Fall Chinook Salmon in the Siuslaw River: Spawner Escapement, Run Reconstruction and Survey Calibration 2001 - 2002

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Coastal Chinook Research and Monitoring Project
Oregon Department of Fish and Wildlife

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EXECUTIVE SUMMARY

Using mark-recapture methods, we estimated there were 8600 adult fall chinook spawners (95% relative precision of 22.6%) in the mainstem Siuslaw River in 2001 and 22,500 (95% relative precision 13.9%) in 2002. We expanded our efforts to include the North Fork Siuslaw in 2002, and we estimate 1550 adult fall chinook spawners there (95% relative precision of 50%). Calibration of spawning survey indices is very preliminary at this point as we have only 2 years of data and no clear patterns are emerging yet.

Radio telemetry tracking of fall chinook in the mainstem Siuslaw in 2002 suggests that 75 – 80% of the fall chinook spawn in what is classified as 'mainstem' habitats. This is consistent with similar studies in other basins such as the Nehalem and Coos.

In 2002, we also performed an experimental study to coded-wire tag downstream migrating juvenile chinook in the Siuslaw. The impetus for this study was the then-expected closure of Salmon River hatchery which serves as the exploitation rate indicator stock for the North Oregon coast fall chinook aggregate. We successfully tagged nearly 42,000 fall chinook pre-smolts with a mortality rate of just over 1.1%. It is generally agreed that using a wild stock as an exploitation rate indicator is preferable to using a hatchery stock that may not have the same ocean movement patterns as the wild counterparts. While our feasibility study can be viewed as a success, it must also be noted that a wild stock juvenile tagging project would be much more expensive to conduct than a comparable hatchery tagging project. With Salmon River hatchery presently expected to remain open, we do not have the funding from the Pacific Salmon Commission or the Department to continue this work.

INTRODUCTION

The Oregon Department of Fish and Wildlife (ODFW) is conducting a multi-year, multi-basin study designed to develop methods that provide reliable estimates of fall chinook (*Oncorhynchus tshawytscha*) spawner escapements for Oregon coastal streams. Chinook salmon that are are produced in Oregon coastal rivers north of Elk River are north-migrating and vulnerable to fisheries off of southeast Alaska and British Columbia. The U.S. – Canada Pacific Salmon Treaty establishes the Pacific Salmon Commission (PSC) and provides a framework to manage salmon fisheries. The 1999 modification to the Treaty establishes an aggregate abundance based management (AABM) regime whereby harvests will vary with abundance. A broader goal of this U.S. – Canada treaty is to restore and rebuild production of naturally spawning chinook (PSC 1997).

In order to accomplish these goals and monitor the rebuilding of specific chinook stocks, the PSC's Chinook Technical Committee (CTC) assesses three elements for each stock: 1) spawner escapement level, 2) fishery harvest and exploitation rate, and 3) subsequent production from spawners. Data on different chinook stocks provided by PSC participants (Canada and U.S. state, federal and tribal agencies) are incorporated into the PSC's Chinook Model that generates information on yearly pre- and post-season cohort abundance estimates. These estimates are used by the PSC to set ocean harvest levels and determine the relative health of chinook stocks under PST jurisdiction.

Currently, Oregon coastal chinook stock assessment information comes from a standard spawner survey program, a voluntary angler-returned catch card system, and two exploitation rate indicator stocks. These traditional monitoring programs do not supply the CTC with adequate information that is required for the management and rebuilding of Oregon's coastal chinook stocks. ODFW has, and the Bureau of Land Management. Watershed elevations range from sea level to 3,900 ft. Water flows average 1,985 cfs and range from 45 to 49,400 cfs. conducted standard surveys for more than 50 years to monitor the status of chinook stocks along coastal Oregon (Jacobs and Cooney 1997). A total of 56 standard index spawner surveys (45.8 miles) are monitored throughout 1,500 stream miles on an annual basis to estimate peak escapement levels and track trends of north-migrating stocks. Although counts in these standard surveys may be sufficient to index long-term trends of spawner abundance, they are considered inadequate for deriving dependable annual estimates of spawner escapement.

The Siuslaw River is the southernmost river contributing to the North Oregon Coast (NOC) aggregate of fall chinook and has been designated as an escapement indicator stock for the NOC. Zhou and Williams (2000) estimated the maximum sustainable yield (MSY) escapement goals for the Siuslaw River as 12,925 (90% CI: 9,541-20,958) adult spawners. However, the spawner escapement data used in the analysis was from a historical peak count database and its relationship to true spawner abundance is unknown. The Siuslaw watershed has had limited historical abundance analysis other than commercial fisheries records (Nicholas and Hankin 1988). Commercial fishing records indicate that the harvest on the Siuslaw ranged from 5,000-13,000 chinook (Henry et al. 1950). Siuslaw River chinook salmon are considered mid-age maturing, ocean-type, "fall-run" chinook and spawn from September to January. Fish move into the Siuslaw Bay from May to December and the relationship between residence time in the bay and freshwater entry date is not known.

The Siuslaw River Chinook Escapement Project is a multi-year study initiated in 2001 by Oregon Department of Fish and Wildlife (ODFW) with funding from the U.S. section of the CTC. The focus of the project is to establish a precise, accurate estimate of chinook salmon spawner escapement in the Siuslaw River and to calibrate the annual spawning ground surveys that extend back several decades (Table 1). This report presents results of the research funded by the CTC in 2001 and 2002.

STUDY AREA

The Siuslaw watershed occupies 788 square miles of Oregon's Coast Range (Figure 1). Most lower watershed riparian zones are privately owned and the upper watershed has multiple ownerships including commercial forestry companies, the Siuslaw National Forest and the Bureau of Land Management. Watershed elevations range from sea level to 3,900 ft. Water flows average 1,985 cfs and range from 45 to 49,400 cfs.

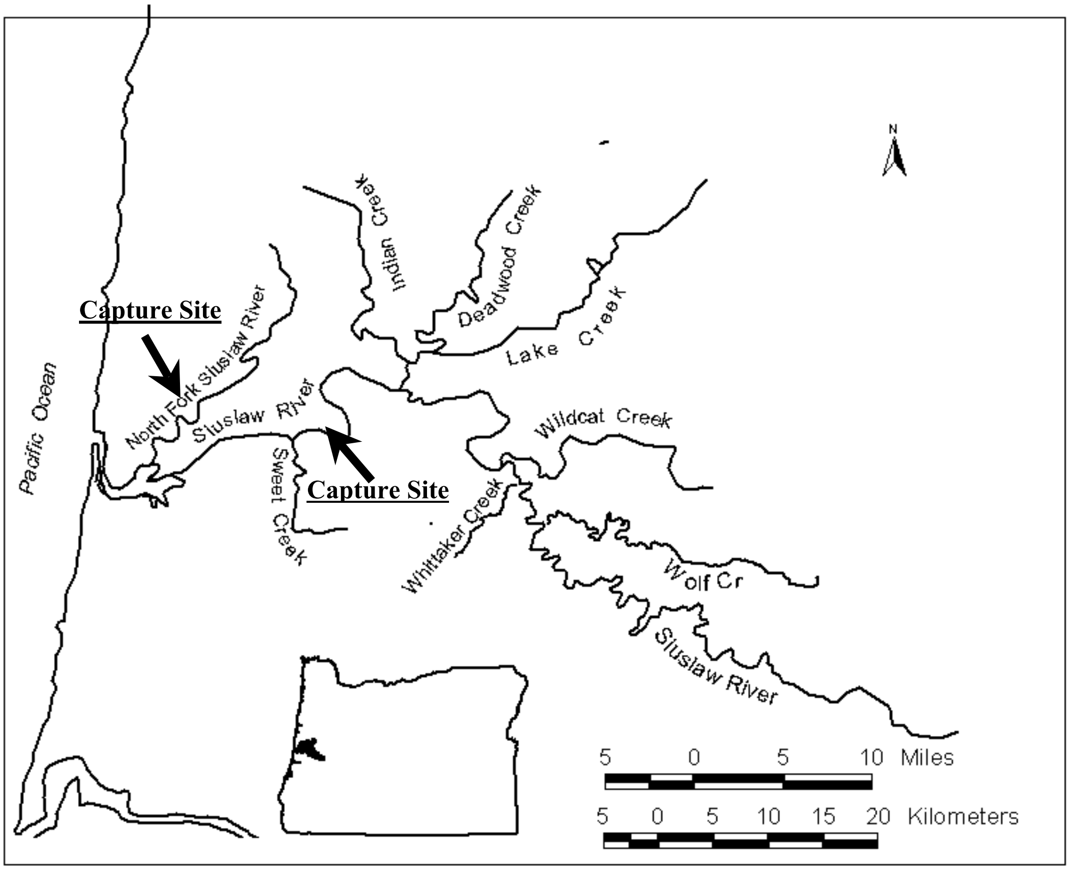

Figure 1. Map of the Siuslaw River Basin showing capture sites at the head of tide.

OBJECTIVES

The goal of the Siuslaw River Escapement Indicator Project is to estimate the age specific escapement of adult chinook salmon to the Siuslaw River and to annually update a brood-year run reconstruction for that stock in partial fulfillment of the requirements for an escapement indicator stock. These data will augment the stock recruitment analysis that is underway to estimate the biologically based escapement goal for the basin, they will permit post season assessment of management success at meeting escapement goals, and they will enable managers to calibrate escapement estimates in the Siuslaw and other NOC basins that are based on less precise random survey methodologies. In keeping with this goal, the specific objectives of the project are to:

1) Estimate the total escapement of adult chinook from ocean fisheries into the Siuslaw River within ± 25% of the true value 95% of the time and to estimate the age specific proportions of the escapement within ± 5% of the true value 95% of the time.

2) Determine the appropriate spawner survey methodology that can be implemented in the Siuslaw basin and in the other five chinook salmon production river systems in the NOC, by measuring several indexes of spawner abundance using ODFW's standard spawning survey methods.

3) Estimate the distribution of spawning adult chinook salmon between mainstem and tributary habitat strata based on radio telemetry (2002 only).

DATA COLLECTION METHODS

Mark-Recapture

Adult fall chinook escapement (adults > 600 mm FL) is estimated using a two-event stratified Peterson mark-recapture experiment. In the mainstem Siuslaw River, fish were captured using tangle nets at Mapleton (approximately RM 15). This site is located in the riverine freshwater areas of the mainstem to alleviate handling during the freshwater to saltwater transition phase. This site is below all chinook spawning habitat except for the North Fork Siuslaw. A separate mark-recapture experiment is conducted on the North Fork Siuslaw, a feasibility study for this portion of the study was initiatied in 2002. In the North Fork Siuslaw, a temporary weir was installed on public land at approximately RM 11.

Chinook captured and marked at these two sites comprise the first capture event. Initial capture and marking took place from mid-September and continuing to mid-November (Fig. 2). Tangle-netting in the mainstem Siuslaw River was conducted at night to reduce net avoidance and angler conflicts. Tagging crews of four or five persons captured chinook during nightly netting sessions. Daily logs were kept to record each net set, water temperature, tidal flow when pertinent, number of fish captured, and mortalities. Capture crew maintained visual contact with the net at all times to ensure fish would be observed and removed quickly. Fish were generally removed from the net less than three minutes after its presence was detected. Captured chinook to be marked were held in an aerated livewell containing artificial slime to minimize stress and bacterial infection due to handling. All captured chinook salmon were placed into a hooded cradle for tagging and inspection. They were sampled for length (fork length), sex, and scales (age composition), and marked. Net-caught fish were allowed to recover in the aerated live well and subsequently released away from the net (upstream or downstream depending on tide) to continue its upstream migration.

At times, multiple fish became entangled in the net. Field crews were responsible for ensuring that no fish were left in the net to suffocate or die. When the field crew could not efficiently remove fish from the net in a timely manner, the amount of net being fished was reduced. Captured chinook that appeared stressed were placed in the recovery livewell and released without sampling.

The North Fork weir was also operated at night, albeit with a crew of one or two individuals, from early October through mid-November 2002. Chinook voluntarily entered and were captured in a ten foot square cage. Subsequently they were captured with a large dip-net, handled and marked as described above, and then released upstream of the weir.

In 2001, we used a Dennison Mark II tagging gun to place an anchor tag on the left side of the dorsal. Tags displayed a unique number and were of a neutral color, as not to bias recovery of tagged fish. In 2001, each anchor-tagged fish was also given a left operculum mark with a _" paper punch. Regeneration of opercular tissue is unlikely to occur in the relatively short time between marking and recovery on spawning grounds in this study, consequently this is a mark that 'cannot' be lost. Surveyors were trained to look for opercular punches. Recovered tags enabled us to develop a regression between fork and mid-eye posterior scale (MEPS) lengths taken on spawning ground surveys.

In 2002, we determined that uniquely identifying individual fish did not significantly contribute to project objectives, so we used only a single or double operculum punch to mark fish. The side, location and number of punches was changed weekly to enable project analysts to investigate possible relationships between time at marking and time at liberty or location of carcass recovery.

Carcass Recovery and Spawner Surveys

Carcass recovery overlapped with surveys of standard and randomly selected reaches, but was not confined to these reaches. For purposes of the mark-recapture experiment, we sought to find and sample as many carcasses as possible in order to generate the most precise estimate possible. Our efforts to calibrate spawning ground surveys involved recording numbers of live and dead chinook salmon, and redds within specified standard and randomly selected survey reaches. Standard survey reaches were surveyed in both 2001 and 2002. Randomly selected reaches were surveyed beginning in 2002. Six standard reaches totaling 5 miles were surveyed (one additional standard reach was surveyed in 2001, but access was denied in 2002). In addition, 36 randomly selected stream reach segments totaling 45.3 miles were surveyed in 2002.

Randomly selected survey reaches were divided into two strata, mainstem and tributary. Surveyors collected basic biological and physical data including live counts and carcasses counts. Each carcass was sampled for scales, length, and sex. Sampled carcasses had the tails removed to prevent re-sampling, unless chosen to be part of a carcass mark-recapture experiment. All of these surveys were performed according to ODFW spawner survey protocol (ODFW 2000). Surveys were walked in an upstream direction and at a pace adapted to weather and viewing conditions. Surveys were not conducted if the bottom of riffles could not be seen. Surveyors worked in pairs and each wore polarized glasses to aid in location and identification of live fish. Surveyors searched all areas of the banks, pools, and other low energy areas where carcasses are likely to be deposited.

The tributary and mainstem strata were determined according to ODFW coho spawner distributions. For the purpose of this study, tributary strata were defined as those stream areas with spawning habitat used by both coho (*Oncorhynchus kisutch*) and chinook as documented in the ODFW database of spawning distribution (Jacobs and Nickelson 1998). The random survey design in tributary reaches incorporated all coho surveys selected through the EMAP selection process as part of the monitoring associated with the Oregon Plan for Salmonids and Watersheds (Firman 1999) that overlapped with chinook spawning habitat. Additional surveys were selected randomly to increase the sampling rate. Sixteen randomly selected tributary reaches totaling 16.03 miles were surveyed in 2002.

Mainstem strata were designated as chinook spawning areas that were downstream of coho spawner distribution and potentially included all river and tributary areas upstream of tidewater. Surveys were conducted on foot in mainstem strata (as described above) when flows permitted. Surveyors floated these mainstem surveys in inflatable kayaks or pontoon boats during periods of higher flows. Twenty randomly selected mainstem reaches totaling 29.3 miles were surveyed in 2002.

Table 1. Siuslaw Basin Fall Chinook Surveys

Standard Surveys

Sub-basin	Reach	Reach ID	Miles	Year	Times Surveyed
Mainstem	Sweet Creek	24058	0.5	2001	6
	Whittaker Creek	24301	0.3	2001	13
				2002	10
	Whittaker Creek	24303	0.4	2001	13
				2002	10
	Esmond Creek	24349	1	2001	13
				2002	9
Lake Creek	Rogers Creek	24135	1.3	2001	13
				2002	11
	Indian Crk, WFrk	24136	1.2	2001	8
				2002	6
	Lake Creek	24206	0.8	2001	12
				2002	9
North Fork	Siuslaw R, NFrk	24026	0.8	2001	10
				2002	6

Siuslaw Basin Random Fall Chinook Surveys
2002

Chinook Habitat Type	Reach ID	Reach	Start	End	Length (miles)
Mainstem	24020.0	Siuslaw R, N Fk	Condon Cr	Jim Dick Cr	1.80
Mainstem	24119.0	Siuslaw R	Count Cr	Camp Cr	1.00
Mainstem	24124.0	Lake Cr	Mouth	Indian Cr	1.50
Mainstem	24127.0	Indian Cr	Velvet Cr	Elk Cr	3.20
Mainstem	24131.0	Indian Cr	Cremo Cr	Indian Cr, W Fk	1.20
Mainstem	24150.0	Lake Cr	Indian Cr	Green Cr	1.90
Mainstem	24152.0	Lake Cr	Green Cr	Deadwood Cr	0.80
Mainstem	24155.0	Deadwood Cr	Boyle Cr	Failor Cr	1.00
Mainstem	24157.0	Deadwood Cr	Failor Cr	Deadwood Cr, W Fk	1.30
Mainstem	24182.0	Lake Cr	Deadwood Cr	Johnson Cr	1.50
Mainstem	24186.0	Lake Cr	Hula Cr	Almasie Cr	1.40
Mainstem	24198.0	Lake Cr	Nelson Cr	Wheeler Cr	1.00
Mainstem	24202.0	Lake Cr	Steinhauer Cr	Greenleaf Cr	2.10
Mainstem	24204.0	Lake Cr	Greenleaf Cr	Lamb Cr	0.60
Mainstem	24240.0	Siuslaw R	Brush Cr	Tilden Cr	0.70

Mainstem	24256.0	Siuslaw R	Rock Cr	Turner Cr	1.40
Mainstem	24263.0	Wildcat Cr	Mouth	Fowler Cr	1.20
Mainstem	24363.1	Siuslaw R	Fawn Cr	Pugh Cr	2.00
Mainstem	24363.5	Siuslaw R	Trail Cr	North Cr	1.40
Mainstem	24384.0	Siuslaw R	Luyne Cr	Siuslaw R, East Trib	2.30
□					□
Tributary	24018.0	Uncle Cr	Mouth	Trib A	0.31
Tributary	24019.4	Condon Cr	Condon Cr, Trib A	Headwaters	1.54
Tributary	24025.0	Mcleod Cr	Hanson Cr	Headwaters	1.42
Tributary	24026.0	Siuslaw R, N Fk	Mcleod Cr	Cataract Cr	0.80
Tributary	24088.0	Knowles Cr	Mouth	Jackson Cr	1.10
Tributary	24098.0	Knowles Cr	Sulphur Cr	Knowles Cr, Trib L	1.10
Tributary	24134.0	Indian Cr, W Fk	Long Cr	Rogers Cr	0.94
Tributary	24135.0	Rogers Cr	Mouth	Headwaters	1.30
Tributary	24151.0	Green Cr	Mouth	Headwaters	1.06
Tributary	24158.0	Deadwood Cr, W Fk	Mouth	Trib A	0.50
Tributary	24159.0	Misery Cr	Mouth	Headwaters	1.00
Tributary	24160.2	Deadwood Cr, W Fk	Trib A/B	Trib B	1.10
Tributary	24170.0	Rock Cr	Mouth	Headwaters	0.82
Tributary	24177.0	Panther Cr, N Fk	Mouth	Headwaters	0.80
Tributary	24181.3	Fawn Cr	Mouth	Headwaters	1.00
Tributary	24207.0	Fish Cr	Mouth	Fish Cr, N Fk	1.24

Age Composition Sampling

Scales were collected from all live chinook during the first capture portion of the project and from all unmarked carcasses during the second (recapture) portion of the project. Four or five scales were taken from each fish. Scale samples were placed into small paper envelopes until they could be mounted on gummed cards in the laboratory. An acetate impression of each scale was produced using a heat press. Experienced staff determined age by visual interpretation. Two separate readers independently aged each sample and disagreements were resolved by a third joint reading. Fish age was determined by counting winter annuli. Total age was computed as the count of all annuli plus one. All biological data recorded for each scale sample were transcribed to a database and cross-referenced to the recovery data.

Radio Telemetry

Radio telemetry was used in 2002 to provide information on the distribution of spawning chinook among habitat strata in the Siuslaw basin, and to estimate the residence time on spawning grounds. For the calibration portion of the project, each river is stratified by stream size, tributary and mainstem. In order to partition the mark-recapture estimate into the two strata, the proportions of radio-tagged fish were identified as spawning in either a tributary or mainstem reach was estimated.

Fall chinook were radio-tagged in the lower mainstem Siuslaw at the principal netting site at Mapleton (River Mile 15) during the capture and marking portion of the project. Following a randomly selected initial fish to tag, every fourth captured chinook (if in good condition) received an orally inserted, esophageal radio-transmitter.

Transmitters operated from 150.000 Mhz to 151.999 MHz, and transmitted a unique signal allowing individual identification of each tagged fish. Transmitters have an expected battery life of one year. A 7-V transmitter weighing 39.2g was used on medium and large adults. Transmitter weight did not exceed 2% of body weight for tagged fish.

Tagged chinook were monitored regularly (2-3 days per week) throughout their migration and spawning periods. We manually tracked radio-tagged chinook by driving along the study area several times per week with a portable receiver, scanning the frequencies of tagged chinook. Physical location, habitat type (where identifiable), signal strength, weather and flow conditions, and any other pertinent information was recorded for all detections of radio-tagged chinook. Visual observations of tagged chinook were attempted when possible. Data was entered into an Access database for analysis by ODFW biologists. Tagged fish not located for several consecutive monitoring trips were tracked by aircraft in conjunction with the Oregon State Police.

Verified chinook spawners were used to determine the residence time (days) in spawning areas. The number of days that a spawning fish was found alive in a particular reach was summed from the tracking data. It has been assumed that males and females displayed different behaviors, with females remaining in the areas of spawning redds until death and males drifting downstream. This data is used to develop a residence time estimate and frequency of spawner surveys in area-under-the-curve estimates.

Future Genetic Analyses

The population structure of fall chinook in the Siuslaw River basin is unknown. There may be more than one distinct breeding population of fall chinook. We suspect that the North Fork Siuslaw fall chinook are distinct from mainstem groups, and it could be that there are additional distinctions to be drawn among groups in the main Siuslaw basin. To make this determination possible, ODFW field crews collected tissue samples (a rayed fin clip) from chinook collected by the brood program and from carcasses collected on spawning grounds. Collected tissue samples are stored in ethanol and are archived with Dr. Michael Banks of OSU’s Hatfield Marine Science Center. Dr. Banks will be collaborating with other coastal labs in the establishment of a DNA baseline for fall chinook that will be a significant first step toward genetic stock identification.

DATA ANALYSIS METHODS

Spawner Escapement Estimates

The Chapman version of the Peterson mark/recapture formula was used to estimate fall chinook escapement above trap and netting sites. Estimates were derived using the following formula:

$$\hat{N}_i = \frac{(M+1)(C+1)}{(R+1)} - 1$$

where

$\hat{N}_i$ = the estimated population of fall chinook above the marking site for calibration site i.
M = the number of fall chinook tagged at the marking site.
C = the number of fall chinook recovered on the spawning grounds.
R = the number of recovered tagged fall chinook.

The usual assumptions for use of the pooled Peterson estimator are:

1) a. all fish have an equal probability of being marked at the trap site; or,
   b. all fish have an equal probability of being inspected for marks; or,
   c. marked fish mix completely with unmarked fish in the population between events; and,
2) there is no recruitment to the population between capture events; and,
3) there is no trap induced behavior including mortality; and,
4) fish do not lose their marks and all marks are recognizable.

In order to ensure the accurate use of the Peterson estimator (pooled model), each assumption was evaluated whether it had been violated or not violated. Equal probability of capture in the first or second event (Assumption 1a and 1b) did not occur when using fish ladders or netting. Assumption 1c, equal mixing of unmarked and marked fish, was critical in using the pooled model for estimating chinook abundance. To estimate if there was random geographic (river sub-basins or tributaries) and temporal (weekly) mixing of marks, the ratios of marked to unmarked fish were compared between strata using chi-square analysis. If a significant difference was observed, the stratified model was used (Darroch 1961; described below). The estimate generated by the stratified model was then compared to the pooled model estimate, if they did not differ by more then 5% the pooled model was used. By using the stratified model or reduced models (individual estimates for several size categories), the estimate should be less biased than with the pooled model but precision is worse. Therefore, if the difference, or "bias", between the pooled model and the alternative model is small, then the pooled model with the better precision estimate should be used.

Additionally, size selectivity in the first and second capture events was estimated using a battery of tests to determine if further stratification of the data set was appropriate to meet the assumptions (Appendix A). Size (FL) cumulative distribution functions (CDF) between tagged and recaptured fish were compared using the Kolmogorov-Smirnov (KS) two-sample test. If there was a significant difference ($P<0.05$), then each CDF was broken into separate size categories until the KS test was non-significant; if the KS test was not significant, a pooled model using all lengths was used for the estimate. Tag recovery rates between each size group were then compared using chi-square analysis to determine if the tag recovery rates differed. If they did not differ the pooled model was still valid to be used for the abundance estimate.

In order to use carcasses for size analysis, MEPS length had to be converted to FL using simple linear regression. Length data was obtained from recaptured fish (MEPS) that had a FL recorded during the tagging event. An equation was obtained for both females and males; these equations were used to adjust carcass MEPS lengths to FL.

Assumption 2 does not apply to this situation. Only adult chinook salmon migrating upstream of the capture site were used in the mark-recapture study and recruitment to the population is not possible.

Assumption 3 was avoided in the second capture event by using active sampling techniques and utilizing multiple capture techniques to collect tags within the spawning areas. However, for the first event, trap induced behavior could occur and this was estimated as discussed above for age/sex selectivity. Mortality due to handling could be a problem with tagging studies, however, using anecdotal information from recovery of carcasses near the tagging sites, there was minimal pre-spawn mortality observed.

Tag loss (assumption 4) is assumed zero with multiple tags. From 1999 - 2001 field data, when projects used anchor tags, operculum punches and axillary clips, at least one of the multiple marks was observed if a fish was tagged. The axillary clip was also determined to be nonessential as every fish with an axillary clip had an operculum punch. It is assumed all tags will be seen on fish if present and that at least one of the tags will be observed if a fish was captured in the first event. The redundant application of anchor tags and operculum punches should insure that trained field crews would identify marked individuals among all fish observed. Carcasses recovered on spawning grounds without tags and with missing opercula could not be assigned to marked or unmarked categories; therefore these fish were excluded from abundance calculations.

As mentioned above, a stratified estimator should be used if either of the two following conditions are not met:

1) the recovery probabilities are similar between all strata; or,
2) the tagged to untagged ratios are constant between recovery strata.

Analysis methods for the stratified estimate followed the descriptions in Arnason, et al. (1996) and Schwarz and Taylor (1998) and used the program SPAS (Stratified Population Analysis System). When using the stratified estimator the normal pooled model assumptions are expanded to include:

1) all fish have a non-zero probability of being found in the recovery strata and all fish in the recovery strata were present in one of the initial capture strata; and,
2) all tagged and untagged fish in each recovery stratum have equal probability of being sampled; and

3) all tagged fish released in each capture area have the same probability of movement to the recovery strata as well as the tagged and untagged fish move with the same probability distribution.

For the pooled model estimator, a bootstrap method is used to estimate variance, bias and confidence intervals of the population estimate (Buckland and Garthwaite 1991, Mooney and Duval 1993). The fate of chinook that pass by each trapping facility were divided into several capture histories to form an empirical probability distribution (EPD) as follows:

1) marked and were captured out of the experiment area ($=F_i$),
2) marked and recaptured on the spawning grounds ($=R_i$),
3) marked and never seen again ($=\hat{M}_i - R_i$),
4) unmarked and inspected on the spawning grounds ($=C_i - R_i$), and
5) unmarked and never seen ($= \hat{N}_i - \hat{M}_i - C_i + R_i$).

where $M_i =$ the number of fish tagged at a trap site (event 1), $C_i =$ the number of carcasses inspected on spawning grounds (event 2), $R_i =$ the number of marked fish recovered on spawning grounds (event 3), and N_i is the population estimate.

A random sample of size N_i was drawn with replacement from the empirical probability distribution. Values for the statistics M_i^*, C_i^*, R_i^* were calculated and a new population size N_i^* estimated. We repeated this process 1,000 times to obtain samples for estimates of variance, bias and bounds of 95% confidence intervals.

Variance was estimated by:

$$v(\hat{N}_i^*) = \frac{\sum_{b=1}^{B} \left(\hat{N}_{i(b)}^* - \overline{\hat{N}}_i^*\right)^2}{B - 1}$$

where B equals 1,000 (the number of bootstrap samples).

The 95% confidence intervals of the estimate are taken as +/- 1.96*$\sigma(\hat{N}_i^*)$ from the bootstrap simulation. The 95% relative precision of the estimate is thus 1.96*$\sigma(\hat{N}_i^*)/\hat{N}_i$.

To estimate the statistical bias, the average or expected bootstrap population estimate was subtracted from the point estimate (Mooney and Duvall 1993:31).

$$Bias(\hat{N}_i) = \hat{N}_i - \overline{\hat{N}}_i^*,$$

where $$\overline{\hat{N}}_i^* = \frac{\sum_{b=1}^{B} \hat{N}_{i(b)}^*}{B}$$

Age and Sex Composition Analysis

If a population estimate was not stratified by size or sex, the proportion of chinook at age from the scale analysis is used to estimate the number of chinook at age for the population. The variance was a simple variance of a product:

$$\mathrm{var}(N_i) = \sum_i \left[\mathrm{var}(\hat{p}_i)\hat{N}^2 + \mathrm{var}(\hat{N})\hat{p}_i^2 - \mathrm{var}(\hat{N}_i)\mathrm{var}(\hat{p}_i)\right]$$

If a mark-recapture experiment was stratified by size or sex, then to estimate the age composition of the whole population the following equations are used:

$p_{ij}=n_{ij}/n_i$

where

n_i = the number sampled from stratum I in the mark-recapture experiment

n_{ij} = the number sampled from stratum I that belong to age group j

p_{ij} = the estimated fraction of the fish in age group j in stratum I

$v[p_{ij}]= p_{ij}(1-p_{ij})/(n_i-1)$

The estimated abundance of age group j in the population (N_j) is:

$N_j = \sum(p_{ij}N_i)$

Where N_i = the abundance in stratum I of the mark-recapture experiment.

$v[N_j] = \sum(v[p_{ij}]N_i^2+v[N_i]p_{ij}^2-v[N_{ij}]v[p_{ij}])$

The estimate fraction of the population that belongs to age group j (p_j) is :

$p_j = N_j/N$ where $N=\sum N_i$.

$v[p_j] = \sum v[p_{ij}]\{N_j/N\}^2 + \sum(v[n_i]\,(p_{ij}-p_j)^2/N^2$

Radio Telemetry

Radio telemetry information was used to partition the basin wide mark-recapture estimate into tributary and mainstem strata. Several assumptions must be taken into consideration in order to effectively use telemetry data:

1. fish tagged are typical of the population of interest, and
2. behavior is not altered by handling or the presence of a tag, and
3. survival is not altered by handling or presence of a tag.

   Fish were selected by a systematic random sample over the entire run during capture activities on all river systems, which minimized any bias in selection of tagged fish (Assumption 1). From the mark-recapture experiment, data on selectivity of fish either by size, sex or timing was available to assess any bias in the tagging procedure if it exists. The population of interest is the distribution of tagged fish within each river basin and above capture sites, since that is the only information the mark-recapture estimate will be using. Initial behavior has been noted by several authors, however, we did not observe any sulking or dropping downstream (Assumption 2). Even with a change in initial behavior, Bernard et al. (2000) did not estimate a change in the spawner distribution, only a change in migratory rates. Changes in survival between tagged and non-tagged fish (Assumption 3) were assessed by anecdotal information gathered at the tagging sites and on the spawning grounds.

The fraction of chinook located in each stratum i (tributary or mainstem) was estimated by (Cochran 1977):

$$\hat{p}_i = \frac{n_i}{\hat{n}}, \text{ where}$$

$\hat{n} = n_h - n_f - n_m - n_l$, and

n_i = number of fish with transmitters that spawned in either a trib. or mainstem stratum,
n_h = fish with transmitters returned from anglers,
n_f = fish with transmitters that did not continue migrating,
n_m = fish with transmitters that died before spawning, and
n_l = transmitters that were regurgitated, batteries failed, or not recorded again.

The estimated variance of p_i is:

$$\text{var}(\hat{p}_i) = \frac{\hat{p}_i(1 - \hat{p}_i)}{\hat{n} - 1}$$

Therefore the estimated number of chinook ($\hat{N}_i$) in each stratum i is:

$$\hat{N}_i = \hat{p}_i \hat{N}, \text{ where}$$

$\hat{N}$ = the chinook salmon escapement estimate from the mark-recapture experiment.

The variance of the estimated chinook population in stratum i is (Goodman 1960):

$$\mathrm{var}(N_i) = \sum_i \left[\mathrm{var}(\hat{p}_i)\hat{N}^2 + \mathrm{var}\left(\hat{N}\right)\hat{p}_i^2 - \mathrm{var}\left(\hat{N}_i\right)\mathrm{var}(\hat{p}_i) \right]$$

RESULTS

Escapement Estimates

2001

In the 2001 feasibility study, we successfully marked and released 541 adult (>600 mm fork length; 328 males and 213 females) fall chinook at the initial capture site at Mapleton (River Mile 15) from September 27 through November 12th (Fig 2). In addition, we tagged and released 244 jacks. Carcass recovery and spawning ground surveys overlapped with the latter portion of the tagging effort and continued through December. We inspected 1,010 carcasses of adult fish, and 65 of these had been tagged for a recapture rate of 12%.

A pooled Peterson estimate gives a spawner escapement estimate of 8301 fish. Stratified Peterson estimates (by sex, size or sex and size) were within 5% of the fully pooled Peterson estimate. Chi-square analysis (Appendix B) showed that we could not accept the hypothesis of random mixing of marked and unmarked fish. Darroch stratified estimates (by time and space) were also performed; these were also within 5% of the fully pooled Peterson estimate (Table 2).

Bootstrapping provided a probability distribution for our estimate of spawner escapement. From this procedure we calculate the 95% relative precision of our spawner escapement estimate is 22.6% (Table 3).

2002

We conducted marking, carcass recovery, and spawning ground surveys in 2002 using the same methodology employed in 2001. In 2002, we marked 849 adult fish in the mainstem Siuslaw at Mapleton, and also marked 50 adult fall chinook at the weir at River Mile 11 on the North Fork Siuslaw River. Marking again took place from late September through mid-November (Figure 2).

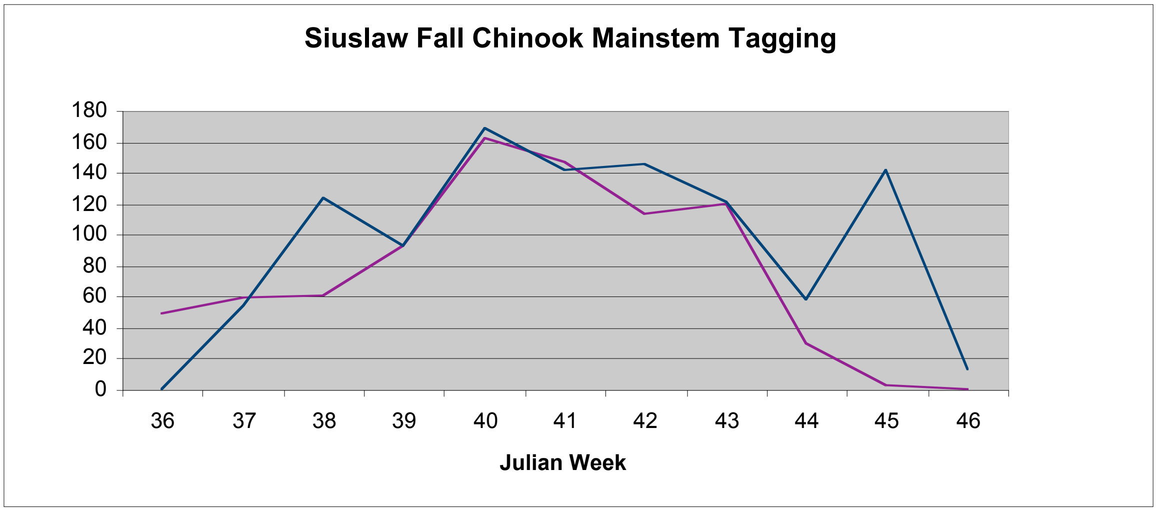

Figure 2. Numbers of fall chinook tagged per week in the Siuslaw mainstem.

Low flows and warmer temperature contributed to delayed movement of fall chinook in 2002. While similar numbers were marked in the early portion of the marking period, a large number were captured and marked after the first fall rains in early November. A similar pattern was observed at the North Fork weir in which half of the 50 fall chinook marked came through the weir in the last two weeks of operations.

In 2002, as in 2001, carcass recovery and spawning ground surveys coincided with the latter period of tagging. We inspected 4,368 adult fall chinook carcasses in the mainstem Siuslaw (2,673 males and 1,695 females) and 426 carcasses in the North Fork. A total of 164 marked chinook were recaptured in the mainstem Siuslaw, and 13 marked chinook were recaptured in the North Fork Siuslaw. We developed fully pooled Peterson estimates of spawner escapement of 22,506 adult fall chinook in the mainstem Siuslaw, and 1,555 in the North Fork. As in 2001, stratified Peterson estimates, and Darroch stratified estimates of abundance were within 5% of the mainstem escapement estimate in the mainstem Siuslaw, so we accept the fully pooled Peterson estimate. The 95% relative precision of this estimate through bootstrapping is 13.9%. In the North Fork Siuslaw, stratified estimates diverged more from the fully pooled Peterson estimate, primarily due to the low numbers of recaptured fish. The 95% relative precision of the fully pooled Peterson estimate is a disappointing 50.4% (Tables 2 and 3).

Table 2: Siuslaw River basin fall chinook spawner escapement estimates

Year	Sub-basin	Sex	Size	Marked	Carcasses Inspected	Recaptures	Pooled Peterson	Sex Stratified	Size Stratified	Size & Sex Stratified	% Marked Chinook Recaptured	% Marked Chinook among Carcasses	Darroch Estimates time	Darroch Estimates space
			(fork length)				**22506**	23036	22226	22504	R/M	R/C		
2002	Mainstem	Both	All (>600)	849	4368	164	22506	102.36%	98.75%	99.99%	19.32%	3.75%	22674	22674
			<600	153	175	20	1290				13.07%	11.43%		
			600 - 800	255	1015	45	5653		95% relative precision		17.65%	4.43%		
			800 - 1000	418	2567	83	12808		13.90% □		19.86%	3.23%		
			1000+	176	786	36	3764				20.45%	4.58%		
		Males	All (>600)	608	2673	124	13027				20.39%	4.64%		
			<600	149	175	20	1256				13.42%	11.43%		
			600 - 800	219	914	40	4909				18.26%	4.38%		
			800 - 1000	258	1255	54	5914				20.93%	4.30%		
			1000+	131	504	30	2149				22.90%	5.95%		
		Females	All (>600)	241	1695	40	10010				16.60%	2.36%		
			<600	4	0	0					n/a	n/a		
			600 - 800	36	101	5	628				13.89%	4.95%		
			800 - 1000	160	1312	29	7045				18.13%	2.21%		
			1000+	45	282	6	1859				13.33%	2.13%		
2002	North Fork	Both	All	50	426	13	**1555**	1595	1764	1648	26.00%	3.05%		
			600 - 800	15	83	3	335	102.62%	113.45%	106.03%	20.00%	3.61%		
			800 - 1000	34	280	6	1404				17.65%	2.14%		
			1000+	1	63	4	25				400.00%	6.35%		
									95% relative precision					
		Males	All (>600)	32	248	10	746		50.40% □		31.25%	4.03%		
			<600	9	13	1	69				11.11%	7.69%		
			600 - 800	12	82	3	269				25.00%	3.66%		
			800 - 1000	19	119	4	479				21.05%	3.36%		
			1000+	1	47	3	23				300.00%	6.38%		
		Females	All	18	178	3	849				16.67%	1.69%		
			600 - 800	3	1	0	7				0.00%	0.00%		
			800 - 1000	15	161	2	863				13.33%	1.24%		
			1000+	0	16	1	8					6.25%		

Table 2 (cont'd): Siuslaw River basin fall chinook spawner escapement estimates

Year	Sub-basin	Sex	Size	Marked	Carcasses	Recaptures	Pooled Peterson	Sex Stratified	Size Stratified	Size & Sex Stratified	% Marked Chinook Recaptured	% Marked Chinook among Carcasses	Darroch Estimates time	space
2001	Mainstem	Both	All (>600)	541	1010	65	8301	8477	8047	7929	12.01%	6.44%	8406	8406
			<600	244	60	7	1867	102.11%	96.93%	95.51%	2.87%	11.67%		
			600 - 800	113	135	10	1408				8.85%	7.41%		
			800 - 1000	378	771	48	5970				12.70%	6.23%		
			1000+	50	104	7	668				14.00%	6.73%		
									95% relative precision					
		Males	All (>600)	328	564	44	4130		22.60%		13.41%	7.80%		
			<600	243	60	7	1860				2.88%	11.67%		
			600 - 800	79	116	9	935				11.39%	7.76%		
			800 - 1000	212	367	28	2702				13.21%	7.63%		
			1000+	37	81	7	389				18.92%	8.64%		
		Females	All (>600)	213	446	21	4347				9.86%	4.71%		
			<600	1	0	0	1				0.00%	n/a		
			600 - 800	34	19	1	349				2.94%	5.26%		
			800 - 1000	166	404	20	3220				12.05%	4.95%		
			1000+	13	23	0	335				0.00%	0.00%		

Table 3:

Fall chinook spawner escapement estimates with associated 95% confidence intervals, relative precision and bias estimate for the Siuslaw River in 2001 and 2002

Escapement Estimate		Year	□ **95% CI** **25**	□ □ **975**	**Bootstrap Simulation** Mean	Standard Standard Deviation	□ CV	**95% Rel Precision** (s.d.*1.96)/Mean	□	**Bias** (Pld Ptrsn - Btstrp Mn)	**% Bias** □	**Rel Bias** (Bias/sd)
8301	Siuslaw Mainstem	2001	6782	10378	8339	957.99	11.49%	22.620%		-38	-0.46%	-0.040
22506	Siuslaw Mainstem	2002	19705	26061	22562	1599.86	7.09%	13.933%		-56	-0.25%	-0.035
			□	□			□					
1555	Siuslaw North Fork	2002	1031	2507	1584	399.91	25.25%	50.407%		-29	-1.86%	-0.073

Spawning Ground Survey Calibrations

We conducted spawning ground surveys on 6 standard survey reaches in 2001 and 2002, and 36 randomly selected survey reaches in 2002. In each survey, numbers of live fall chinook, dead fall chinook and redds were counted. From this data, we develop 9 indices of abundance:

1. Peak Count per Mile by Reach – Peak count of live and dead fall chinook within each reach. Average over all reaches surveyed.

2. Peak Count Per Mile by Period – Find the week with the largest count per mile; average over all reaches surveyed that week.

3. Live Chinook AUC per Mile – Area under the curve estimate of live chinook per mile, averaged over all reaches.

4. Average Peak Redd per Mile – Peak count of redds for each reach, averaged over all reaches surveyd.

5. Redd AUC per Mile – Area under the curve estimate of the number of chinook redds per mile, averaged over all reaches surveyed.

6. Sum of Dead – Sum of dead fall chinook observed in a reach, averaged over all reaches surveyed.

7. Dead per Mile – Dead per mile in each reach, averaged over all reaches surveyed.

8. Average Peak Dead – Peak dead per mile for each reach, averaged over all reaches.

9. Peak Dead per Mile by Period – Determine the week with the highest count of dead fish, average over all reaches surveyed that week.

Survey crews made every effort to visit reaches weekly. In some cases, low flow conditions meant that sequential zeroes were recorded, this was particularly true for 2002 with the late onset of fall rains. In other cases, rain events could prevent a reach from being surveyed if visibility criteria were not met.

For each survey index developed, we also calculated an expansion factor by dividing the index value into the spawner escapement estimate for that year (Table 4). For standard surveys, we now have two years of data and can look at the coefficient of variation in the expansion factor across years. The ideal survey index would have an interannual coefficient of variation of 0 if it moved in lock-step with changes in spawner abundance. Preliminary standard survey coefficients of variation range from a low of 22.7% (average peak dead chinook per mile) to a high of 70.5% (live chinook AUC per mile) (Table 5). Two years of data is inadequate for calibration purposes, and we expect this section of the report to be more worthy of discussion in the 2004 edition.

Table 4. Preliminary expansion factors for Siuslaw River fall chinook spawning ground surveys.

Basin	**Year**	**Strata**	**Miles Sampled**	**Reaches Sampled**	**1. Peak Count/mile (Reach)**	**St Dev**	**Expansion Factor**	**2. Avg Peak Count (Period)**	**St Dev**	**Expansion Factor**	**3. Live (AUC)/mile**	**St Dev**	**Expansion Factor**
Siuslaw	2001	Pooled Random		n/a	n/a			n/a			n/a		
		Mainstem Random		n/a	n/a			n/a			n/a		
		Tributary Random		n/a	n/a			n/a			n/a		
		Standard Surveys	5.5	7	204.12	300.07	***40.7***	197.84	303.3	***42.0***	190.29	254.39	***43.6***
	2002	Pooled Random	16.03	36	46.68	59.44	***482.1***	44.69	65.78	***503.6***	32.25	36.91	***697.9***
		Mainstem Random	29.3	20	51.63	61.97	***435.9***	51.09	72.9	***440.5***	28.6	20.08	***786.9***
		Tributary Random	45.33	16	40.05	37.23	***561.9***	37.23	58.65	***604.5***	37.36	52.75	***602.4***
		Standard Surveys	5	6	385.24	664.63	***58.4***	366.62	673.8	***61.4***	172.54	198.09	***130.4***
Pooled Random Calibration(mean)					n/a			n/a			n/a		
Pooled Random Calibration(cv)					n/a			n/a			n/a		
Mainstem Random Calibration(mean)					n/a			n/a			n/a		
Mainstem Random Calibration(cv)					n/a			n/a			n/a		
Tributary Random Calibration (mean)					n/a			n/a			n/a		
Tributary Random Calibration (cv)					n/a			n/a			n/a		
					□			□			□		
StandardSurvey Expansion (mean)					□		49.5	□		51.7	□		87.0
Standard Survey Expansion (cv)					□		25.3%	□		26.6%	□		70.5%

Table 4. (cont'd) Preliminary expansion factors for Siuslaw River fall chinook spawning ground surveys.

4. Avg Peak Redd/Mile	St Dev	Expansion Factor	5. Redd/mile (AUC)	St Dev	Expansion Factor	6. Sum of Dead	St Dev	Expansion Factor	7. Dead/Mile	St Dev	Expansion Factor	8. Avg Peak Dead	St Dev	Expansion Factor	9. Peak Dead (Period): Mean	St Dev	Expansion Factor	Pooled Petersen Escapmer Est.
n/a			n/a			n/a			n/a			n/a			n/a			8301
n/a			n/a			n/a			n/a			n/a			n/a			8301
n/a			n/a			n/a			n/a			n/a			n/a			8301
108.67	103.2	***76.4***	92.11	92.41	***90.1***	153.71	296.4	***54.0***	188.31	371.01	***44.1***	85.53	176	***97.1***	84.95	176.3	***97.7***	8301
28.03	37.35	***802.9***	30.45	55.87	***739.1***	57.78	123	***389.5***	44.54	65.74	***505.3***	34.46	73	***653.1***	37.89	82.66	***594.0***	22506
21.58	25.79	***1042.9***	15.82	16.24	***1422.6***	76.45	159	***294.4***	50.61	76.77	***444.7***	50	95	***450.1***	53.73	107.3	***418.9***	22506
36.09	47.83	***623.6***	50.92	81.6	***442.0***	34.44	47.25	***653.5***	36.96	50.10	***608.9***	16	24	***1406.6***	18.08	26.75	***1244.8***	22506
151.17	110.3	***148.9***	145.04	68.43	***155.2***	228.57	449.1	***98.5***	283.61	562.09	***79.4***	167.85	326	***134.1***	151.91	333.8	***148.2***	22506
																		□
n/a			n/a			n/a			n/a			n/a			n/a			□
n/a			n/a			n/a			n/a			n/a			n/a			□
n/a			n/a			n/a			n/a			n/a			n/a			□
n/a			n/a			n/a			n/a			n/a			n/a			□
n/a			n/a			n/a			n/a			n/a			n/a			□
n/a			n/a			n/a			n/a			n/a			n/a			□
□			□			□			□			□			□			□
□		112.6	□		122.6	□		76.2	□		61.7	□		115.6	□		122.9	□
□		45.5%	□		37.5%	□		41.2%	□		40.4%	□		22.7%	□		29.0%	□

Table 5. Summary of Siuslaw basin fall chinook standard survey expansion coefficients of variation.

Siuslaw River

Index	1	2	3	4	5
Pooled Random Calibration(cv)	n/a				
Mainstem Random Calibration(cv)	n/a				
Tributary Random Calibration (cv)	n/a				
Standard Survey Expansion (cv)	25.3%	26.6%	70.5%	45.5%	37.5%

Index	6	7	8	9
Pooled Random Calibration(cv)				
Mainstem Random Calibration(cv)				
Tributary Random Calibration (cv)				
Standard Survey Expansion (cv)	41.2%	40.4%	22.7%	29.0%

Variability in the interannual coefficient of variation in expansion factors is likely underestimated as this descriptive statistic does not incorporate the precision of the population estimate used, nor does it incorporate the variability within the survey index.

Age Structure

Siuslaw Basin fall chinook were dominated by age 4 individuals in 2001. About 35% of males were age 3, and only about 7% were age 5. Approximately 73% of females were age 4, and another 20% were age 5 (Table 6). Scales from 2002 field work have not yet been completely read, and we are unable to report on them here.

Radio Telemetry

We inserted radio tags into 97 fall chinook at the mainstem tagging site in Mapleton. We successfully followed 38 of these fish until spawning. From these records, we find that Siuslaw Basin fall chinook contribute to a consistent picture of habitat use. Approximately seventy five percent of fall chinook in four studies in three basins spawn in mainstem habitat (Table 7).

Table 7. Distribution of radio tagged fall chinook by strata from telemetry studies from four telemetry studies in three Oregon coastal basins.

Location	**Mainstem Strata**			**Tributary Strata**		
	n	Distribution	SE	n	Distribution	SE
Nehalem River-00	26	76%	0.017	8	24%	0.032
Nehalem River-01	31	72%	0.015	12	28%	0.039
Siuslaw River-02	28	76%	0.016	9	24%	0.050
South Fork Coos River-99	83	82%	0.005	18	18%	0.022

Table 6. Analysis of fall chinook salmon age composition from the Siuslaw River mark-recapture feasibility study, 2001.

Table 6-01. Summary of scale readers analysis of fall chinook salmon tagged in the Siuslaw River mark-recapture feasibility study, 2001.

Count of Age	Age						
Gender	2	3	4	5	6	7	Total
F	0	31	122	31	3	0	187
M	6	100	161	18	1	0	286
U	0						0
Total	6	131	283	49	4	0	473

Std Error of the proportion by age for each sex

Gender	Age 2	3	4	5	6	7
Female	0.0%	1.1%	2.0%	1.1%	0.4%	0.0%
Male	0.5%	1.9%	2.2%	0.9%	0.2%	0.0%
Combined	0.5%	2.1%	2.3%	1.4%	0.4%	0.0%

1.96 = t value at P=

95% Confidence Interval of Proportions by age for each sex

	2	3	4	5	6	7
Female Lower CI	0.0%	4.3%	21.8%	4.3%	-0.1%	0.0%
Female Upper Ci	0.0%	8.8%	29.7%	8.8%	1.4%	0.0%
Male Lower CI	0.3%	17.5%	29.8%	2.1%	-0.2%	0.0%
Male Upper CI	2.3%	24.8%	38.3%	5.5%	0.6%	0.0%
Combined Lower CI	0.3%	23.7%	55.4%	7.6%	0.0%	0.0%
Combined Upper CI	2.3%	31.7%	64.3%	13.1%	1.7%	0.0%

Table 6-02. Summary of the proportion within age by gender of fall chinook salmon tagged in the year 2001 Siuslaw mark-recapture feasibility study.

	Age					
Gender	2	3	4	5	6	7
Female	0.0%	23.7%	43.1%	63.3%	75.0%	0.0%
Male	100%	76.3%	56.9%	36.7%	25.0%	0%

Table 6-03. Summary of the proportion of fall chinook tagged in the year 2001 Siuslaw River as percent of total sample by gender and by age.

	Age					
Gender	2	3	4	5	6	7
Female	0.0%	6.6%	25.8%	6.6%	0.6%	0.0%
Male	1.3%	21.1%	34.0%	3.8%	0.2%	0.0%
Combined	1.3%	27.7%	59.8%	10.4%	0.8%	0.0%

Estimated number of chinook spawners = 8,301

Table 6-04. Summary of the estimated number of fall chinook escaping into the Siuslaw River (excluding the North Fork Siuslaw) in the year 2001 based on tagging.

	Age						
Gender	2	3	4	5	6	7	Total
Female	0	544	2141	544	53	0	3282
Male	105	1755	2825	316	18	0	5019
All Chinook	105	2299	4967	860	70	0	8301

Table 6-05. Confidence intervals (95%) for the age classes of the estimated fall chinook escapement in the Siuslaw River (excluding North Fork Siuslaw), 2001.

	Age					
	2	3	4	5	6	7
Lower CI	21	1964	4599	632	2	0
Upper CI	189	2634	5334	1088	139	0
SE of All Chinook	42.9	170.9	187.8	116.3	34.7	0.0
1/2 95% CI	84	335	368	228	69	0

Table 6 (cont'd). Analysis of fall chinook salmon age composition from the Siuslaw River mark-recapture feasibility study, 2001.

Table 6-06. Summary of scale readers analysis of fall chinook salmon carcasses recovered on spawning grounds in the Coquille River mark-recapture feasibility study, 2001.

Count of Age	Age						
Gender	2	3	4	5	6	7	Total
F	1	26	375	102	7	0	511
M	3	222	365	47	1	0	638
U	0						0
Total	4	248	740	149	8	0	1149

Std Error of the proportion by age for each sex

Gender	Age 2	3	4	5	6	7
Female	0.1%	0.4%	1.4%	0.8%	0.2%	0.0%
Male	0.2%	1.2%	1.4%	0.6%	0.1%	0.0%
Combined	0.2%	1.2%	1.4%	1.0%	0.2%	0.0%

1.96 = t value at P=5%

95% Confidence Interval of Proportions by age for each sex

	2	3	4	5	6	7
Female Lower CI	-0.1%	1.4%	29.9%	7.2%	0.2%	0.0%
Female Upper Ci	0.3%	3.1%	35.3%	10.5%	1.1%	0.0%
Male Lower CI	0.0%	17.0%	29.1%	2.9%	-0.1%	0.0%
Male Upper CI	0.6%	21.6%	34.5%	5.2%	0.3%	0.0%
Combined Lower CI	0.0%	19.2%	61.6%	11.0%	0.2%	0.0%
Combined Upper CI	0.7%	24.0%	67.2%	14.9%	1.2%	0.0%

Table 6-07. Summary of the proportion within age by gender of fall chinook salmon carcasses recovered on spawning grounds in the year 2001 Siuslaw mark-recapture feasibility study.

	Age					
Gender	2	3	4	5	6	7
Female	25.0%	10.5%	50.7%	68.5%	87.5%	0.0%
Male	75%	89.5%	49.3%	31.5%	12.5%	0%

Table 6-08. Summary of the proportion of fall chinook carcases in the year 2001 Siuslaw River as percent of total sample by gender and by age.

	Age					
Gender	2	3	4	5	6	7
Female	0.1%	2.3%	32.6%	8.9%	0.6%	0.0%
Male	0.3%	19.3%	31.8%	4.1%	0.1%	0.0%
Combined	0.3%	21.6%	64.4%	13.0%	0.7%	0.0%

Estimated number of chinook spawners = 8,301

Table 6-09. Summary of the estimated number of fall chinook by age escaping into the Siuslaw River (excluding the North Fork Siuslaw) in the year 2001 based on spawning ground recoveries.

	Age						
Gender	2	3	4	5	6	7	Total
Female	7	188	2709	737	51	0	3692
Male	22	1604	2637	340	7	0	4610
All Chinook	29	1792	5346	1076	58	0	8301

Table 6-10. Confidence intervals (95%) for the age classes of the estimated fall chinook escapement in the Siuslaw River (excluding North Fork Siuslaw), 2001.

	Age					
	2	3	4	5	6	7
Lower CI	1	1594	5116	915	18	0
Upper CI	57	1989	5576	1238	98	0
SE of All Chinook	14.3	101.0	117.3	82.1	20.4	0.0
1/2 95% CI	28	198	230	162	40	0

We were also able to use radio tracking to estimate that residence time that fall chinook spend on the spawning grounds. In the Siuslaw River in 2002, as in the South Fork Coos River in 1999, males spend a shorter period of time on the spawning grounds than do females, by approximately two to three days. Between the two studies, we find that fall chinook spend an average of 16.1 days on the spawning grounds, a figure that is slightly less than reported in the literature.

Table 8 Estimated spawning ground residence time of fall chinook based on radio telemetry.

Location	**Residence Time (days)**				
	Pooled	Males	Females	n	SD
South Fork Coos River-99	15.5	14.3	17.5	37	6
Siuslaw River-02	17.0	16.5	19.0	38	6.5
Average Residence Time	16.1				

The number of tags retained and tracked throughout the spawning run has been unexpectedly low. In the Siuslaw Basin this problem was believed caused in part by recreational harvest. Low flows early in the migration period kept chinook pooled in the estuary and susceptible to angling for long periods of time. Anecdotal information from anglers and the existence of multiple radio transmitters collected below docks and boat landings suggest a substantial proportion of these transmitters may have been intercepted.

DISCUSSION

The Siuslaw escapement stock indicator project demonstrates that mark-recapture escapement estimates can be conducted with a high level of precision in large coastal river systems in Oregon. The project also shows a clear progression as field crews adapt methods based on experience. Our efforts show a clear progression of increasing numbers of chinook marked, carcasses inspected and marked chinook recaptured, all of which contribute to an increasingly precise estimate of spawner escapement.

Results of radio telemetry work in the Siuslaw contribute to our understanding of fall chinook in two ways. First, it improves our understanding of residence time of live fish on spawning grounds, a parameter that is is important in estimating area-under-the-curve(AUC) indices from spawning survey data. Additionally, the telemetry information contributes to an emerging and consistent pattern that approximately three quarters of fall chinook spawn in what ODFW categorizes as mainstem habitat areas. This suggests that future emphasis on spawning surveys for abundance monitoring might best concentrate on these areas. The apparent impact of anglers on marked chinook suggests that our estimates of spawner abundance may be excessive. If marked and unmarked chinook are harvested in equal proportions, then our estimate of spawner abundance is actually an estimate of spawner abundance plus some component of angler harvest. This may be an artifact of 2002 low flow and warm water conditions. However, it may also outline the need for a statistical creel survey to measure this component of angler mortality and consequent reduction in spawner abundance estimates.

Calibration of spawning ground survey indices is an on-going process; the three years of calibration data collected thus far is not yet adequate for us to ascertain whether any of the indices being used will provide a sufficiently precise monitoring mechanism for Oregon fall chinook. There is substantial opportunity for future analysis in this area; the indices we present are simple means of survey values, by reach. It is reasonable to hypothesize and investigate whether indices developed based on a subset of the selected reaches may pose a more reliable tracking mechanism of spawning escapement than the fairly course approach presented here.

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APPENDIX A

Detection of size-selectivity in sampling and its effects on estimation of size composition *[Taken directly from Pahlke et al. 1999, developed by Dave Bernard, Alaska Dept. of Fish and Game, Anchorage, AK].*

Results of Hypothesis Tests (K-S and χ^2) on lengths of fish MARKED during the First Event and RECAPTURED during the Second Event	Results of Hypothesis Tests (K-S and χ^2) on lengths of fish CAPTURED during the First Event and CAPTURED during the Second Event
Case I:	
"Accept" H_o	"Accept" H_o
There is no size-selectivity during either sampling event.	
Case II:	
"Accept" H_o	Reject H_o
There is no size-selectivity during the second sampling event but there is during the first.	
Case III:	
Reject H_o	"Accept" H_o
There is size-selectivity during both sampling events.	
Case IV:	
Reject H_o	Reject H_o
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

Case III: Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data.

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, ages, and sexes from only the second sampling event to estimate proportions in compositions, and apply formulae to correct for size bias to the data from the second event.

Whenever the results of the hypothesis tests indicate that there has been size-selective sampling (Case III or IV), there is still a chance that the bias in estimates of abundance from this phenomenon is negligible. Produce a second estimate of abundance by not stratifying the data as recommended above. If the two estimates (stratified and unbiased vs. biased and unstratified) are dissimilar, the bias is meaningful, the stratified estimate should be used, and data on compositions should be analyzed as described above for Cases III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and analysis can proceed as if there were no size-selective sampling during the second event (Cases I or II).

APPENDIX B

Appendix B: Chi Square tests of random assortment by Julian week and sub-basin for
males and females, and for marked and unmarked chinook salmon.

Marked and unmarked fall chinook by sub-basin, 2001.

□	observed	□	□	□	expected	□	□	chitest	□
subbasin	marked	unmarked	sum		marked unmarned			p=	d.f.
Deadwood	15	161	176		11	165		0.0184622	3
Lake Crk	8	222	230		15	215			□
Indian Crk	19	350	369		24	345			□
Sius. R	23	212	235		15	220			□
sum	65	945	1010	□	□	□	□	□	□

Males and females by sub-basin, 2001.

□	observed	□	□	□	expected	□	□	chitest	□
□	male	female			male	female		p=	d.f.
Deadwood	80	96	176		98	78		0.0231202	3
Lake Crk	136	94	230		128	102			□
Indian Crk	212	158	370		207	163			□
Siuslaw R	136	98	234		131	103			□
sum	564	446	1010	□	□	□	□	□	□

Marked and unmarked fall chinook by Julian week, 2001.

week(s)	observed	□	□	□	expected	□	□	chitest	□
□	marked	unmarked	sum					p=	d.f.
44-45	11	96	107		7	100		0.0043043	3
46	26	235	261		17	244			□
47	15	276	291		19	272			□
48-1	13	338	351		23	328			□
sum	65	945	1010	□	□	□	□	□	□

Male and female fall chinook by Julian week,
2001.

week(s)	observed	□	□	□	□	expected	□	□	chitest	□
□	male	female	sum			male	female		p=	d.f.
44-45	66	41	107			60	47		0.0921976	6
46	133	128	261			146	115			□
47	160	131	291			162	129			□
48	40	34	74			41	33			□
49	80	41	121			68	53			□
50	49	50	99			55	44			□
51-52	13	7	20			11	9			□
1	23	14	37			21	16			□
sum	564	446	1010	□	□	□	□	□	□	□

Appendix B: Chi Square tests of random assortment by Julian week and sub-basin for males and females, and for marked and unmarked chinook salmon.

Male and Female fall chinook by Julian week, 2002

	Observe			Expect				
Week	Male	Female	Sum	M	F		Chi Square	
44	14	10	24	14.69	9.31		p	df
46	19	11	30	18.36	11.64		0.0108	6
47	817	518	1335	816.88	518.13			
48	920	548	1468	898.26	569.74			
49	551	368	919	562.33	356.67			
50	276	171	447	273.52	173.48			
51 - 1	17	32	49	29.98	19.02			
Sum	2614	1658	4272					

Male and female fall chinook by sub-basin, 2002

	Observe				expected			
sub-basin	Male	Female	sum		Male	Female		chitest
Deadwood	327	235	562		343.88296	218.11704		1.109E-07
Indian	500	277	777		475.43961	301.56039		
Lake Cr	1606	951	2557		1564.6063	992.39373		
Siuslaw R	181	195	376		230.07116	145.92884		
sum	2614	1658	4272					

Marked and unmarked fall chinook by Julian week, 2002

	Observe			Expect			Chi Square	
Weeks	Mark	Unmark	Sum	Mark	Unmark		p	df
							0.8189	3
44-47	56	1333	1389	52.01	1336.99			
48	52	1416	1468	54.97	1413.03			
49	36	884	920	34.45	885.55			
50 - 1	16	480	496	18.57	477.43			
sum	160	4113	4273					

Marked and unmarked fall chinook by sub-basin, 2002

	Observed				Expected			chitest	d.f.
sub-basin	Marked	Unmarked			Marked	Unmarked		0.16553	3
Deadwood	18	544	562		21.043763	540.95624			
Indian	33	744	777		29.094313	747.90569			
Lake Cr	88	2468	2556		95.707934	2460.2921			
Siuslaw R	21	357	378		14.15399	363.84601			
sum	160	4113	4273						