined within years by liner regression analysis. If a significant trend was not observed ($p>0.05$), an aggregated average trap efficiency for the year was calculated as the sum of all recaptured fish divided by the sum of all marked fish. However, if a significant trend was observed within a year's estimates ($p<0.05$), the sampling period was subdivided into two or three consecutive sub-periods, and trap efficiency estimates were re-examined within each. When significant trends were no longer apparent within sub-periods, an aggregated average efficiency was calculated for each.

Genetic Stock Identification (GSI) - Determining the production base of summer Chinook is hampered by potential overlap in distribution and out-migration timing with

the Methow River stock spring Chinook smolts. It is well established that reproductive isolation is maintained between these two genetically distinct stocks (Narum et al. 2004). Summer (/fall) Chinook in the Mid-Columbia typically begin smoltification and out-migrate as age 0+ juveniles (ocean-type), whereas spring Chinook out-migrate as age 1+ juveniles (stream-type) (Matthews and Waples 1991). Because of the difference in age at smoltification between the stocks, wild juvenile Chinook out-migrants less than 100 mm have been considered to be ocean-type subyearling summer Chinook, and wild smolts >100 mm as stream-type yearling spring Chinook. In order to confirm the reliability of identifying the stock of a smolt by its size at out-migration, fin clips were collected non-lethally from a subset of the Chinook juveniles captured in the smolt trap, for subsequent genetic stock identification (GSI).

Tissue samples for GSI were obtained each week throughout the migration season (May through July), for a total of 700 fish in 2004, and 296 in 2005. The samples were taken from the upper or lower lobe to the caudal fin using a 1.5 mm disposable circular biopsy punch, and stored in 100% ethanol in individually identified 1.5 mL microcentrifuge tubes. At the end of the season, the samples were sent to the Collaborative Center for Applied Fish Science (Hagerman ID) for analysis of a suite of 13 microsatellite DNA markers and determination of genetic stock following protocols described by Moran et al. (2005).

<u>Juvenile Out-Migration</u> – Over the course of the season in both years of the field study, randomly chosen samples of wild juvenile Chinook salmon greater than 60 mm collected in the smolt trap were PIT tagged in accordance with established PTAGIS protocols (http://www.psmfc.org/pittag/). A total of 2,825 fish were tagged in 2004, and 3117 fish were tagged in 2005. The fish were implanted with BioMark™ 12 mm TX1400ST 134.2 kHz PIT tags (Biomark, Inc., Boise ID). The tags were inserted into the body cavity through a small incision (approximately 1.5 mm made with a size #11 scalpel blade) in the abdominal wall slightly below the pectoral fins. Data for size, PIT tag number and release date were entered into a database using PTAGIS P3 software, then the fish were placed in a holding tank. After 8 to 12 hours, mortalities were noted and removed, and the recovered fish were released back into the river below the trapping site.

Data for detection of the PIT tagged fish at the following mainstem dams - McNary Dam, John Day Dam and Bonneville Dam - were obtained from the Columbia River Data Access in Real Time (DART) website (http://www.cbr.washington.edu/dart/). Travel time between the smolt trap and McNary Dam was calculated for the fish individually. The average (geometric mean) migration time was calculated within years, and the data was assessed for an effect of smolt size and capture date at the smolt trap. A Peterson estimate of detection efficiency of PIT tagged fish at McNary Dam was calculated each year by dividing the number of fish detected at both McNary and John Day Dams, by the total number of fish detected at John Day Dam. The number of detections at McNary was than expanded by dividing this number by the detection efficiency, providing an estimate of the number of PIT tagged fish which survived to McNary. In turn, this number was multiplied by the total smolt abundance estimated from the

Methow River smolt trapping data, then divided by the number of PIT tagged fish to provide an estimate of the total abundance of Methow River Chinook smolts that survived to McNary Dam.

Ocean Migration

Coded-wire tag recovery data can be used to determine the distribution of summer Chinook salmon in both ocean and freshwater fisheries. Mid-Columbia summer Chinook are harvested in ocean fisheries and considered a far-northern migrating stock, however, few naturally-produced ocean-type tagged fish have been recovered in the ocean fisheries. Wells Hatchery, the primary producer of subyearling fish, may be a poor representative of the wild stock and has had very low percentages of CWT recoveries. It has been difficult to tag naturally-produced populations due to limited recruitment and the high potential of confusing spring and summer life history types.

Over the 2004 season, 1,132 wild summer Chinook salmon subyearlings ranging in size from 45-70 mm collected from the lower Methow River smolt trap were CWT-tagged (CWT code: 619900). Tagging involved insertion of the tag in the snout of each fish using a Northwest Marine Technologies™ Mark IV automatic tag injector (Northwest Marine Technologies, Inc., Shaw Island WA). The fish were held in a live-well for a 24-hour time period to assess short-term fish health. The fish were checked for tag retention using an electronic tag detector, then released back into the river below the trapping site during the evening hours.

RESULTS

Adult Escapement Estimation

<u>Tower Counting</u> – In the summer of 2004, high intensity precipitation events occurred in the Chewuch River Basin (Figure 4), a major tributary to the Methow River. The Chewuch has experienced extensive fire activity in recent years, and the resultant erosion and high flows from this tributary in 2004 created protracted conditions of high turbidity in the Methow River. The turbidity precluded making any regular visual counts during the entire months of July and August– the period during which the summer Chinook run was presumed to have initiated and peaked. Counting in 2004 did not commence until September 3, and continued until October 18. A net upstream migration of 113 adult summer Chinook was observed during this period, with the frequency of observations decreasing progressively over time (Figure 5). Of note, observation number was highly correlated with time of day, with 83 (74%) of the observations of in-migrating adults at this lower river site having been made during the 5 pm to 1 am shift (of which all but 2 were after 7 pm). Because of the lack of observations during the initial two months and the irregularity of observations during the remaining six weeks, it was not possible to expand the data in an attempt to estimate escapement. Additional details for this portion of the project are provided in the 2004 Project Progress Report (Evenson and Narum 2005).

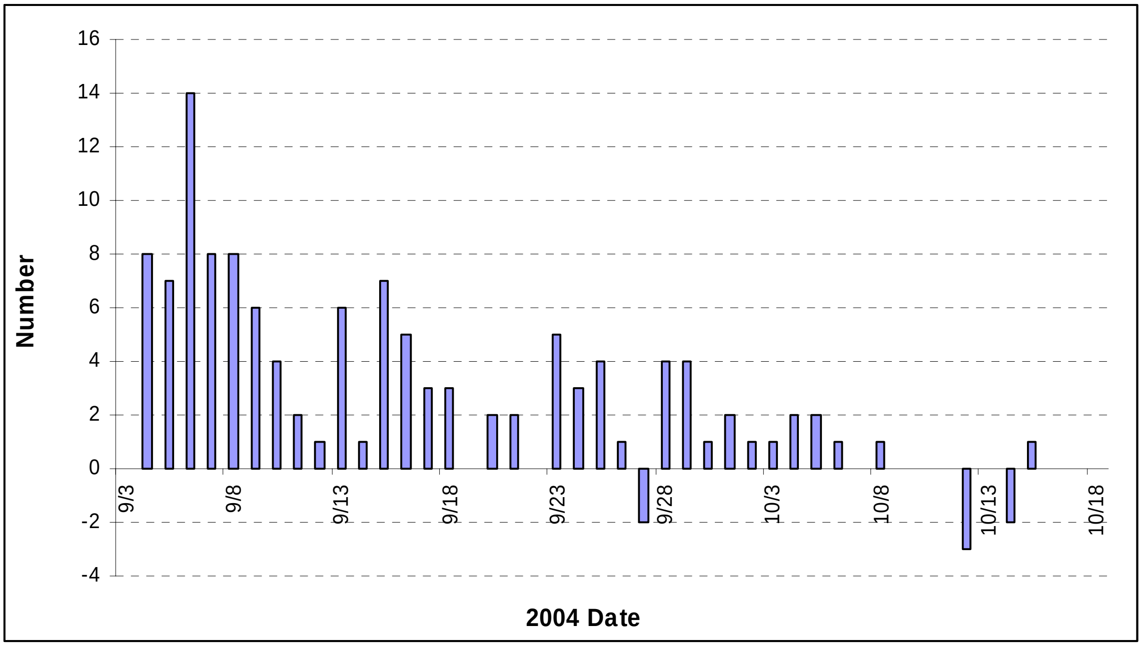


Figure 4. Total daily net upstream migration number of summer Chinook salmon observed during tower counting in the Methow River in 2004. (note: days were not equally sampled – some involved counting during 1 8-hour shift, others for 2 shifts, and some for 3 shifts.)

Summer rainstorms of the nature experienced in 2004, though unusual, occur with sufficient frequency that tower counting was deemed impractical as a methodology to obtain reliable counts in the Methow River. Therefore, the technique was abandoned, and in 2005, project researchers collaborated on two other projects associated with escapement estimation techniques; the first involving radio telemetry and the other testing use of a DIDSON.

Radio Telemetry – In-migrating adult summer Chinook were captured at Wells Dam for tagging with radio transmitters on periodic days over the full 2005 return migration season for summer Chinook. The number of Chinook chosen for tagging on a given day was not reflective of the relative size of the run. Instead, this proportion tended to increase as the season progressed, in order to have sufficient observations with which to characterize the migration patterns of the fish which returned at lower numbers later in the season (Figure 5).

Of the 280 radio tagged adults which were successfully tracked upstream of Wells Dam, 35 (12.5%) were identified as having entered and remained in the Methow River, ostensibly for spawning. When this proportion was calculated within tagging periods, there was no apparent trend of increase or decrease over the season (Figure 6).

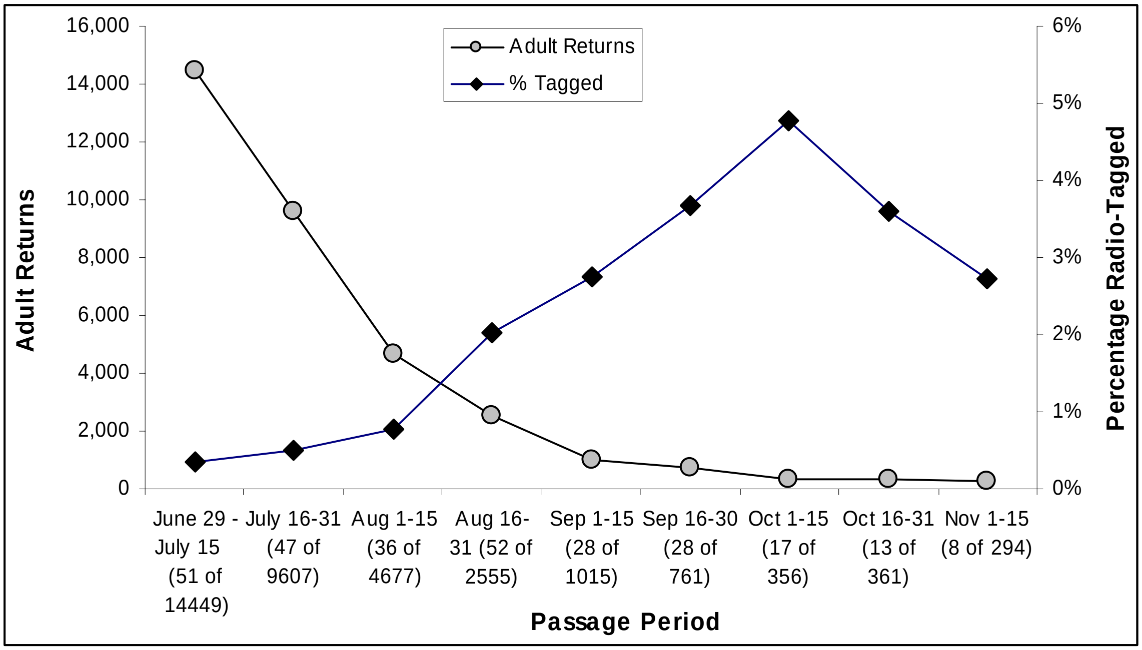


Figure 5. Total adult summer Chinook return number and percent of adults chosen for radio tagging per period of passage at Wells Dam in 2005.

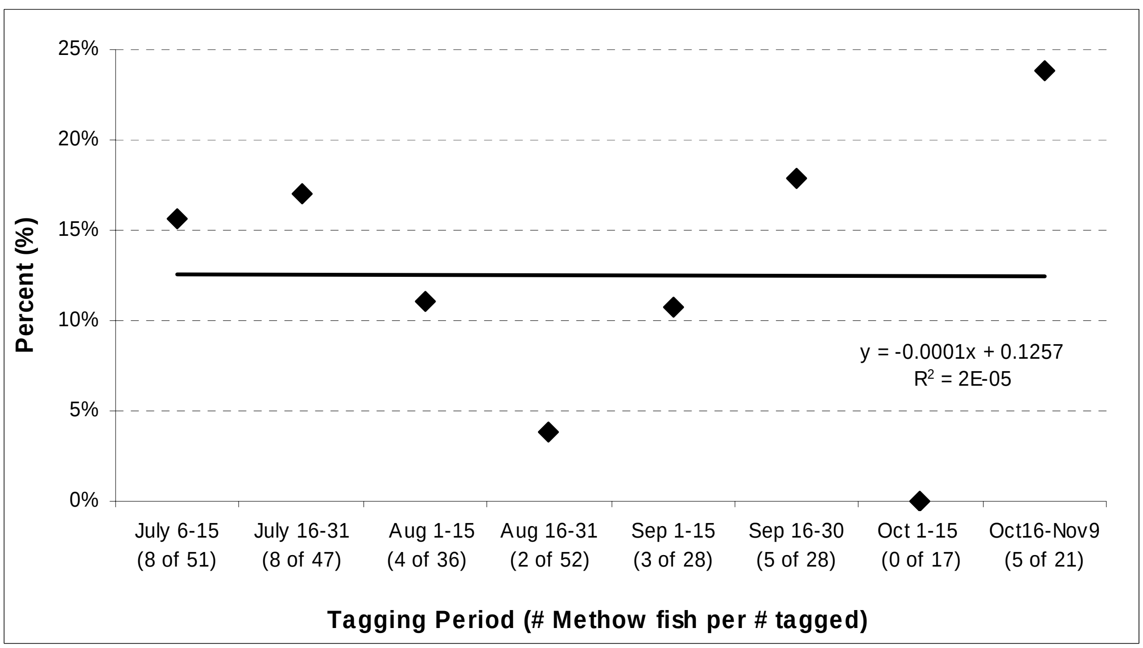


Figure 6. Percent per tagging period of summer Chinook adults chosen for radio tagging at Wells Dam in 2005, which entered the Methow River.

This proportion was then multiplied by 34,075, the total number of summer and fall Chinook salmon counted at Wells Dam in 2005 (arrival at Wells Dam from June 29 and August 28, and from August 29 to November 15, respectively; USACE 2005), providing an estimate of 4259 ± 1320 (95% confidence interval) for the total escapement to the

Methow River. This estimate was significantly greater than the estimate for spawning escapement of 2,651 produced by the WDFW from expanded redd counts in 2005. The estimate also exceeded all other annual spawning escapement estimates for the Methow River since 1990, with the exception of 2002 (Table 2; Miller 2006, Miller 2005, and preceding years' WDFW annual reports).

Table 2. Estimated annual spawning escapement of summer Chinook salmon to the Methow River, based on expanded redd counts.

Year	Total Redd Count	Expansion Factor	Escapement Estimate
1990	409	3.10	1,268
1991	153	3.10	474
1992	107	3.10	331
1993	154	3.10	477
1994	310	3.10	961
1995	357	3.10	1,107
1996	181	3.40	615
1997	205	3.40	697
1998	225	3.00	675
1999	448	2.20	986
2000	500	2.40	1,200
2001	675	4.10	2,768
2002	2013	2.30	4,630
2003	1624	2.42	3,930
2004	973	2.25	2,190
2005	874	2.93	2,561

Summer Chinook which returned to the Methow River showed no apparent differences in measured characters relative to the other radio tagged adults which migrated upstream towards Chief Joseph Dam and/or into the Okanogan/Similkameen River system. A t-test indicated that the Methow fish were not significantly different in size (fork length) ($p>0.05$), and Chi Square tests for goodness of fit indicated that actual and expected observations for sex (females versus males), ladder of capture (east versus west) and origin (natural versus hatchery) among the Methow fish did not significantly differ from the observed ratios among all fish measured at Wells Dam ($p>0.05$) (Table 3).

Of note, the percentage of hatchery-origin fish among adult Chinook arriving at Wells Dam was much larger than the 7.5% which received radio tags. In addition to fish collected for radio tagging, others were collected for tagging with jaw tags. Data on the latter was collected from fish entering upstream hatcheries, from harvest returns, and

from carcasses during spawning ground surveys. Over the season, a total of 1,010 adults were intercepted at Wells Dam, and which represented a more-or-less random sample of the run, of which 692 (68.5%) were wild and 318 (31.5%) were hatchery-origin. Similarly, during spawning ground surveys conducted in 2005 by WDFW in the Methow, Okanogan and Similkameen rivers, a total of 2,617 carcasses were censused, of which 732 (28%) were hatchery-origin (Miller 2006). It should also be noted that a (very) small portion of the fish with intact adipose fins, and thus presumed to be naturally-spawned, were possibly of hatchery-origin. The majority of hatchery-origin adults in 2004 and 2005 were most likely derived from smolt releases in 1999, 2000, 2001 and 2002, which were held in the Carlton Acclimation pond in the Methow River, the Similkameen Acclimation Pond in the Similkameen River – a tributary to the Okanogan River, or ponds at the Wells Dam hatchery prior to release. During this period, 100% of the yearling and sub-yearling smolts released were adipose-clipped. However, some of the fish may have originated from smolt releases from Turtle Rock Hatchery (river km 765; 65 km downstream of Wells Dam). While 100% of the yearlings in all 4 years and 100% of the sub-yearlings in 1999, 2000 and 2002 were adipose-clipped, only 1/3 of the sub-yearlings in 2001 were adipose-clipped (http://www.fpc.org/hatcheryQuery_By_Species.html).

Table 3. Number and percent of adult summer Chinook radio tagged at Wells Dam in 2005 and successfully redetected upstream (n=280) versus those which returned to the Methow River (n=35), relative to sex (female or male), Wells Dam fish ladder of return (east or west), and origin (natural or hatchery).

	Wells Dam		Methow River	
	Number	Percent	Number	Percent
Sex				
Female	138	50.2%	22	62.9%
Male	137	49.8%	13	37.1%
Return Ladder				
East	152	54.3%	16	45.7%
West	128	45.7%	19	54.3%
Origin				
Natural	259	92.5%	33	94.3%
Hatchery	21	7.8%	2	5.7%

Travel time from Wells Dam to arrival in the Methow River varied widely among the 35 Methow fish – from less than 1 day to 55 days. Among these fish (22 females and 13 males), no sex-related differences ($p>0.05$) were apparent in either their arrival time at Wells Dam, or in their average travel time to the Methow River (Figure 7)

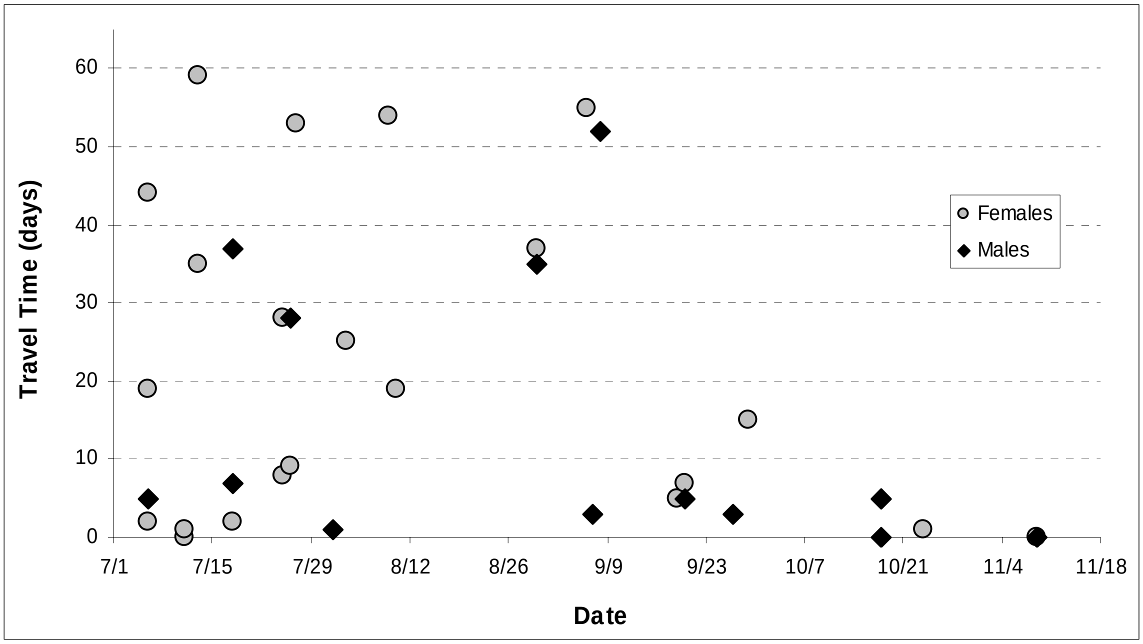


Figure 7. Arrival date at Wells Dam versus travel time of female and male summer Chinook adults which migrated directly to the Methow River in 2005.

Prior to final entry in the Methow, approximately 2/3 of the fish (n=22) migrated upstream in the Columbia River to the vicinity of Chief Joseph Dam (35 km upstream of the confluence of the Methow), including one which was detected at a fixed receiver located 27 km upstream into the Okanogan River), before returning downstream to enter the Methow River. Average travel time from Wells Dam to entry in the Methow for these fish was 30 days. Most of the fish which exhibited this upstream/downstream migration pattern (upstream migrators) arrived at Wells Dam during the first half of the season (July and August). The remaining third of Methow fish (n=13) migrated more or less directly into the Methow River from Wells Dam (12 km), with an average travel time of 3 days (range: <1 to 9 days). Arrival dates at Wells Dam for these fish occurred evenly over the full extent of the season (Figure 8).

DIDSON-LR – A total of 55 visual observations were made of migrating salmon in the Methow River during periods of operation of the DIDSON-LR in 2005. For 48 of these observations, a corresponding image (concordant relative to time, distance and direction of movement) was noted in the DIDSON recordings. In seven instances, an image was not observed in the recording, although these discrepancies are more likely explained by factors related to the positioning of the DIDSON or observer error, rather than technical inadequacy of the instrument. When operated at low frequency (LF, 0.7 MHz), the DIDSON-LR provided images of fish at distances to 42 m (the limit of the tests). For fish passing at the farther end of this range, the recordings were easier to read when a 20m Window Length was used in combination with a 22m Start Length, as opposed to a 40m Window Length and a 2 m Start Length. When operated at its higher frequency (HF, 1.2 MHz) the DIDSON-LR provided images of improved resolution, although the maximum distance at which it could be operated at HF was 33 m - a 20 m

Window Length and a Start Length up to 13 m. In either case (LF or HF), however, the level of resolution of the images was only sufficient to provide a qualitative measure of size and pattern of movement. The level of resolution did not to permit distinguishing between species of similarly sized fish, e.g., between Chinook salmon and steelhead, which were both migrating in the Methow River during our trials and had overlapping size ranges (total range 60 to 100+ cm). Additional DIDSON-LR files recorded over extended periods without visual observation from the counting tower confirmed that salmon/steelhead passage in the Methow River at this site occurred primarily shortly following nightfall (during the hours from 9 pm to 2 am), similar to observations made during tower counting activities in 2004. The project final report, and a series of photos and video clips illustrating operation of the DIDSON-LR and the effects of the different settings on resolution of the resulting images are provided in the final report for the project (Galbreath and Barber 2005; http://www.critfc.org/didson-lr).

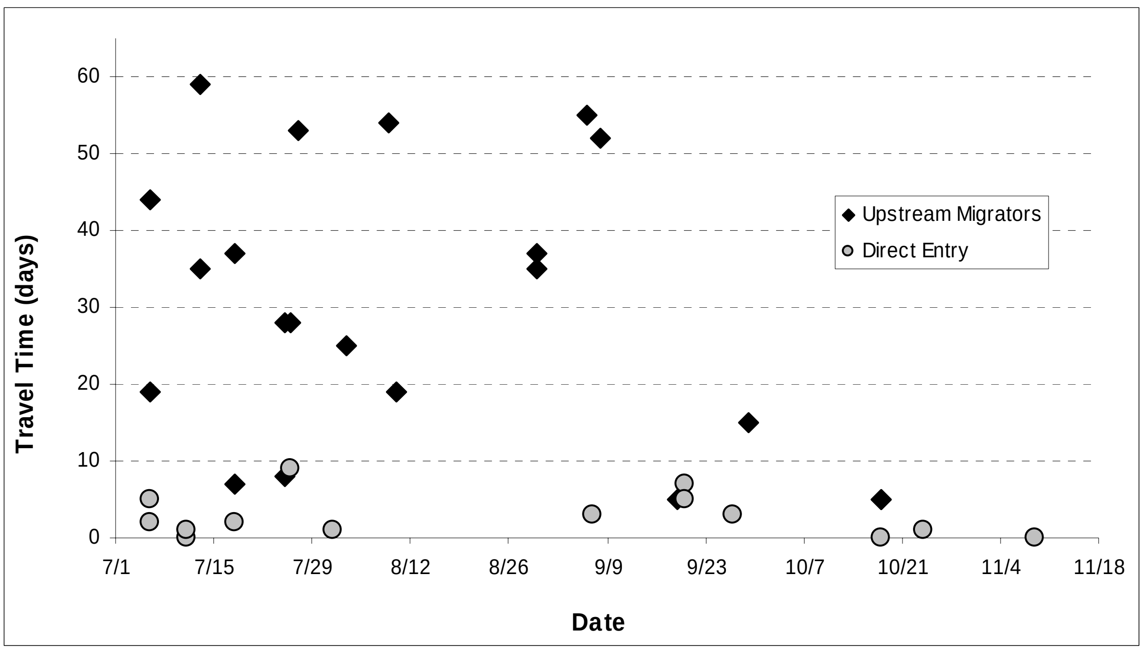


Figure 8. Date of entry versus travel time from Wells Dam of Methow River summer Chinook adults which entered the Methow directly versus those which initially traveled upstream in the Columbia River.

Juvenile Production

<u>Smolt-Trapping</u> - Total numbers of salmon and steelhead captured in the rotary screw-trap in 2004 and 2005 are provided in Table 4. Other species captured but not enumerated, included: bull trout *Salvelinus confluentus*, cutthroat trout *Oncorhynchus clarki*, mountain whitefish *Prosopium williamsoni*, lamprey spp. *Lampetra spp.*, northern pikeminnow *Ptychocheilus oregonensis,* and peamouth *Mylocheilus caurinus*.

Table 4. Summary catch data by species/stock from smolt-trapping in the Methow River in 2004 and 2005.

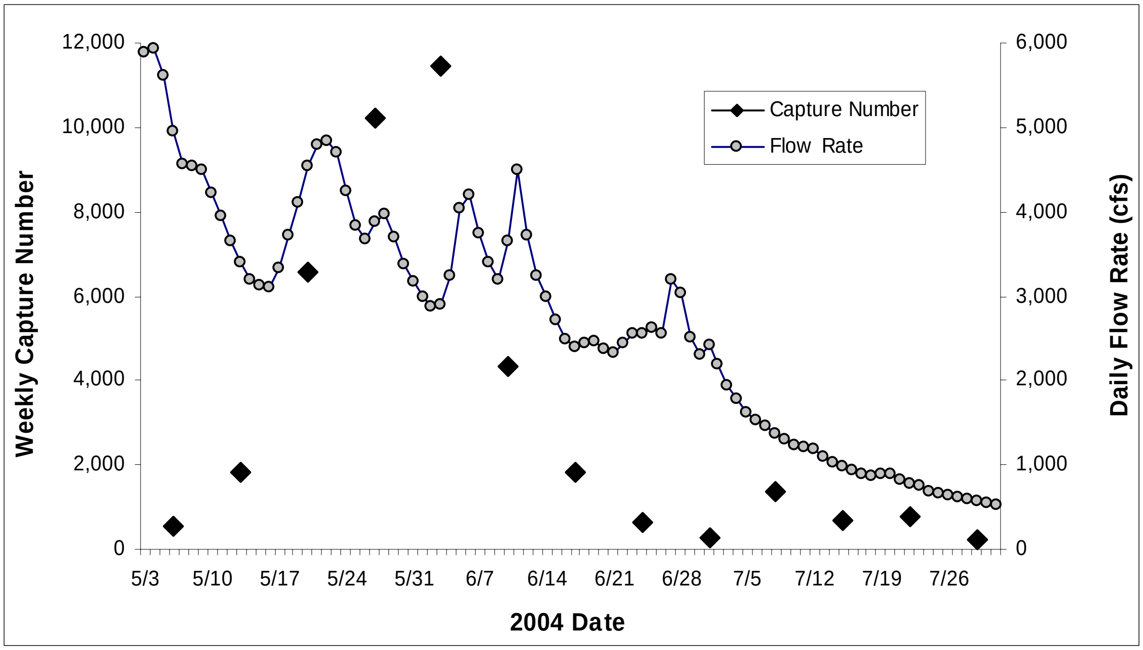
Chinook salmon	2004	2005
Sub-yearlings, presumed summer Chinook	40,783	16,230
hatchery* subyearling summer Chinook**		445
hatchery* yearlings - spring or summer	73	52
wild yearlings - spring Chinook	24	9
Other species		
Steelhead		
hatchery*	1222	1305
wild	174	144
coho		
hatchery*	82	564
wild	9	20

* hatchery origin determined by lack of adipose fin, presence of CWT and/or excessive fin/snout erosion
** in 2005, a large number of summer Chinook were released early (as subyearlings instead of yearlings) from the Methow State Fish Hatchery, Winthrop WA, in an effort to preclude mortality associated with a bacterial kidney disease outbreak.

The total catch of naturally-produced (adipose fin present) juvenile Chinook was markedly greater in 2004 (40,783; May 3 to August 2) than in 2005 (16,230; May 3 to July 11). In 2004, catch peaked dramatically at over 10,000 fish per week in the last week of May and first week of June – this in spite of the high flow rate in the river in this period. In 2005, the highest catch rates were 2,000 to 3,000 fish per week, which occurred all through the month of June (Figure 9).

Part of the reason the total catch in 2005 was lower than 2004 was because sampling in 2005 ceased in early July. Experience in 2004 indicated that out-migration of sub-yearling smolts was very low through the month of July, and sampling in 2005 was therefore scheduled to finish early in the month. However, as of July 11, 2005 when operation of the screw-trap was halted, weekly capture rate was still close to 2,000, and in hind-sight sampling should have continued though the month as in 2004.

However, the foreshortened sampling season in 2005 would account for only a minor portion of the difference in total capture number between years. The primary cause for the difference was likely attributable to the manner in which the screw-trap was operated in 2005, which resulted in a relatively low capture efficiency that year. In fact, expanding total capture numbers by their respective estimates of capture efficiency yields abundance estimates of out-migrating juvenile Chinook which are markedly similar for 2004 and 2005.



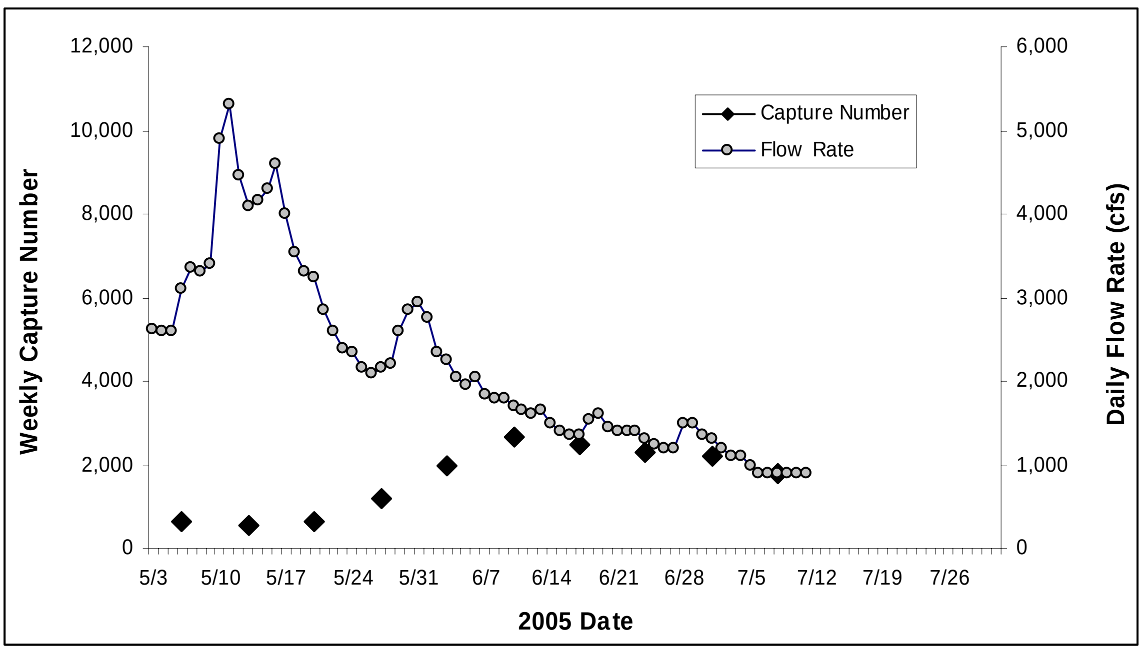


Figure 9. Weekly capture rate of juvenile Chinook from smolt-trapping in the Methow River and daily flow rate for 2004 and 2005

On 16 occasions over the season in 2004, 100 to 200 (total = 2,775) of the captured Chinook were marked with Bismark Brown and released for estimation of trap efficiency. Capture efficiency estimates ranged from 3-15% in this year (Figure 10). Despite a trend for decreasing flow over the season (which might be expected to lead to an increase in capture efficiency), linear regression analysis indicated no significant trend of increase or decrease in capture efficiency over time (p>0.05). Therefore, data were aggregated and an average capture efficiency of 7.75% was calculated. Expanding the

total number of juvenile out-migrants intercepted in the screw-trap by this capture efficiency yields an estimate for total Chinook smolt out-migration of 526,385. This number when adjusted downward by the percentage (15.6%) of DNA samples that were classified as coming from spring Chinook (see following section), provides an estimate of 444,269 as the total number of subyearling summer Chinook out-migrating past the Methow River screw-trap in 2004.

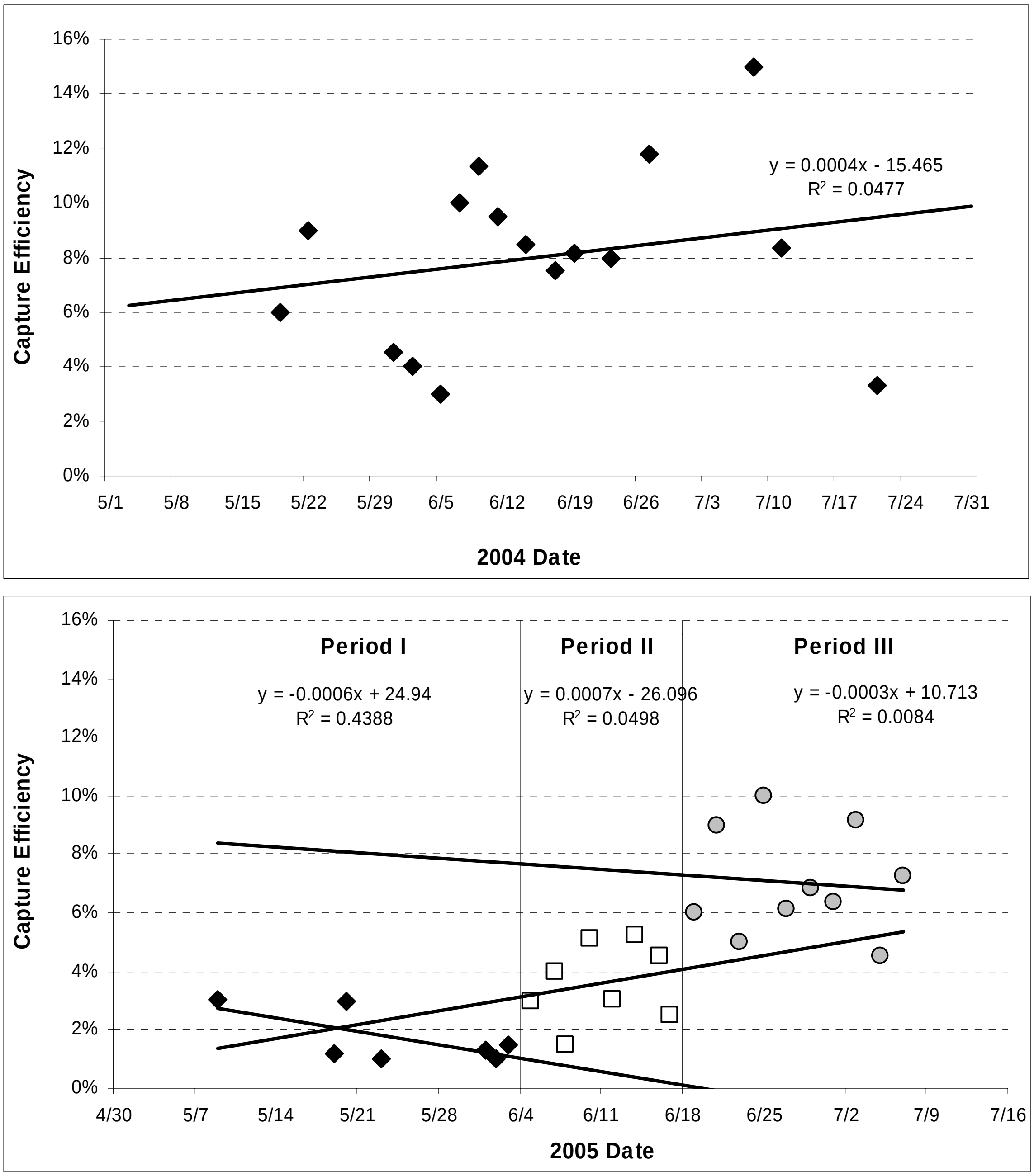


Figure 10. Juvenile Chinook salmon capture efficiency estimates for the rotary screw-trap operated in the Methow River in 2004 and 2005.

In 2005, trap efficiency tests were conducted 25 times, using groups of marked fish numbering from 66 to 230. Capture efficiencies were much lower than in 2004, ranging from 1.0 to 10.0%, with an aggregated average of only 4.3%. Additionally, capture efficiencies demonstrated a significantly increasing trend over the season ($p<<0.001$; Figure 10). Examination of these data indicated that the estimates could be grouped into three sub-periods. The earliest period (May 3 to June 3) was characterized by very low capture efficiencies, possibly attributable to having used an insufficient concentration and duration in the dye-marking process (leading to under-counting of recaptured fish), and to relatively high water flows and improper positioning of the screw-trap (resulting in reduced capture rates). Indeed, the researchers indicated that during this initial period, data for a few additional mark-recapture trials had to be discarded because it was strongly suspected that the dying protocol used had been insufficient to assure distinguishing marked fish after 24 hours. Also, the trap was repositioned several times during this period, as the researchers sought the location in the river where the Chinook smolts appeared to be migrating in greatest numbers – found to be between the fastest deepest portion above the thalweg, and the slower shallow near-shore area. During the second period (June 4 to June 17), efficiencies were higher, likely related to improved positioning of the trap, albeit with water flow remaining somewhat high. The third period (June 18 to July 11) showed the highest efficiencies - presumed associated to proper positioning of the trap and to the relatively low water flow rates. Regression analysis indicated no significant trend in capture efficiency estimates over time within Periods II and III ($P>>0.05$), and an aggregated average capture efficiency for each period was calculated. Within Period I there still appeared to be a downward trend to the data, although regression analysis indicated this trend was not quite significant ($p=0.105$). Also, further subdivision did not seem justifiable, as only a single efficiency estimate was successfully conducted during the first half of this sub-period, and the researchers were concerned that some of the later estimates within this period were spuriously low. An aggregated average was therefore calculated for Period I as well, it being presumed to provide the best estimate available for a somewhat compromised data set. The resulting capture efficiency estimates for 2005 were: 1.52% for Period I, 3.53% for Period II, and 7.14 for Period III (Figure 10).

Total numbers of subyearling Chinook captured during these three sub-periods in 2005 were 4,000, 4,732 and 7,714, respectively. Expanding these numbers by the associated capture efficiencies yields an estimated total smolt out-migration number of 504,908 for the year. Reducing this estimate by 14.18% - the percentage of smolts later determined by genetic analysis to be spring Chinook (see following section) - provides an estimated out-migration of subyearling summer Chinook smolts from the Methow River in 2005 of 433,312.

<u>Genetic Stock Identification (GSI)</u> - Data for genetic analyses (performed for the purpose of distinguishing spring versus summer stock) of tissue samples collected from out-migrating juvenile Chinook collected in 2004 and 2005, and are provided in Table 5.

The ability for analysis of samples with the 13 microsatellite loci to identify a fish as being either a Methow River spring or summer Chinook was highly robust. Using this

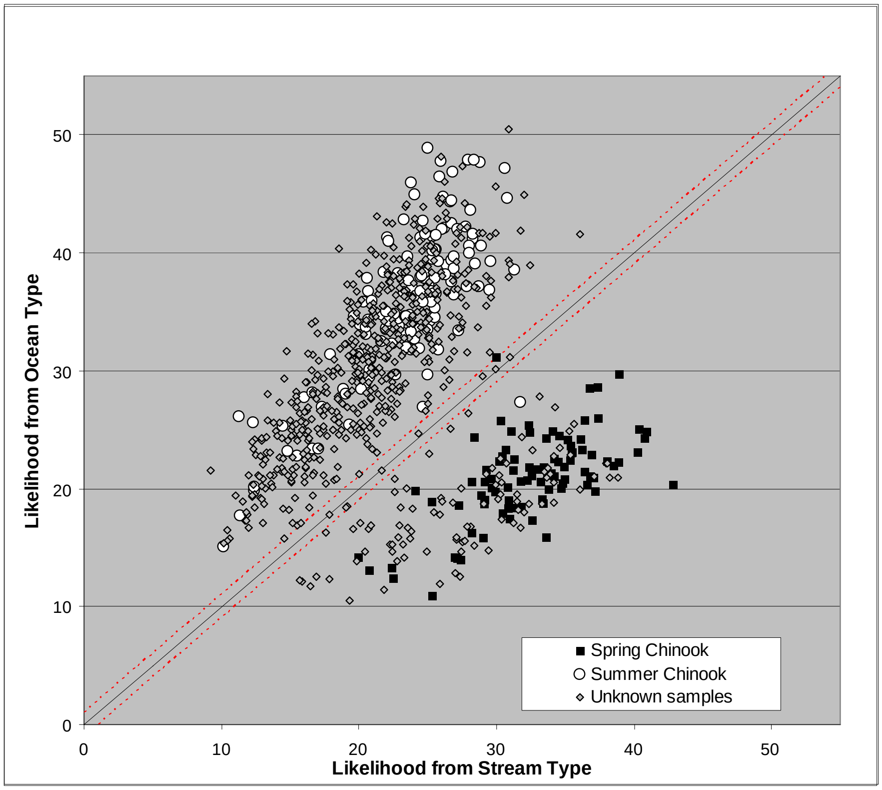
analysis, the reference populations of spring (n = 90) and summer (n = 135) adult Chinook included within the Chinook Technical Committee (CTC) Baseline are assigned to the expected life history with 99.1% accuracy (223 / 225; Figure 11). Of the 610 juvenile Chinook sampled from the Methow River in 2004, 84.4% were identified as summer Chinook, while 15.6% were identified as spring Chinook. In 2005, the data were markedly similar, with 85.8% assigned as summer Chinook and 14.2% as spring Chinook (Figure 1).

Table 5. Data for juvenile Methow River Chinook salmon sampled for genetic stock identification (summer versus spring Chinook) in 2004 and 2005.

	2004	2005
Number juveniles sampled	700	300
Number successfully analyzed	610	275
Number summer Chinook	515	236
Percent summer Chinook	84.4%	85.8%
Number spring Chinook	95	39
Percent spring Chinook	15.6%	14.2%

Juveniles were collected for sampling in a manner that was not entirely random (particularly in 2004). Large-sized juveniles were relatively infrequent, and they were retained for tissue sampling at a disproportionately higher rate, in order to increase the number of samples for the large size groups. Also, growth of the fish during the sampling season lead to a general increase in size over time (Figure 12). Therefore, a single factor statistical test to compare size (length) between stocks was not conducted. However, as expected, the spring (yearling) Chinook tended to be larger than the summer (subyearling) Chinook (Figure 12). As illustrated in Figure 13, the proportion of spring Chinook among fish in the small size classes was very low in both years, and this proportion increased with increase in size class of the fish. However, there was significant overlap in size ranges between stocks, indicating that size alone is of limited usefulness in distinguishing between stocks.

Spring Chinook are generally considered to out-migrate from the Methow River somewhat earlier than summer Chinook. Data from 2005 appear to support this – from May to July, there was a decreasing proportion of spring Chinook among the captured juveniles (Figure 14). In contrast, data from 2004 show the proportion of spring Chinook to be relatively constant over time (Figure #14). Bias due to the non-random sampling procedures could possibly account for the lack of a trend in the 2004 data.



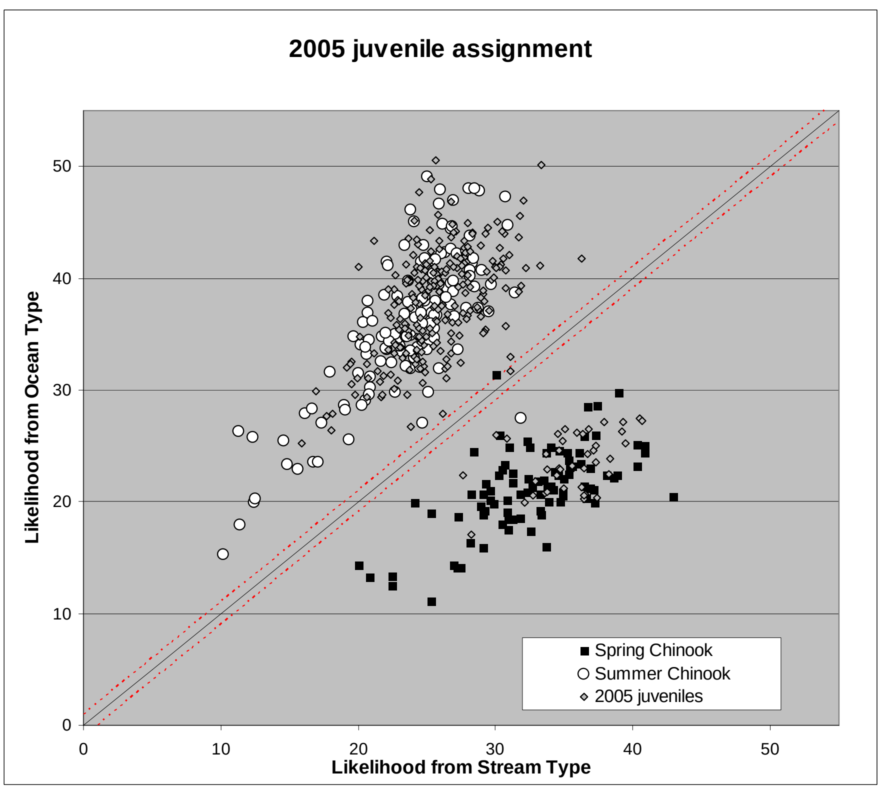


Figure 11. Assignment by individual genotype of reference populations - Methow River spring (stream type) and summer (ocean type) Chinook - and unknown juvenile individuals sampled in 2004 and 2005. Black diagonal line is the line of equal probability. The dotted lines represent the region in which assignment likelihood is within one order of magnitude of equal probability.

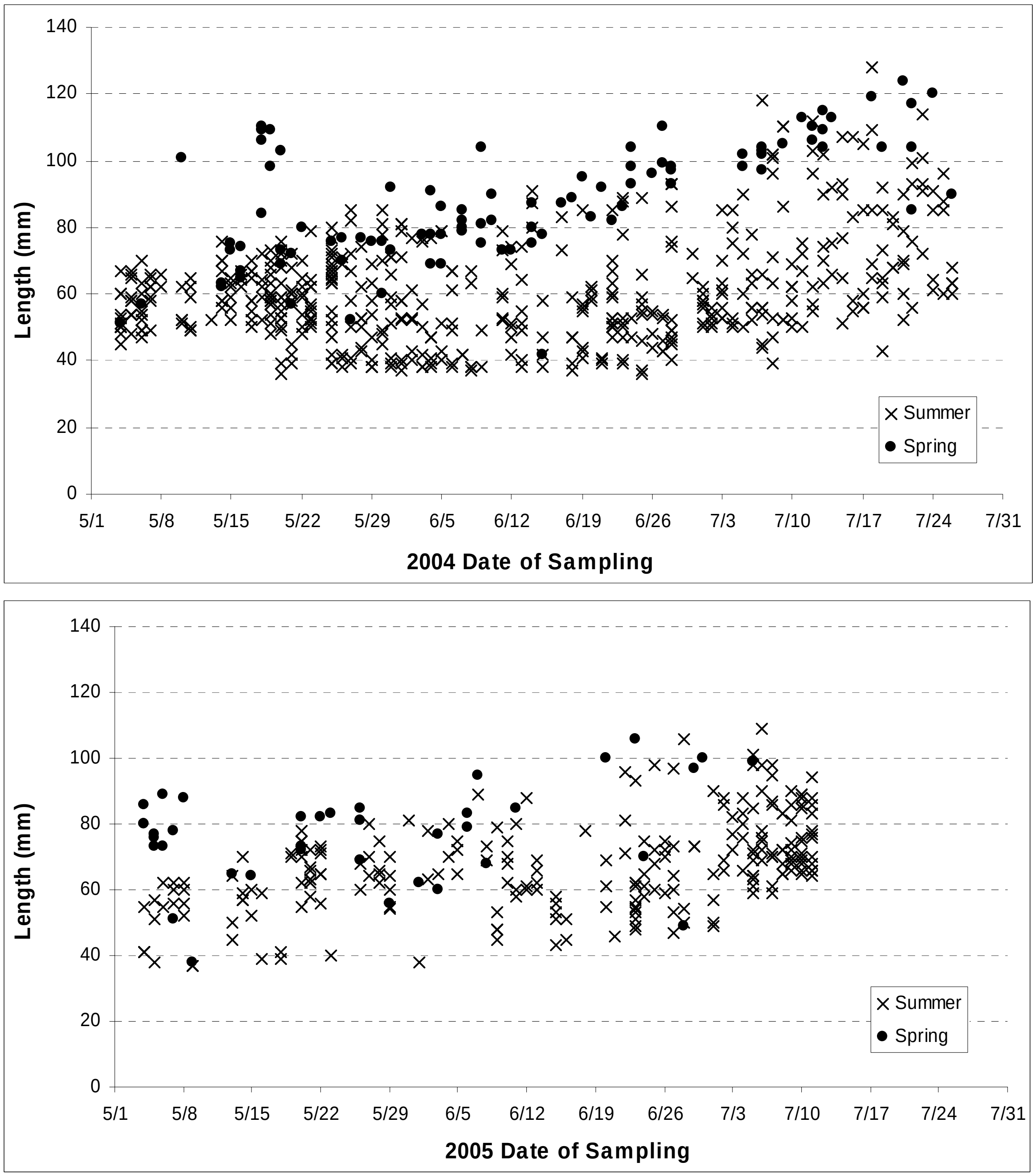


Figure 12. Length versus date of capture of juvenile Chinook salmon in 2004 and 2005, which were tissue sampled and through genetic analysis identified as either spring and summer stock.

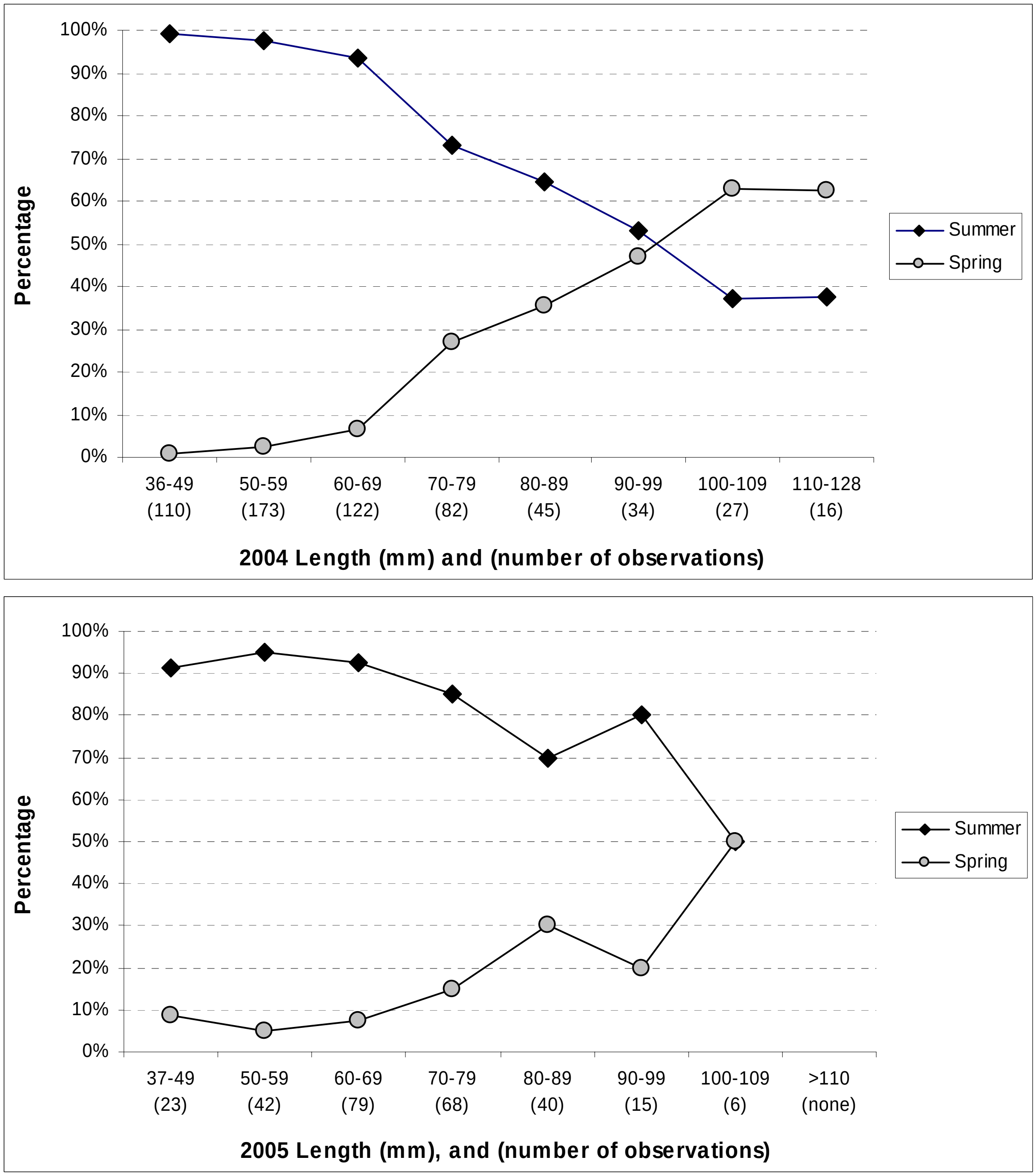


Figure 13. Percent of juvenile salmon identified as either spring or summer Chinook within size groups in 2004 and 2005.

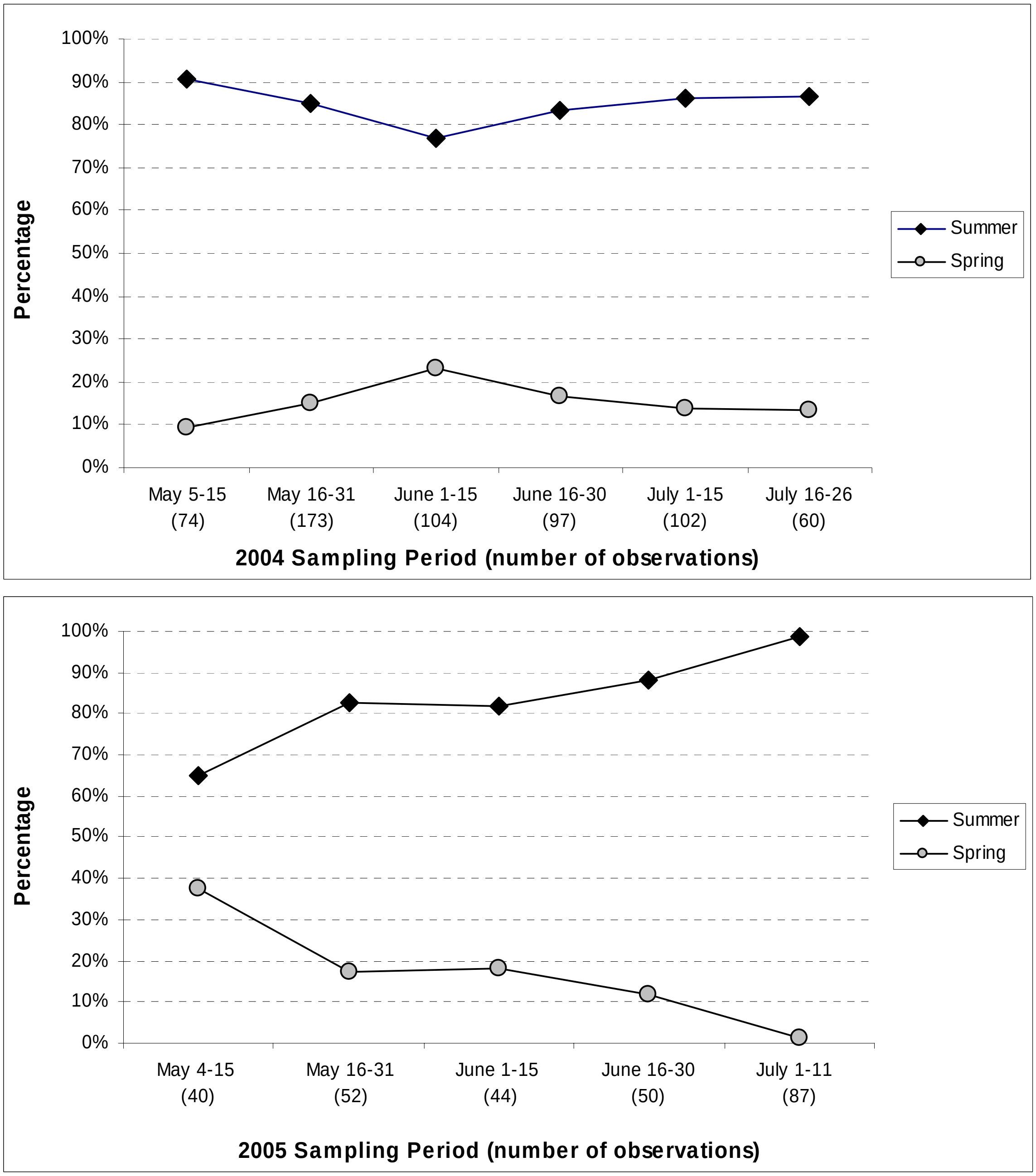


Figure 14. Percent of juvenile salmon identified as either spring or summer Chinook within sampling periods in 2004 and 2005.

Juvenile Out-Migration - The number of the naturally produced subyearling Chinook (adipose fin present) collected at the smolt trap on the lower Methow River and PIT tagged in 2004 and 2005 is provided in Table 6, along with the number which were subsequently detected at downstream mainstem Columbia River dams, including McNary and John Day and Bonneville dams.

Table 6. Number of PIT tagged Methow River juvenile Chinook smolts detected at McNary Dam, John Day Dam and Bonneville Dam in 2004 and 2005.

	Number	Dam		
Year	Tagged	McNary	John Day	Bonneville
2004	2823	65	7 (2)*	0
2005	3117	32	14 (2)	2

* (#) indicates the number of individuals which were also detected at McNary Dam

Travel time from the screw-trap to McNary Dam varied widely among fish within years – from 14 to 117 days in 2004, and from 19 to 148 days in 2005 (Figure 15). Nonetheless, the geometric mean travel time was essentially the same between years – 31.1 days in 2004 and 30.9 days in 2005. The percent of tagged smolts detected at McNary was much higher in 2004 than in 2005. This included a high proportion (8%) of the smolts tagged during the month of May in 2004, although no detections were made of fish tagged in May 2005 (Figure 16).

Travel time appeared to be correlated to some extent with size (length) of the smolts. In both years, almost all of the larger (>80 mm) smolts demonstrated travel times equal to the geometric mean or less. In contrast, the smaller (<80 mm) smolts showed much greater variation in travel time, with the large majority of them exceeding the overall geometric mean (Figure 17).

An estimate of the total number of PIT tagged smolts which arrived at McNary Dam in a given year (detected + non-detected; $N_{(McN)}$) can be calculated by the following formula (this presumes zero mortality of smolts during travel from McNary to John Day Dam):

$$N_{(McN)} = n_{(McN)} / (n_{(McN + JD)} / n_{(JD)})$$

where $n_{(McN)}$ = the number of PIT tagged smolts detected at McNary Dam; $n_{(JD)}$ = the number of PIT tagged smolts detected at John Day Dam, and $n_{(McN + JD)}$= the number of PIT tagged smolts detected at John Day Dam which were also detected at McNary Dam.

2004: $N_{(McN)} = 65 / (2 / 7) = 228$

2005: $N_{(McN)} = 32 / (2 / 14) = 224$

Then, an estimate of the percent survival of all summer Chinook smolts from the Methow River to McNary Dam can be estimated by dividing $N_{(McN)}$ by the total number of PIT tagged smolts:

2004: (228 / 2,823) * 100 = 8.08%

2005: (224 / 3,117) * 100 = 7.17%

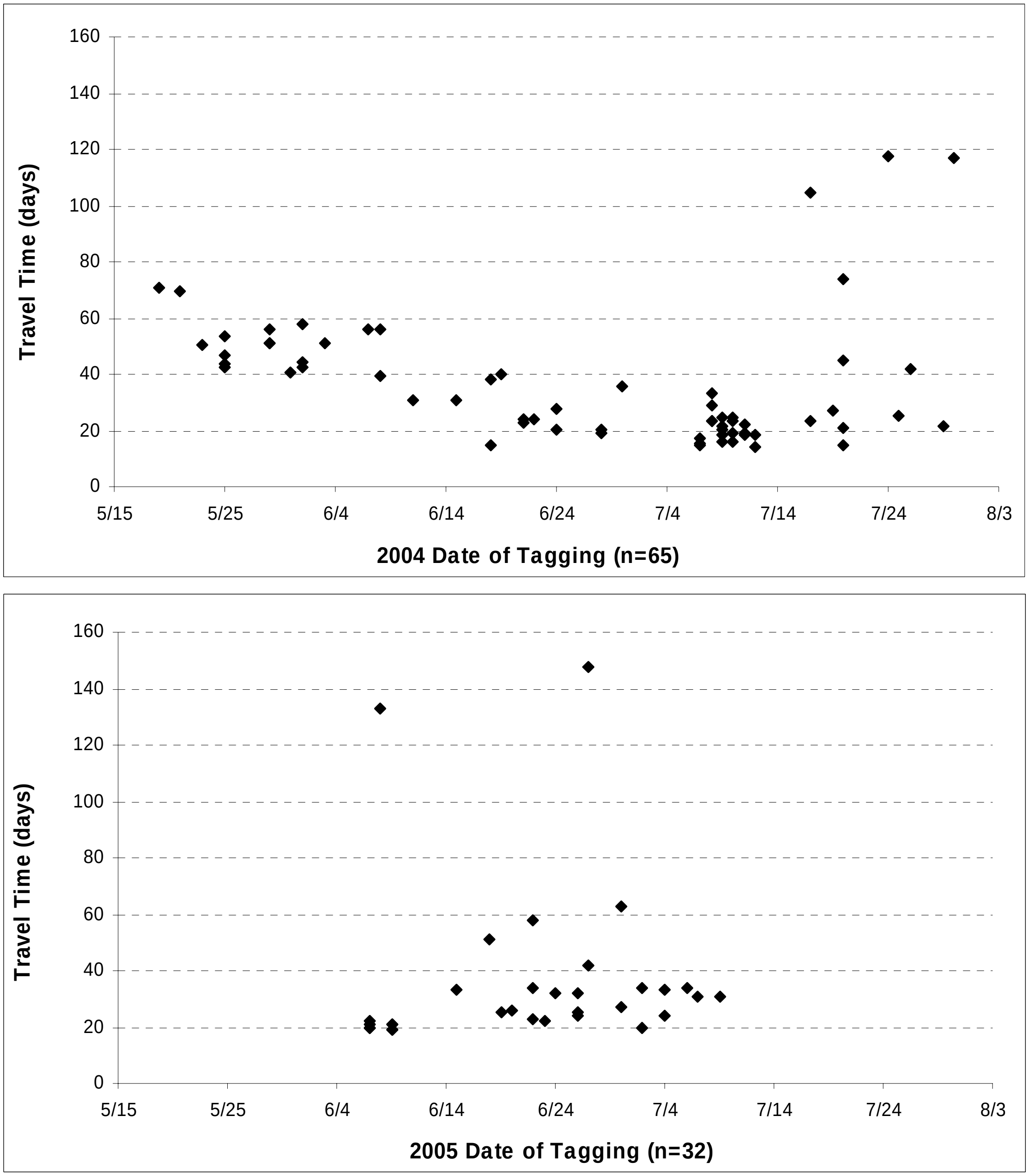


Figure 15. Travel time of juvenile Chinook smolts from PIT tagging at the Methow River rotary screw-trap to detection at McNary Dam, versus date of tagging in 2004 and 2005.

Finally, the total number of Methow River summer Chinook smolts arriving at McNary Dam can be estimated by multiplying the estimate for total out-migrants by these estimates for smolt survival:

2004: 444,269 * 8.08% = 35,881

2005: 433,312 * 7.17% = 31,139

As for the smolt abundance estimates, survival estimates of the smolts from the Methow River to McNary Dam, and thus abundance estimates for smolts at McNary Dam, were very similar between years.

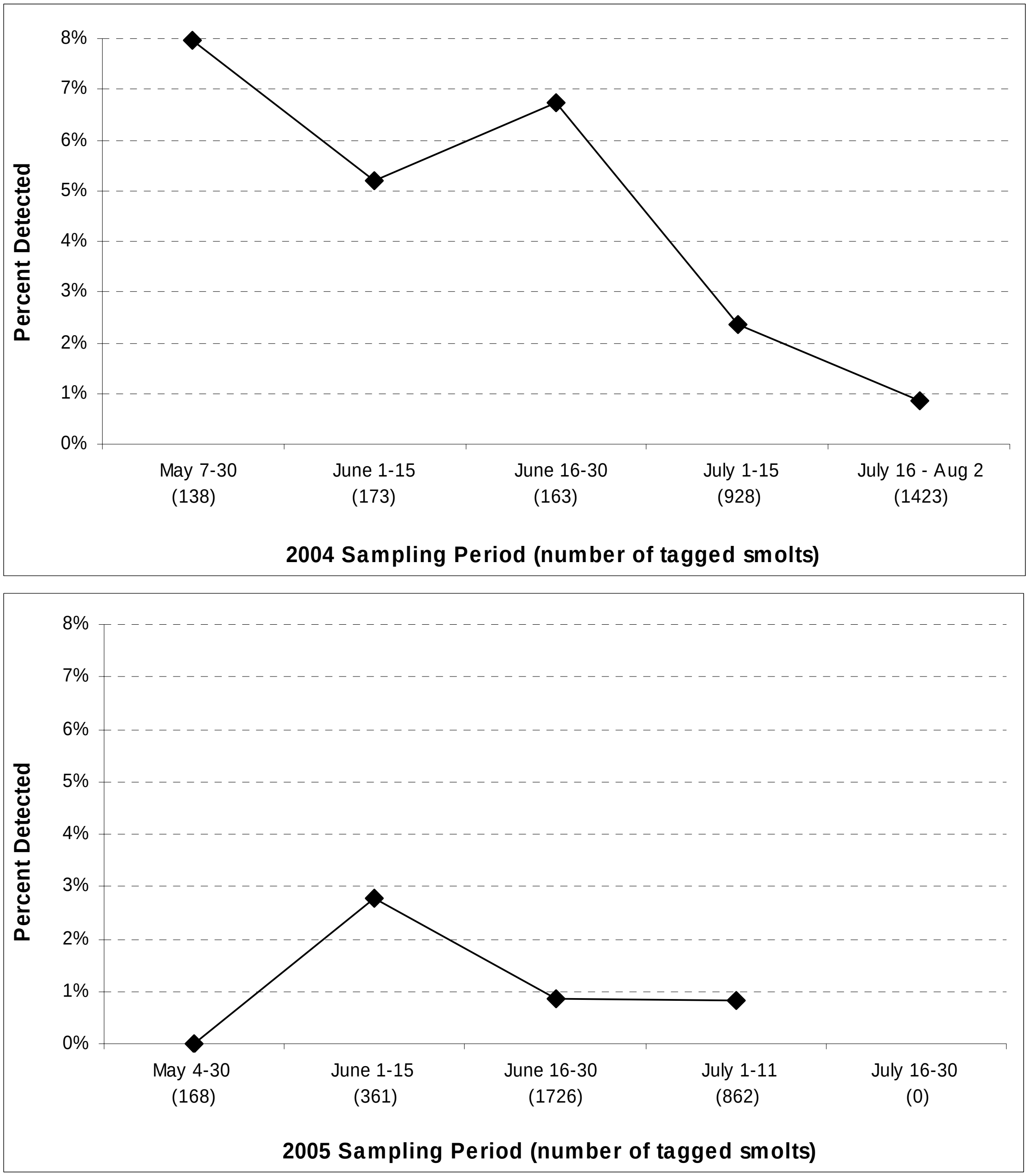
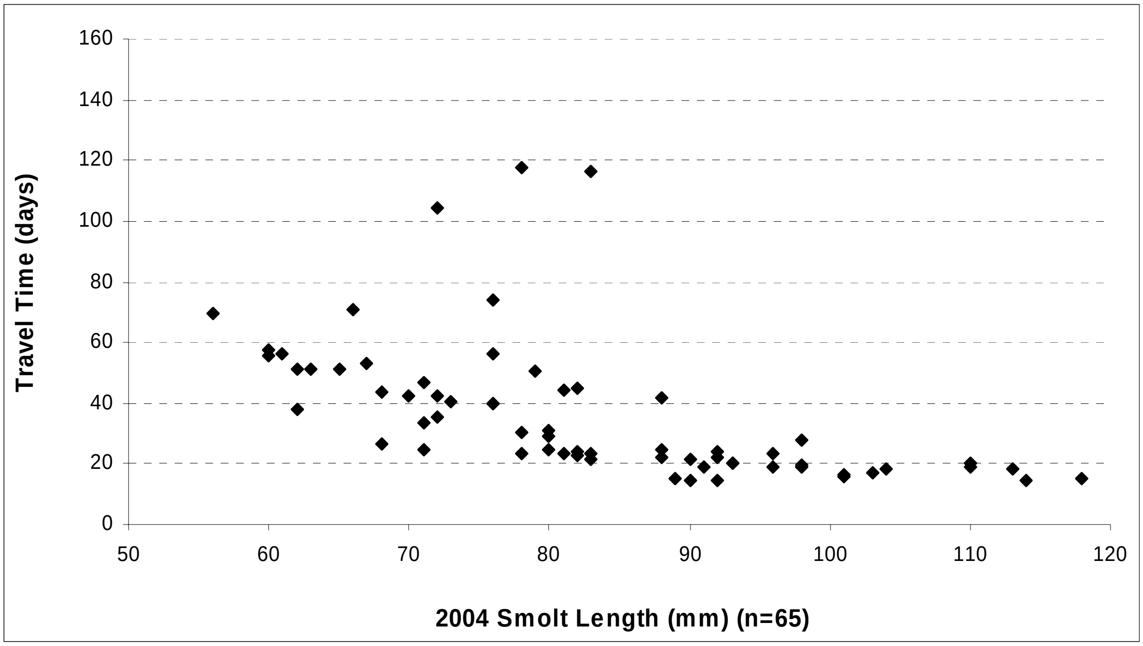


Figure 16. Percent within sampling period of PIT tagged juvenile Chinook smolts detected at McNary Dam in 2004 and 2005.



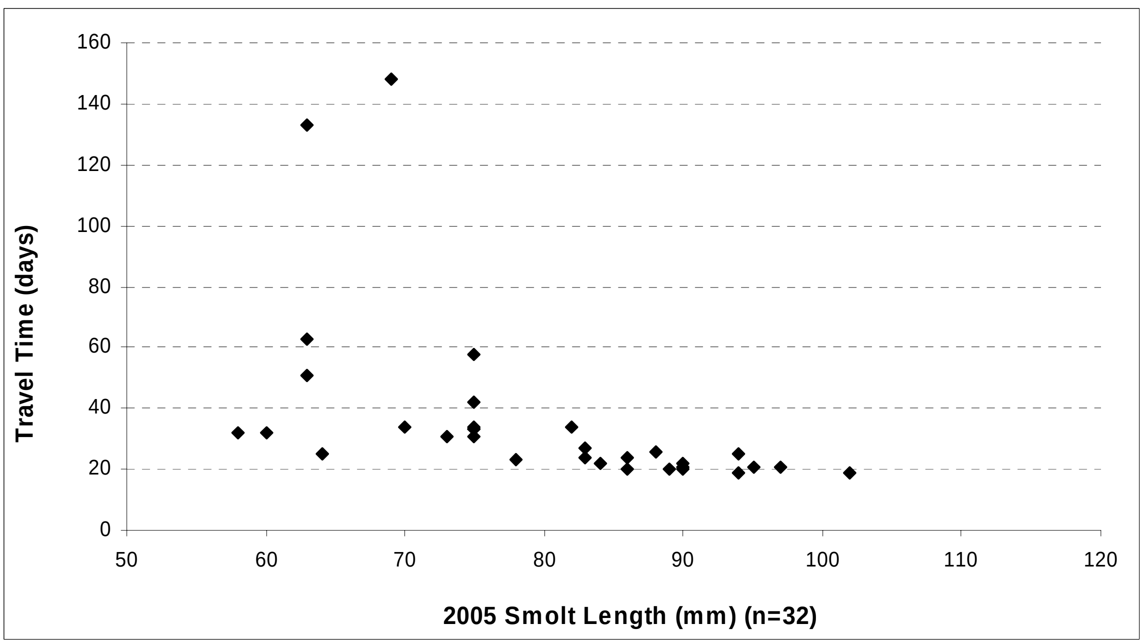


Figure 17. Travel time of juvenile Chinook smolts from PIT tagging at the Methow River rotary screw-trap to detection at McNary Dam, versus smolt size in 2004 and 2005.

Ocean Migration

An analysis of data on CWT recovery is as yet unavailable. Return of the CWT-tagged fish will not be complete until following termination of the present project.

DISCUSSION

Adult Escapement Estimation

Tower counting – The practice of tower counting for salmon escapement estimation was first developed in Alaska in the 1950's, and has since been widely adopted by the Alaska Department of Fish and Game as a means to obtain annual escapement estimates in many of the state's rivers (Becker 1962, Thompson 1962, Cousens et al. 1982, Menard and Kent 2005, Woody in press). In appropriate circumstances, tower counting can provide estimates which are reasonably reliable and economical to obtain. Design of the project in the Methow River followed published guidance for tower counting projects in terms of site selection in the river (a glide with shallow, even water depth and laminar flow), height, proximity and accessibility of the observation point ("tower"), installation of underwater panels and lights, use of polarized glasses, training of observers, etc. (Becker 1962, Thompson 1962, Woody in press). However, the uncontrollable effects of weather proved fatal to the project's efforts in 2004. While rain storm events are generally expected to result in only a temporary increase in turbidity of a river system (Woody in press), fire-damage to the riparian area of the Chewuch River (tributary to the Methow River) in recent years apparently resulted in such a heavy sediment load in the stream that the couple heavy rainstorm events which occurred in July and August of 2004 resulted in a level of turbidity in the Methow which increased and remained high for a full two month period, and precluded making any visual counts during that time. The researchers therefore concluded that tower counting could not provide reliable escapement estimates on an annual basis in the Methow, and plans for repetition of tower counting in 2005 were abandoned. Instead, project researchers allied themselves with two other projects involving techniques being tested to estimate escapement of summer Chinook in the Methow River.

Radio Telemetry – In 2005, WDFW, CRITFC, YN and the Confederated Colville Tribes (CCT) collaborated on a radio telemetry project to assess whether there was populational sub-structuring among the summer Chinook that pass Wells Dam. The project was designed to describe the spawning migration patterns of these fish upstream of Wells Dam, and to quantify the proportion which migrated into either the Methow River, the Okanogan/Similkameen River system, or remained in the mainstem Columbia downstream of Chief Joseph Dam. The data was also used to produce an escapement estimate for fish entering the Methow River. Participation of CRITFC and YN-Fisheries and the reporting of project results here concern specifically escapement of the Methow River portion of the run.

An improved understanding of the behavior and population structure of Mid-Columbia summer Chinook is important for several reasons. Construction of the Chief Joseph Dam Hatchery has been proposed by the CCT as a means to mitigate against the loss of the traditional salmon fishery in that portion of the Columbia and in the Okanogan River. Prior to construction, baseline information is needed about the migration and spawning characteristics of summer Chinook so that questions about the proposed hatchery location, design, and management can be further developed and answered.

These questions include: Do the summer Chinook salmon migrating above Wells Dam demonstrate differences relative to arrival time at Wells Dam and in their subsequent spawning location and timing? Are Chinook that spawn in the lower and the upper Okanogan River a single, fully integrated spawning unit, or is there population substructuring, reflected perhaps in differences in spawn timing? If so, is there a related difference in migration timing past Wells Dam, and should this be considered in the design of the Chief Joseph Dam Hatchery Program broodstock collection and acclimation protocols?

Additionally, Mid-Columbia summer Chinook have been identified as a stock of interest in the Pacific Salmon Treaty, however, only as an aggregate stock (PSC 2000). Improved information on escapement to and smolt production from the various tributary rivers whose (sub)populations comprise this aggregate stock, is needed to monitor trends in abundance and for making run size forecasts essential to proper harvest allocation decision making.

Results from the radio telemetry study conducted in 2005 indicated that 12.5% of the run arriving at Wells Dam consisted of Methow River fish. Based on the total count of 34,075 adults at the dam, this provides an escapement estimate to the Methow of 4,259 ± 1,320. This figure is significantly greater than the corresponding estimate for spawning escapement of 2,561 for 2005 calculated by the WDFW from expanded redd counts in the Methow. While the lower value for the spawning escapement estimate calculated from redd counts might indicate that this technique underestimated the total number of fish which spawned naturally within the Methow, the tributary escapement estimate obtained with the radio telemetry data might represent an over-estimate of the actual spawning population, as some percent of prespawn mortality probably occurred. Repetition of the tagging effort, preferably with increased numbers of tags, would permit improved comparison of the reliability between the two estimation techniques.

Among the 35 radio tagged Methow fish which returned to the Methow River, 2 (6%) were of hatchery-origin, which is similar to the 7.8% of hatchery-origin fish among the 280 tagged fish which were successfully redetected above Wells Dam. However, inclusion of hatchery-origin summer Chinook among the radio tagged fish was not a part of the original design, and the number was much too low to make observations of any certainty as to differential migration pattern.

The fish destined for the Methow River did not appear to differentiate themselves from those migrating upstream in the Columbia River relative to their date of arrival at Wells Dam. Also, sex ratio and size were similar. Among the Methow fish, the majority demonstrated a prolonged (geometric mean travel time of 30 days) migration upstream towards Chief Joseph Dam before returning downstream to enter the Methow. All of these fish were ones which arrived at Wells Dam in July or August. The remainder migrated more or less directly into the Methow River (geometric mean travel time of 3 days), and their Wells Dam arrival dates occurred evenly across the July to November period. A full report on the project, providing additional information on the fish that migrated to the Okanogan River or remained in the mainstem Columbia River, can be

found in the WDFW project final report (Ashbrook et al. 2006).

DIDSON-LR - The PSC Southern Boundary Fund project to test use of a DIDSON-LR was designed to utilize the counting tower facilities to confirm passage counts recorded by this acoustic camera. There is growing interest in use of DIDSONs for escapement estimation, particularly in Alaska where positive results from initial tests has prompted ADF&G to consider replacing some of their aging split-bean sonar systems and counting towers with DIDSONs (Maxwell and Gove 2004, Sandall and Pfisterer 2006). The primary technical disadvantage of the DIDSONs, however, is their limited range of operation (Maxwell and Gove 2004, Sandall and Pfisterer 2006). To address this concern, a long-range model of the DIDSON was recently developed, which when tested with artificial targets detected objects well beyond the 20 m maximum range of the standard DIDSON (Maxwell et al. draft). The objective of the present study conducted in the Methow River was to validate the ability of the DIDSON-LR to record images of adult salmon passage in an open river at distances to 40+ m. Validation was obtained by making visual observations of in-migrating summer Chinook from the counting tower, and confirming that images of these fish on DIDSON files (recorded concurrently with the visual counts) were in concordance in terms of time, distance and direction of movement. As indicated in Results, when properly positioned and operated at low frequency (0.7 MHz), the instrument reliably detected fish migrating at distances up to 42 m. Resolution of the DIDSON-LR improved when operated at its higher frequency (1.2 MHz), however detection range decreased to a maximum of 33m. Whichever transducer frequency was used, the level of resolution did not to permit distinguishing between species of similarly sized fish. A full description of project results can be found in the final report (Galbreath and Barber 2005; http://www.critfc.org/didson-lr).

Juvenile Production

Smolt-Trapping - Estimated juvenile summer Chinook out-migration was very similar between 2004 and 2005 (444,269 and 433,211, respectively). This observation was somewhat unexpected in that the 2003 WDFW escapement estimate of 3,930 for the returning adults (which produced the 2004 juveniles) was close to twice the 2004 escapement estimate of 2,190 adults which produced the 2005 juveniles. Smolts per adult estimates for the 2003 and 2004 return runs would be 113 and 198, respectively.

Genetic Stock Identification (GSI) – The proportion of smolts captured in the screw-trap and identified as summer versus spring stock was very similar between years – 84.4% and 85.8% were summer Chinook in 2004 and 2005, respectively. While the summer Chinook tended to be smaller and to migrate out of the Methow over a more extended period than did the spring Chinook, there was nonetheless considerable overlap between stocks both relative to size and migration period.

Juvenile Out-Migration – PIT tag detection data in 2004 and 2005 indicated that travel time of smolts from tagging in the Methow River to arrival at McNary Dam was highly variable within both years. Nonetheless, the geometric average travel time was

markedly similar between years - 31.1 and 30.9 days, respectively. In both years, fish tagged early in the May to July out-migration period from the river, tended to have longer travel times. Likewise, smaller fish demonstrated slower migration rates. Smolt survival between years was also similar – 8.08% in 2004 and 7.19% in 2005.

These estimates of mainstem out-migration survival are disappointingly low. However, there are few studies of migration survival of subyearling (average weight <5 g) Mid-Columbia summer/fall Chinook to which this estimate may be compared. Survival of subyearling Chinook through the Rock Island project (one of the six impoundments between the Methow River and McNary Dam) is reported to have averaged approximately 90% annually (http://www.fpc.org/smolt/mortqueries/TotalProjectMorts_Query.html). Of note, survival of larger yearling Chinook smolts through this project has averaged almost 98%. Eppard et al. (1999) studied mainstem migration survival of yearling hatchery-reared fall Chinook (average weight = 45g) and estimated survival from Wells Dam to McNary Dam to be approximately 60%.

Stress related to tagging mortality could account for additional loss, although 10% would be a high estimation for this, in the opinion of the Biologist who conducted the tagging. Some “mortality” could in fact be related to a portion of the smolts ceasing their out-migration and over-wintering upper reservoirs, before recommencing their migration. Two smolts each from the 2004 and the 2005 PIT tagged groups were detected at McNary Dam in the spring of the following year. However, even presuming the lower 2005 McNary Dam detection efficiency (2/14 = 14%), this would represent only about 0.5% of the originally tagged fish.

Ocean Migration

CWT recovery data can be used to analyze distribution of naturally produced sub-yearling Chinook from the Methow River, and if possible, to compare to distribution of hatchery-produced yearling and subyearling Chinook from Wells Hatchery and Carlton Acclimation Pond. However, data on CWT recovery will not be finalized for some years following completion of the present project. Collection and analysis will have to be incorporated among the activities of a future project.

PROJECT STAFF

Primary Personnel

Alford, Rick. Technician II, Yakama Nation. Crew member on both adult monitoring and juvenile sampling field projects.

Barber, Peter. Fishery Biologist II, Yakama Nation. Responsible for coordinating, implementing, and overseeing field sampling, updating data sets, and assisting in report writing.

Bergeron, Jason. Fish Technician II, Yakama Nation. Crew member on the Methow River smolt sampling project.

Evenson, Dani. Fishery Scientist, and Project Leader, CRITFC. Responsible for organization of the Methow River summer Chinook escapement indexing and juvenile sampling, and for report writing and other administrative tasks.

Galbreath, Peter. Conservation Scientist, and Project leader of the DIDSON validation project, CRITFC. Supervised final data analyses and writing of the Project 2005 Progress and Final Report.

Hyun, Saang-Yoon. Quantitative Fisheries Scientist, CRITFC. Assisted in project design and statistical analyses.

Kiona, Ralph. Fish Technician II, Yakama Nation. Crew member on both adult monitoring and juvenile sampling field projects. Responsible for collecting temperature data, and for smolt database design and management.

Narum, Shawn. Senior Scientist/Lead Geneticist, CRITFC. Responsible for supervising analysis of DNA samples from Chinook juveniles at the Collaborative Center for Applied Fish Science, Hagerman, Idaho.

Stephenson, Jeff. Conservation Geneticist/Lab Manager, CRITFC. Assisted in the analysis of DNA samples from Chinook juveniles at the Collaborative Center for Applied Fish Science, Hagerman, Idaho.

Assisting Personnel

Fryer, Jeff. Fishery Scientist, CRITFC.
Scribner, Tom. Fishery Biologist III, Yakama Nation.
Talbot, André. Senior Fishery Scientist, CRITFC

REFERENCES

Ashbrook, C. E., E. A. Schwartz, C. M. Waldbillig and K. W. Yi. 2006. Migration and movement patterns of adult Chinook salmon (*Oncorhynchus tshawytscha*) above Wells Dam. WDFW Technical Report.

Becker, C. D. 1962. Estimating red salmon escapements by sample counts from observation towers. U. S. Department of the Interior, U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries. Fisheries Bulletin No. 192, Vol. 61: 355-369.

Chapman, D. W. 1986. Salmon and steelhead abundance in the Columbia River in the nineteenth century. Transactions of the American Fisheries Society 115: 662-670.

Chapman, D. W., A. Giorgi, T. Hillman, D. Deppert, M. Erho, S. Hays, C. Peven, B. Suzumoto, and R. Klinge. 1994. Status of summer/fall Chinook salmon in the Mid-Columbia Region. Don Chapman Consultants Inc., Boise, ID.

Cousens, N. B. F., G. A. Thomas, C. G. Swann, and M. C. Healey. 1982. A review of salmon escapement estimation techniques. Canadian Technical Report of Fisheries and Aquatic Science. No. 1108. 122 pp.

Dunham, J., B. Rieman and K. Davis. 2001. Sources and magnitude of sampling error in redd counts for bull trout. North American Journal of Fisheries Management 21:343-352.

Eppard, M. B., S. G. Smith, B. P. Sandford, G. A. Axel, J. G. Williams, R. D. McDonald. 1999. Survival estimates for the passage of yearling fall Chinook salmon through Rocky Reach and Rock Island Dams, 1998. Report to, Public Utility District No. 1 of Chelan County, 62 p.

Evenson, D and S. Narum. 2005. Summer Chinook juvenile sampling and adult monitoring in the Mid-Columbia. Progress Report, 2004, Southeast Sustainable Salmon Fund Project No. 45060. Portland OR.

Faurot, D. and P. A. Kucera. 2005. Chinook salmon (Oncorhynchus tshawytscha) adult abundance monitoring in Lake Creek and Secesh River, Idaho, 2004, Annual Report January 2004 – December 2004. Project Number 199703000, Contract Number 04600, Bonneville Power Administration, Portland, Oregon.

Galbreath, P. F. and P. E. Barber. 2005. Final Report - PSC Southern Fund 2004/2005 Project: Validation of a Long-Range Dual Frequency Identification Sonar (DIDSON-LR) for Fish Passage Enumeration in the Methow River. Columbia River Inter-Tribal Fish Commission Technical Report 05-4, Portland, Oregon.

Hetrick, N. J., K. M. Simms, M. P. Plumb and J. P. Larson. 2004. Feasibility of using video technology to estimate salmon escapement in the Ongivinuk River, a clear-water tributary of the Togiak River. U. S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Technical Report Number 72, King Salmon, Alaska.

Lichatowich, J. and S. Cramer. 1979. Parameter selection and sample sizes in studies of anadromous salmonids. Information Report Series, Fisheries No. 80-1. Oregon Department of Fish and Wildlife Fish Division. Portland, Oregon.

Matthews, G. M. and R. S. Waples. 1991. Status Review for Snake River Spring and Summer Chinook Salmon. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-F/NWC-200. (http://www.nwfsc.noaa.gov/publications/techmemos/tm200/tm200.htm)

Maxwell, S. L. and N. E. Gove. 2004. The feasibility of estimating migrating salmon

passage rates in turbid waters using a dual frequency identification sonar (DIDSON). Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A04-05,. Anchorage.

Maxwell, S. L. D. Burwen and C. Pfisterer. draft. Testing the range limitations of the long range and standard versions of the dual frequency identification sonar (DIDSON). Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A04-xx,. Anchorage.

Menard, J. and S. Kent. 2005. Salmonid escapements at Kwiniuk, Niukluk and Nome Rivers, 2004. Alaska Department of Fish and Game, Fishery Data Series No. 05-24, Anchorage.

Miller, T. L. 2005. 2004 Upper Columbia River Summer Chinook Spawning Ground Surveys Report to HCP Hatchery Committee, January 25, 2006. Washington Department of Fish and Wildlife, Wenatchee.

Miller, T. L. 2006. 2005 Upper Columbia River Summer Chinook Spawning Ground Surveys Report to HCP Hatchery Committee, January 19, 2006. Washington Department of Fish and Wildlife, Wenatchee.

Moran, P., and 27 other authors. 2005. Interlaboratory Standardization of Coast-wide Chinook Salmon Genetic Data for International Harvest Management. LOA Technical Report prepared for the Pacific Salmon Commission Chinook Technical Committee. 44 pp.

Mosey, T. R., and K. Truscott. 1999. Spring and summer Chinook spawning ground surveys on the Wenatchee River Basin, 1998. Chelan County Public Utility District, Wenatchee, Washington.

Mullan, J. W. 1987. Status and propagation of Chinook salmon in the Mid-Columbia River through 1985. U.S. Fish and Wildlife Service, Biological Report (87)3, Leavenworth, Washington, 111 p.

Murdoch, A. and T. Miller. 1999. Summer Chinook spawning ground survey in the Methow and Okanogan River Basins in 1998. Report to Chelan County Public Utility District. Washington Department of Fish and Wildlife, Olympia, Washington.

Narum S. R., M. S. Powell and A. J. Talbot. 2004. A distinctive microsatellite locus that differentiates ocean-type from stream-type Chinook salmon in the interior Columbia River Basin. Transactions of the American Fisheries Society 133:1051-1055.

Nehlsen, W., J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho and Washington. Fisheries 16(2):4-21.

Pacific Salmon Commission (PSC). 2000. Pacific Salmon Commission, Pacific Salmon Treaty, 1999 Revised Annexes, Memorandum of Understanding (1985), Exchange of Notes.

Sandall, H. D. and C. F. Pfisterer. 2006. Sonar estimation of chum salmon passage in the Aniak River, 2003. Alaska Department of Fish and Game, Fishery Data Series No. 06-32, Anchorage.

Thompson, W. F. 1951. An outline for salmon research in Alaska. University of Washington, Fisheries Research Institute Circular 18, Seattle, Washington, 49 p.

Thompson, W. F. 1962. The research program of the Fisheries Research Institute in Bristol Bay, 1945-58. Pages 3-36 *in* T. S. Y. Koo, editor. Studies of Alaska red salmon. University of Washington Press, Seattle.

U.S. Army Corps of Engineers (USACE). 2005 Annual fish passage report Columbia

and Snake Rivers for salmon, steelhead, shad and lamprey. U.S. Army Engineer Districts - Portland and Walla Walla, North Pacific Division, USACE (https://www.nwp.usace.army.mil/op/fishdata/docs/afpr2005.pdf)

Washington Department of Fisheries (WDF), Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. Washington State salmon and steelhead stock inventory 1992. Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Treaty Indian Tribes, Olympia, Washington.

Woody, C. A. *In press*. Counting Towers as an Abundance Estimation Tool for Salmon. *in* D. H. Johnson, editor. Salmonid field protocols handbook. American Fisheries Society, Bethesda, Maryland.