DRAFT

UMPQUA RIVER

FALL CHINOOK SALMON

ESCAPEMENT INDICATOR PROJECT

1998 – 2002

CUMULATIVE PROGRESS REPORT

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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 salmon (*Oncorhynchus tshawytscha*) spawner escapements for Oregon coastal streams. Chinook salmon originating 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 established the Pacific Salmon Commission (PSC) to provide a framework to manage salmon fisheries. The 1999 modification to the Treaty defines an aggregate abundance based management (AABM) regime whereby harvests will vary with abundance. A broader goal of this 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 placed 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 monitor the relative health of chinook stocks under PST jurisdiction and to set ocean harvest levels.

Currently, Oregon coastal chinook stock assessment information comes from a standard spawner survey program, a voluntary angler punch 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 conducted standard surveys for more than 50 years to monitor the status of chinook stocks along coastal Oregon (Jacobs et al 2000). 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 Umpqua River Basin is a significant contributor of north migrating fall chinook alongthe mid-Oregon coast. The Umpqua River stock has little hatchery influence, thus making this stock a likely candidate to become an escapement indicator stock for the mid-Oregon coast (MOC) stock aggregate. A biologically based escapement goal would need to be developed for it to be adopted as an escapement indicator stock.

The Umpqua River is composed of three major tributaries, South Umpqua, North Umpqua, and Smith River. Most fall chinook spawning takes place in the mainstem Umpqua, the South Umpqua, and Cow Creek. The chinook run is monitored through counts at Winchester Dam on the North Umpqua near Roseburg (generally < 200 fish annually) (Table 1), and aerial redd counts on the South Umpqua and Cow Creek (Table

Table 1. Fall Chinook Counts at Winchester Dam, North Umpqua River

Year	Count
1992	60
1993	133
1994	87
1995	119
1996	223
1997	217
1998	118
1999	52
2000	31
2001	?
2002	?

Table 2 Adult Spawner Population - Redd Comparison for South Umpqua Basin, Oregon

Year	Estimated Population	Total	Redd Counts (flight) S. Umpqua mainstem	Cow Creek	Fish/Redd	Redd Counts (float)		Fish/Redd
2002	**10,477**	notes 1,2				1147	note 4	9.13
2001	**5402**	1887	1276	611	**2.86**	925		5.84
2000	**2697**	910	504	406	**2.96**	1082		2.49
1999	**1979**	523	329	194	**3.78**	308		6.43
1998	**1231**	319	215	104	**3.86**			
1997	6758	2112	1189	923	3.2			
1996	9293	2904	1276	1628	3.2			
1995	10563	3301	2549	752	3.2			
1994	6611	2066	1513	553	3.2			
1993	3120	975	592	383	3.2			
1992	7558	2362	1343	1019	3.2			
1991	6230	1947	625	1322	3.2			
1990	3488	1090	544	546	3.2			
1989	5715	1786	818	968	3.2			
1988	3475	1086	956	130	3.2			
1987	2592	810	662	148	3.2			
1986	1459	456	211	245	3.2			
1985	2083	651	369	282	3.2			
1984	2406	752	383	369	3.2			
1983	1510	472	304	168	3.2			
1982	938	293	182	111	3.2			
1981	826	258	152	106	3.2			
1980	646	202	177	25	3.2			
1979		NA	NA	NA	3.2			
1978	371	116	37	79	3.2			

Notes:
1. Douglas County OR cut funding for survey flights in 2002
2. 2002 Adult spawner estimate is very preliminary
3. 2002 - 1998 adult spawner estimates based on mark-recapture methods.
Pre 1998 adult spawner estimates are based on 3.34 fish/redd times number of redds
4. Float redd counts in 2002 were incomplete

2). Index chinook spawning surveys have been conducted on tributaries below Smith River trap and Mill Creek sporadically for the last 5 years. (ODFW unpublished data).

STUDY AREA

The Umpqua River drainage is one of two coastal drainages that originates at the Cascade mountain crest, and covers about 14,245 km^2, most of which is accessible to anadromous fish (Fig 1). Principal tributaries are the Smith, North Umpqua, and South Umpqua rivers. The South Umpqua and it's major tributary, Cow Creek, account for the majority of the fall chinook spawning area within the Umpqua basin. Within the South Umpqua only the lower 65 miles of stream is utilized by fall chinook, and the majority of spawning occurs between the Happy Valley trap site at RM 18 to Cow Creek (RM 47.5). Fall chinook spawning also takes place below Happy Valley at RM 4.5, 8, 12, and 15. In Cow Creek the majority of spawning occurs in the lower 26 miles of stream. The capture site at Happy Valley has been operated since 1987 as a volunteer brood collection facility. In 1998 ODFW began operating Happy Valley as a mark-recapture /brood facility.

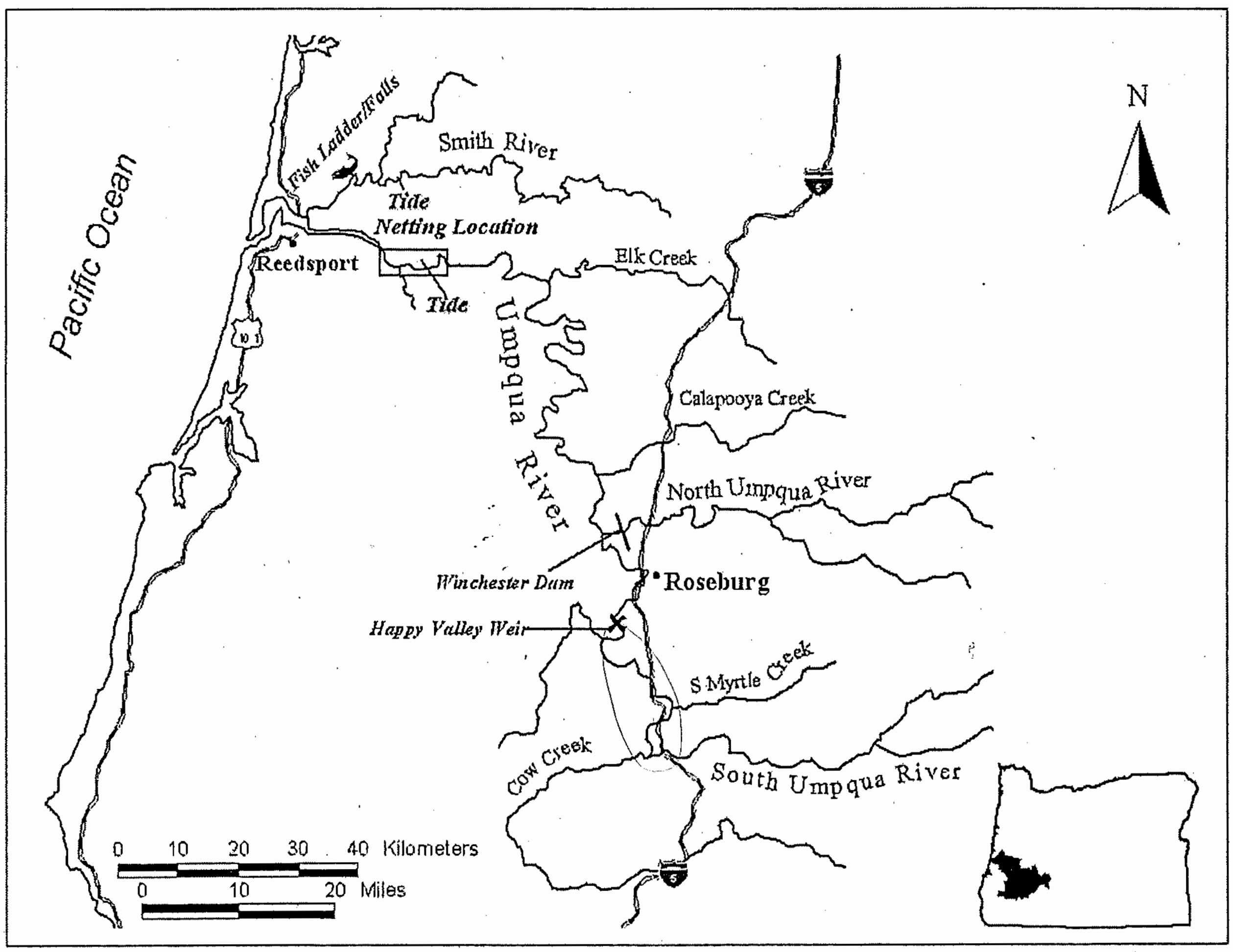

Figure 1. Umpqua River drainage.

OBJECTIVES

1) Estimate the total escapement of adult chinook from ocean fisheries into the Umpqua 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. Specific tasks that must be completed to achieve the overall objective are:
   a) Estimate the sport harvest of chinook salmon in Umpqua River such that the estimate is within ± 25% of the true value 95% of the time, and estimate age/sex specific proportions of that harvest such that the estimate is within ± 5% of the true value 95% of the time (2001 and 2002 only).
   b) Estimate the spawning escapement of chinook salmon in Umpqua River such that the estimate is within ± 25% of the true value 95% of the time, and estimate age and sex specific proportions of the spawning escapement such that estimates are within ± 5% of the true value 95% of the time. This sub-objective focuses on the South Umpqua River and Cow Creek. Beginning in 2000, additional marking in the mainstem Umpqua River enables a basin-wide spawner escapement estimate in addition to the S. Umpqua/Cow Creek estimate.

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

3) Derive an expansion factor that relates the mark-recapture population estimate to aerial survey redd counts.

DATA COLLECTION METHODS

Mark-Recapture

Lower Mainstem

Adult fall chinook escapement (> 600 mm FL) was estimated using a two-event stratified Peterson mark-recapture experiment. In the Umpqua River system, this became a dual two-event experiment with the addition of efforts to develop a basin-wide estimate beginning in 2000. Fish were captured and marked (first event) both in the lower mainstem Umpqua River (basin-wide escapement estimate 2001 and 2002 only), and in the lower mainstem South Umpqua River (South Umpqua – Cow Creek escapement estimate 1998 - 2002).

Fish were captured using tangle nets at three riverine freshwater sites on the lower mainstem Umpqua (RM 23, 29.5, 40). (Fig 1). These three sites are located in riverine freshwater areas of the mainstem to alleviate handling during the freshwater to saltwater transition phase. The site at RM 29.5, known as Family Camp, is the primary site. The sites at RM 23 and 40 were explored and used during 2001; lower mainstem tangle netting was done exclusively at Family Camp in 2002. These sites are located below all mainstem-spawning areas with the exception of Mill Creek, Dean Creek, Scholfield Creek, and Smith River.

Chinook captured and marked at these three sites comprised event 1. Initial capture and marking generally took place from mid-August and continuing to mid-October. Netting occurred at night to reduce net avoidance and angler conflicts. Tagging crews of four-person captured chinook during ten hour work sessions. Daily logs were kept to record each net set, water temperature, tidal flow when pertinent, number of fish captured, and mortalities. Duration of tagging effort in the lower mainstem Umpqua is constrained by encounters with coho salmon; Umpqua River coho are among a federally listed (threatened) evolutionarily significant unit (ESU) and the Department's permit conditions for this project require us to end operations before the full run of fall chinook salmon has passed by the tangle net site.

Capture crew maintained tactile or 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 a minute after its presence was detected. Captured fish 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. A single sequentially numbered colored (yellow) anchor tag was placed on the left side of the dorsal fin. Yellow anchor tags were used to increase visibility of marked fish in the fish counting tapes at Winchester Dam. A left operculum punch, using a ¼" paper punch, was administered as the secondary mark. Beginning in 2002, we discontinued the use of numbered anchor tags. Rather, fish were marked with operculum punches and clipping the right axillary appendage at upper river site only). Location and number (one or two) of punches served to identify the week of capture and marking. After tagging each fish was allowed to recover in the aerated live well and subsequently released 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.

Happy Valley Trap, South Umpqua Mainstem

South Umpqua chinook escapement was estimated with a two-event stratified Peterson mark-recapture experiment. Event one involved capturing upstream migrant chinook salmon at a floating weir site at river mile 18 on the South Umpqua (Fig 2). The weir, consisting of 19 four foot wide by twenty foot long panels, forced adult chinook into a trap. The trap was fished twenty-four hours a day from late-September to the first week of November.

Chinook salmon were removed from the trap and placed into a hooded cradle for tagging, measurements and inspection. Fish were first checked for marks from the lower mainstem tagging. If a mark was found, tag numbers, color, operculum marks, condition of each fish were recorded, and then given an additional left operculum punch. Unmarked fish were sexed, measured (fork length), scales taken for age analysis, and marked with a sequentially numbered gray Floy anchor tag and a left operculum punch. Multiple marks were used to minimize tag loss as well as ensure accurate identification of carcasses on the spawning groups. Beginning in 2002, we discontinued the use of numbered anchor tags as identification of individual fish was no longer deemed important. Rather, fish were marked with operculum punches and clipping the right axillary appendage. Operculum punches were coded by location and number to indicate the week of marking.

CARCASS RECOVERY ON SPAWNING GROUNDS

The second event of the two event mark-recapture experiment involves actively locating chinook carcasses throughout the river basin upstream of Happy Valley Trap. The South Umpqua and Cow Creek were broken up into multiple floating spawning surveys.

Cow Creek spawning surveys consisted of 4 floats that surveyed 27 miles of stream. South Umpqua surveys were comprised of 6 floats above Happy Valley trap (58 stream miles) and two floats below the trap (18 stream miles). Float lengths ranged from eight to twelve miles and within each float were multiple EPA reaches (ranging from 4 to 8 per float). Each float was surveyed by two catarafts to increase survey effort and for safety. Locations of known, high-density areas of fish carcasses were emphasized during survey periods. Only carcasses with intact opercula were used for the second capture event. All carcasses sampled were examined for tags and fin clips, measured for MEPS length (mid-eye to posterior scale), sex, and scales taken for age analysis.

Aerial redd counts were conducted twice during the spawning season once in late October and the other in the third week of November. During each flight all chinook redds were counted and an annual index was derived from the peak number of redds seen on the two flights. No aerial redd counts were made in 2002 due to funding reductions by Douglas County.

Age Composition Sampling

Scales were collected from all live chinook tagged and from all unmarked carcasses examined for tag recovery. Four to 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 was recorded directly onto the scale envelope. Due to time limitations and the volume of scales collected across ODFW research projects, readers were required to take systematic samples that are representative of the run.

Creel Survey

Sport caught chinook salmon in the Umpqua River (2001 and 2002) were estimated from data collected by a stratified random, multi-stage creel survey conducted throughout the fishing season (July through November). The creel surveys were used to estimate the number of fish removed from the migratory population after the chinook had been tagged. Roving surveys were used to make angler or boat counts, to determine effort (pressure counts) and to conduct angler interviews throughout the fishery. Depending on the angler type, a roving-access survey or a roving-roving survey design was employed (Pollock et al. 1994). Roving-access surveys were used where anglers concentrated at known locations (e.g. boat launches), and were interviewed upon completion of fishing. Roving-roving style surveys were used where anglers were at widely distributed locations (e. g. bank anglers), and the surveyor moved throughout the fishery interviewing anglers while they were still fishing.

Both boat and bank anglers were interviewed on the mainstem Umpqua; chinook harvest is not allowed on the South Umpqua River. Surveys were conducted from August through November. The creel survey was stratified by catch area, month, day (weekend, weekday), and angler type (bank or boat). Anglers were separated into three groups: shore anglers, private boat anglers, and guided anglers. Angler interviews collected information on the number of hours fished, number of anglers in the boat or on shore, the number of salmonids by species caught or released, target species, and whether bait or lures were used. All data was entered onto paper forms or hand-held electronic dataloggers. All fish checked were sampled for scales, length (FL), sex, and the number and types of fin marks. If an adipose fin was missing, the snout was removed for future tag decoding.

Angling effort or pressure counts were conducted by driving the river in each catch area and counting all people fishing, and occurred at three equally spaced intervals throughout the day. Pressure counts took thirty minutes and were considered instantaneous. Upon completion of the pressure counts, surveyors conducted angler interviews until the next scheduled pressure count. Interviews of non-anglers in the catch area were also conducted in order to estimate the use by non-anglers in and to appropriately adjust the effort count. The roving surveyors also sampled boats at boat launches when the anglers fishing trip was complete. Effort was determined by counting trailers at each boat launch during the bank angler pressure count.

RADIO-TELEMETRY

Radio telemetry was used in 2001 and 2002 to provide information about distribution and run timing of Umpqua river chinook stock(s). Aerial redd counts are conducted upstream of the Happy Valley capture site on the South Umpqua River and on Cow creek. In order to calibrate this survey design to the escapement estimates developed through mark-recapture methods, the distribution of spawners between mainstem and tributary habitat, and throughout the remaining Umpqua basin must be determined.

Fall chinook were radio-tagged in the lower mainstem Umpqua during the capture and marking portion of the project. Adult chinook were captured using gill and tangle nets. Captured fish were placed into an aerated live well during processing and recovery, then released to immediately resume their upstream migration. All captured chinook, unless very stressed, were marked as described above. One out of every four captured chinook 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 and two sizes were used during the project. A 3-V transmitter weighing 21.9g was used for small adult chinook, while 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. ODFW biologists manually tracked tagged chinook by driving along the study area several times per week with a portable receiver, scanning the frequencies of tagged chinook. Physical location, signal strength, weather and flow conditions, and pertinent comments was recorded for all detection's of radio-tagged chinook. Visual observations of tagged chinook were attempted when possible. Weekly aircraft tracking in conjunction with the Oregon State Police was also employed. Two fixed telemetry stations were employed in 2001, but did not perform adequately; these are not included in our analyses. Data was entered into an Access database for analysis by ODFW biologists.

Creel surveyors encouraged anglers to report any captured and released radio-tagged chinook that occurred during the 2001 and 2002 Umpqua River recreational salmon fishery. Two radio tags were returned by angles in each of 2001 and 2002.

FUTURE GENETIC ANALYSIS

The number and uniqueness of the different chinook races in the South Umpqua River is unknown. ODFW biologists know that a small run of spring chinook exist in upper South Umpqua. However, there is some speculation from run timing and spawning observed in the South Umpqua that there may be more than one distinct breeding population of fall chinook. 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. Brood fish are collected throughout the chinook run and should provide a representative sample of run timing. 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

Spawner Escapement Estimates

The Chapman version of the Petersen 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 Petersen 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 Petersen 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 was converted to fork length using simple linear regression based on recaptured fish for which we had both MEPSand fork lengths.

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 the application of mutilation marks. Field feasibility studies from 1998 and 1999 in the South Fork Coos River and North Fork Nehalem River, where the use of an anchor tag and a operculum punch were employed, found no instances where an anchor tag was identified without an associated operculum punch. 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. It is assumed all mutilation marks will be seen on fish if present and that at least one of the tags will be observed by trained field crews if a fish was captured in the first event (having difficulty following event sequence). 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 was used if either of the two following conditions were 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, $\hat{M}_i = M_i - F_i$, $M_i =$ the number of fish tagged at a trap site, and $\hat{N}_i$ is the population estimate.

A random sample of size $\hat{N}_i^*(=\hat{N}_i + F_i + H_i)$ was drawn with replacement from the empirical probability distribution. Values for the statistics $\hat{M}_i^*, R_i^*, C_i^*, F_i^*, H_i^*$ were calculated and a new population size $\hat{N}_i^*$ estimated. This process was repeated 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).

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

The percentile method was used to calculate the 95% confidence intervals from the 1,000 bootstrap samples (Mooney and Duvall 1993). The interval lies between the 25th lowest value and 25th highest value of bootstrap population estimates, $\hat{N}_{i(b)}^*$.

Radio Telemetry

Radio telemetry information was used to partition the basin wide make-recapture estimate into multiple geographic 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 the river basin and above the first capture site, since this is the only information the mark-recapture estimate will be using. Deviations in the expected behavior of handled chinook has been noted by several authors, Bernard et al. (2000) found that there are handling induced behavior changes, but did not estimate any differences in the spawner distribution, only a change in migratory rates (Assumption 2) 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):

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

$\hat{n} = n_h - n_f - n_m - n_l$, and (it seems that this equation also needs an n_i term on the right side, yes?)
n_i = number of fish with transmitters that spawned in either a trib. or mainstem statum,
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:

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

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

$\hat{N}_i = \hat{p}_i \hat{N}$, 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):

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

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:

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

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 $N\sum N_i$.

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

Creel

The creel surveys were stratified by month, catch area, and angler type (shore or boat). Depending on harvest rates, anglers could be further post-stratified into private trips and guided trips. Data analysis procedures for post-stratification of private and guided trips will follow Bernard et al. (1998) if harvest rates differ significantly between the trip types. Missing data points from surveyor illness or equipment failures were treated as random events and removed from the sampling frame. Bernard et al. (1998) describes several other events which must be taken into account during analysis that can bias harvest estimates including 1) zero interviews, but angling effort was counted, 2) zero harvest rate, but effort was counted, and 3) very low (1-2) numbers of interviews but with harvest. If any of these situations are encountered and deemed to bias the data-set, the data will be treated as missing data points and the substituted values derived from methods described in Bernard et al. (1998).

Roving-Access Survey: Harvest was determined separately for kept fish and for released fish. Estimated harvest per sample day in a particular stratum is (Pollock et al. 1994, Bernard et al. 1998):

$\hat{H}_i = \hat{E}_i \overline{cpue}_i$,
where:

i denotes sampling days,
$\hat{E}_i$ = estimated effort, and
$\overline{cpue}_i$ =average catch per unit.

Because the roving-access surveys only interview completed angler trips, average catch per unit effort is estimated as the ratio of means (Hoenig et al. 1997):

$$\overline{cpue}_i = \frac{\sum_{k=1}^{m_i} h_{ik}}{\sum_{k=1}^{m_i} e_{ik}}, \text{ where,}$$

k denotes individual anglers,
m denotes the number of anglers interviewed,
h is the number of fish caught during fishing trips that were interviewed, and
e is the length in hours of fishing trips of interviewed anglers.

Variance of cpue is estimated as (Bernard et al. 1998):

$$v(\overline{cpue}_i) = \frac{\sum_{k=1}^{m_i} \left(h_{ik} - e_{ik}\overline{cpue}_i\right)^2}{\overline{e}_i^2 m_i \left(m_i - 1\right)}.$$

Fish harvested per catch/month strata equals:

$$\hat{H} = D \frac{\sum_{i=1}^{d} \hat{H}_i}{d} \text{ where,}$$

d = number of sampled days in stratum, and
D = total available sampling days in stratum.

Daily effort is estimated as:

$$\hat{E}_i = T \frac{\sum_{t=1}^{r} x_{it}}{r} \text{ where,}$$

t denotes the individual roving count of anglers,

r = number of pressure counts per day, and
T = the length of the sampling period (usually day length).
Since effort is determine systematically and not randomly the variance equation is (Wolter 1985):

$$v(\hat{E}_i) = T^2 \frac{\sum_{t=2}^{r}\left(x_{it} - x_{i(t-1)}\right)^2}{r^2(r-1)}.$$

The variance of the daily harvest is (Goodman 1960 as cited by Bernard et al. 1998):

$$v(\hat{H}_i) = \hat{E}_i^2(\overline{cpue}_i) + \overline{cpue}_i^2 v(\hat{E}_i) - v(\overline{cpue}_i)v(\hat{E}_i),$$

and the variance for each catch/month stratum is:

$$v(\hat{H}) = D(D-d)\frac{s_1^2}{d} + \frac{D}{d}\sum_{i=1}^{d} v(\hat{H}_i), \qquad \textit{where}$$

$$s_1^2 = \frac{\sum(\hat{H}_i - \overline{\hat{H}})^2}{d-1}.$$

Total harvest is the sum of all catch in each strata and the total variance of the catch is the sum of all strata variances (Pollock et al. 1994).

Roving-Roving Surveys: The only difference in estimation between the roving – roving survey and the roving – access survey is the catch per unit effort (cpue) estimator. With roving surveys anglers are interviewed that have not completed fishing and the mean of ratios estimator should be used (Pollock et al. 1994).

$$\overline{cpue}_i = \frac{\sum_{k=1}^{m_i} \frac{h_{ik}}{e_{ik}}}{n}, \text{ where,}$$

k denotes individual anglers,
m denotes the number of anglers interviewed,
h_{ik} is the number of fish caught for an interviewed angler,
e_{ik} is the length in hours fished for an interviewed angler, and
n is the number of interviews for each day i.

The variance is calculated as (Jones et al. 1995):

Table 4. Stratified, fully pooled Peterson and Darroch spawner escapement estimates for Umpqua System 1998 - 2002 (percentages under stratified estimates and Darroch estimates are relative to the fully pooled Peterson estimate for that year)

Year	Sex	Size (mm FL)	Marked	Carcasses	Recaptures	Fully Pooled Peterson Estimate	Sex-Stratified Peterson Estimate	Size Stratified	Size and Sex Stratified	Darroch Estimates SPACE	Darroch Estimates TIME	% of marked fish ultimately recaptured	% of carcasses inspected on spawning grounds that were marked
						PPE							
1998													
S. Umpqua		600 <	65	111	5	1231						7.69%	4.50%
1999													
S. Umpqua	all	600 <	297	411	61	1979	1866					20.54%	14.84%
							94.26%						
	males	600 <	148	174	30	840						20.27%	17.24%
	females	600<	149	218	31	1026						20.81%	14.22%
	all	600 - 800	72	17	5	218						6.94%	29.41%
		800 - 1000	217	266	48	1187						22.12%	18.05%
		> 1000	7	1	2	4						28.57%	200.00%
		all > 600	296	284	55	1511						18.58%	19.37%
2000													
S. Umpqua	all	600 <	469	573	99	2697	2808			2681	2681	21.11%	17.28%
							104.12%			99.41%	99.41%		
										95% CI			
	males	600 <	240	236	34	1631				(2273-3089)		14.17%	14.41%
	females	600<	229	337	65	1177						28.38%	19.29%
	all	600-800	183	130	22	1047						12.02%	16.92%
		800 --1200	303	446	77	1741						25.41%	17.26%
			486	576	99	2809						20.37%	17.19%
2001													
S. Umpqua	all	600 <	1323	958	234	5402	5470			5159		17.69%	24.43%
							101.25%			95.50%			
	males	600 <	700	482	106	3163				95% CI		15.14%	21.99%
										(4675-5644)			
	females	600<	623	476	128	2306						20.55%	26.89%
Umpqua entire basin	all	600 <	117	1344	23	6612		6297.61				19.66%	1.71%
		600-765	35	174	6	899		95.25%				17.14%	3.45%
		>765	82	1170	17	5399						20.73%	1.45%
	males	all											
		600 <											
	females	all											
		600<											

Table 4. continued

2002										Darroch Estimates SPACE	TIME		
S. Umpqua	All	Sum>600	1141	2357	256	10477	10707	10418	10513	10505	10505	22.44%	10.86%
		<600 mm	65	82	4		102.20%	99.44%	100.34%	100.27%	100.27%	6.15%	4.88%
		600-800	373	621	57	4010						15.28%	9.18%
		800-1000	636	1423	158	5704						24.84%	11.10%
		1000+	132	313	41	993						31.06%	13.10%
	Males	Sum>600	717	1313	158	5933						22.04%	12.03%
		<600 mm	63	80	4							6.35%	5.00%
		600-800	320	427	47	2861						14.69%	11.01%
		800-1000	285	612	73	2368						25.61%	11.93%
		1000+	112	274	38	796						33.93%	13.87%
	Females	Sum>600	424	1044	98	4485						23.11%	9.39%
		<600 mm	2	2	0							0.00%	0.00%
		600-800	53	194	10	956						18.87%	5.15%
		800-1000	351	811	85	3323						24.22%	10.48%
		1000+	20	39	3	209						15.00%	7.69%
2002 Umpqua entire basin	All	>600 mm	204	2357	36	13064	12788	14172	13164			17.65%	1.53%
		600 - 800	95	624	7	7499	97.89%	108.48%	100.77%			7.37%	1.12%
		800 - 1000	93	1421	21	6075						22.58%	1.48%
		1000+	16	316	8	598						50.00%	2.53%
		>600 mm	129	1313	23	7117						17.83%	1.75%
		600 - 800	66	428	5	4790						7.58%	1.17%
		800 - 1000	49	613	10	2790						20.41%	1.63%
		1000+	14	276	8	461						57.14%	2.90%
		>600 mm	75	1044	13	5672						17.33%	1.25%
		600 - 800	29	196	2	1969						6.90%	1.02%
		800 - 1000	44	808	11	3033						25.00%	1.36%
		1000+	2	40	0	122						0.00%	0.00%

$$v(\overline{cpue}_i) = \frac{\sum_{k=1}^{m_i} e_{ik}\left(\frac{h_{ik}}{e_{ik}} - \overline{cpue}_i\right)^2}{m\sum_{i=1}^{m} e_{ik}}.$$

RESULTS

Spawner Escapement Estimates

Estimates of Umpqua basin fall chinook spawner escapement have become increasingly precise over the five years of the Umpqua River escapement study reported here. For each year, we present the time-frame of chinook capture, a summary table of adult chinook (>600 mm) marked, carcasses inspected and marked fish recaptured, the resulting population estimate with confidence intervals and precision, and the results of spatial, temporal and length comparisons of marked and unmarked fish to test for violations of assumptions of equal mixing.

1998

The 1998 field season was funded as a feasibility study of mark-recapture techniques to assess escapement estimates. Sixty five adult fall chinook were marked at the Happy Valley weir from October 2 through November 3, 1998 (Fig. 2), and 111 carcasses were inspected on spawning grounds. Of these, five were recaptures of marked individuals, leading to a spawning escapement estimate for the South Umpqua of 1232 adult fall chinook. The 95% relative precision was estimated as 105% through bootstrapping. This disappointing figure results from the low numbers of chinook salmon marked and carcasses recovered on spawning grounds during this feasibility study. No tests for violations of assumptions of random mixing were performed due to the low number of recaptured fish (Tables 3 and 4).

1999

First capture and marking of Umpqua fall chinook took place at Happy Valley weir through the month of October in 1999 (Fig. 2). Carcass counts on spawning grounds, and inspection of carcasses for marks took place from mid-October through the end of November 1999. Numbers of marked fish, and numbers of carcasses inspected increased nearly four-fold relative to 1998, and numbers of marked fish recaptured on the spawning grounds increased by a factor of 12. Unsurprisingly, the spawner escapement estimate was larger. More importantly, the 95% relative precision of our spawner escapement estimate is 21.7% which meets the project objective (Tables 3 and 4).

Based on chi square analysis of spatial and temporal distribution of tagged vs nontagged and male vs female chinook, the null hypotheses that all fish mix randomly was not rejected. (Appendix B). Thus, we present a simple pooled Peterson abundance estimate of 1980 adult fall chinook for the 1999 spawning year.

2000

A feasibility study to develop a full-basin mark-recapture spawner estimate (including the mainstem above tidal influence, the North Fork Umpqua, and the South Fork mainstem below the Happy Valley trap) was initiated in 2000. Thirty seven chinook salmon were captured in tangle nets, principally at RM 29.5 (Fig. 2). However, 70 coho salmon were captured and released. Initial daytime netting efforts were shifted to the night due to observed night avoidance. Soak times at night varied depending on the number of coho captured.

First capture and marking of adult fall chinook salmon at the Happy Valley trap on the South Umpqua was highly concentrated in the month of October (Fig. 2). Seven hundred thirty nine chinook salmon were captured and examined for marks from earlier netting. Of these, 469 adult fall chinook salmon (240 males and 229 females) were marked and released to continue upstream. Carcass recovery in the South Umpqua and Cow Creek extended from mid-October through the first week of December. Six hundred and six carcasses (five hundred seventy three of adult size (>600 mm fork length) were inspected for marks; ninety-nine adult sized marked fish were recaptured. Only two of the fish recaptured had been marked during mainstem netting operations.

Chi-square analysis of the distribution of carcass recoveries by sex and by time (early or late) indicated that the null hypothesis of random mixing could not be rejected. However, chi-square analysis of carcass distribution between the South Umpqua and Cow Creek reveals that a disproportionate number of marked fish were found in Cow Creek where 20% of the carcasses inspected bore marks, whereas only 14% of inspected carcasses in the South Umpqua were marked (Appendix B).

As all stratified estimates (by sex, size and sub-basin) were within 10% of the fully pooled Peterson estimate, we present the latter estimate of 2697 adult as our spawner escapement estimate for the South Umpqua/Cow Creek subsystem. The 95% relative precision of this estimate is 16%, a further improvement over previous years (Tables 3 and 4). No basin-wide estimate was developed as only two fall chinook marked in mainstem tagging operations were recovered on spawning grounds.

2001

One hundred sixteen (116) adult chinook (> 600 mm FL) and 53 jack chinook were captured, tagged with anchor tags and released in the lower mainstem Umpqua between July 31 and October 2, 2001 (Fig. 2). Thirty one adult chinook salmon had Lotek digital esophageal radio transmitters implanted.

At Happy Valley trap, 1,704 chinook were examined for marks, of which 238 were taken for brood, 1,466 were marked and released. Nine percent (9%) of the chinook marked and released at Happy Valley trap were jacks (<600 mm FL). Eight-six percent (86%) of the chinook were captured in a three-week period (October 7 to October 27), with a peak weekly count of 827 chinook the week of October 21 (Fig. 2). The sex ratio at the trap is slightly skewed towards males (900 males, 804 females). Thirteen marked fish from event 1 were recovered at the trap site. Eleven of the marked fish had retained their numbered anchor tag. The remaining two were identified by the secondary mark, the left operculum marks on all 13 fish had grown over but were visible due to coloration differences from the unpunched operculum. In addition, 879 coho were captured and released.

Extreme flows (high or low) can have an adverse effect on the catchability of migrating chinook at the Happy Valley trap. In 2001, Happy Valley trap was hampered by large amounts of aquatic vegetation that weighed down the floating weir and allowed chinook to avoid the trap. Extremely low summer flows and high water temperatures throughout the South Umpqua basin are thought to be the catalyst for this dense vegetation growth. During the first three weeks of trap operation, maintenance of the weir during daylight hours resulted in three to six hours of trap operation.

Spawning surveys were conducted from October 14 through November 24, 2001. Spawning surveys involved floating each reach with two catarafts. Water conditions through November 10 were ideal for spawning surveys, low water with high visibility. From November 10 to November 24 higher flows with increased turbidity reduced visibility on all spawning surveys.

Chi-square tests of the assumptions of random mixing of marked and unmarked fish and of males and females in the South Umpqua basin allow us to accept the null hypothesis of equal mixing (Appendix B)

The fall chinook spawner escapement estimate for the Umpqua basin, including the South Umpqua basin above Happy Valley trap, was 6,612 in 2001. This estimate was based 1,344 adult carcasses inspected for marks, 23 were recaptured fish. Not included in this estimate were 206 chinook that were observed crossing Winchester Dam, two of which were marked. The spawner escapement estimate for the South Umpqua/Cow Creek portion of the system was 5402 based on 958 adult carcasses inspected for marks, and 234 recaptured fish. The 95% relative precision of these estimates are 9.8% and 38.3% for the South Umpqua sub-basin, and the full Umpqua basin, respectively. (Tables 3 and 4).

2002

Crews conducted tangle netting at River Mile 29.5 (Family Camp) from 7 August through 24 September 2002 (Fig. 2). Two hundred four adult size fall chinook (>600 mm fork length) were captured, marked with an operculum punch and released. Seventy two of these fish received an esophageal implant of a Lotek digital radio transmitter.

At the Happy Valley trap, 1380 adult size fall chinook were handled and inspected for marks from Family Camp netting. Twenty-one adult fall chinook marked at Family Camp were recaptured. Approximately one hundred and sixty five adult fish were retained for broodstock. 1141 adult fall chinook received an additional operculum punch and were released above the weir, thus becoming the marked population for the South Umpqua/Cow Creek portion of the mark-recapture experiment.

Carcass recovery on spawning grounds in the South Umpqua/Cow Creek subsystem took place from October 4 through the end of December 2002. 2465 carcasses were recovered and inspected for marks, of which 2357 were of adult size and had intact opercula (1313 males and 1044 females). Of these, 256 were recaptures of chinook initially marked at the Happy Valley weir and 36 were recaptures of chinook initially marked at the Family Camp netting site.

The fall chinook spawner escapement estimate for the South Umpqua/Cow Creek subsystem is 10,477 adult fall chinook. The 95% relative precision as estimated through bootstrapping is 10.2%. Stratified Peterson estimates (by size and/or sex) and independent Darroch estimates of spawner escapement numbers were all within 3% of the fully pooled Peterson estimate.

The thirty six recaptures of adult fall chinook initially marked at Family Camp allow us to develop a pooled Peterson spawner escapement estimate of 13,064 for the entire Umpua basin. Stratified estimates were within 10% of this figure. The 95% relative precision of this estimate is 31.4% Alternatively, a comparison estimate can be based on the number of fall chinook inspected, and recaptures observed, at the Happy Valley weir site. In this case, 21 adult recaptures of 1380 fish inspected results in a basin-wide pooled Peterson estimate of 12,867 adult fall chinook. The precision of this alternative estimate would be correspondingly lower than that described above because of the lower numbers of fish inspected for marks and of recaptures (Tables 3 and 4).

Summary

Through the five years of this project, we have successfully increased the number of fish marked, carcasses inspected and marked fish recaptured each year, resulting in increasingly narrow relative precision of our estimates. In each case, we have presented a fully pooled Peterson estimate as our spawner escapement estimate. Table 3 presents a summary of escapement estimate, precision and bias for each year of this study. Table 4 presents escapement estimates stratified by length and sex, and a Darroch estimate stratified by location or time. Each of these estimates was within 10% of the corresponding fully pooled Peterson abundance estimate, therefore we present the fully pooled estimate as this provides the best precision.

AGE AND SEX COMPOSITION RECONSTRUCTION

Age and sex composition of the 1998 – 2001 South Umpqua fall chinook runs are presented in Table 5. We do not yet have scales read from the 2002 field season.
Age distribution of males is strongly weighted toward age 3 individuals (approximately 65%) with the majority of the balance being age 4. Age 5 and 6 males are unusual in our study. (n.b. Our study is largely exclusive of jack males that make up a significant

Table 5A. Analysis of fall chinook salmon age composition from the South Fork Umpqua River mark-recapture feasibility study, 1998.

Table 5A-01. Summary of scale readers analysis of fall chinook salmon carcasses tagged at Happy Valley weir in the South Fork Umpqua River mark-recapture

Count of A	Age						
Gender	2	3	4	5	6	7	Total
F	0	10	7	4	1	0	22
M	0	32	12	2	1	0	47
U	0						0
Total	0	42	19	6	2	0	69

Std Error of the proportion by age for each sex						
	Age					
Gender	2	3	4	5	6	7
Female	0.0%	4.3%	3.7%	2.8%	1.4%	0.0%
Male	0.0%	6.0%	4.6%	2.0%	1.4%	0.0%
Combined	0.0%	5.9%	5.4%	3.4%	2.0%	0.0%
95% Confidence Interval of Proportions by age for each sex						
Female Lower CI	0.0%	6.1%	3.0%	0.2%	-1.4%	0.0%
Female Upper Ci	0.0%	22.9%	17.3%	11.4%	4.3%	0.0%
Male Lower CI	0.0%	34.5%	8.4%	-1.1%	-1.4%	0.0%
Male Upper CI	0.0%	58.2%	26.4%	6.9%	4.3%	0.0%
Combined Lower CI	0.0%	49.3%	16.9%	2.0%	-1.1%	0.0%
Combined Upper CI	0.0%	72.5%	38.2%	15.4%	6.9%	0.0%

1.96 = t value a

Table 5A-02. Summary of the proportion within age by gender of fall chinook salmon carcasses tagged at Happy Valley weir in the 1998 South

	Age					
Gender	2	3	4	5	6	7
Female	0.0%	23.8%	36.8%	66.7%	50.0%	0.0%
Male	0%	76.2%	63.2%	33.3%	50.0%	0%

Table 5A-03. Summary of the proportion of fall chinook in the 1998 South Fork Umpqua River as percent of total sample by gender and by age.

	Age					
Gender	2	3	4	5	6	7
Female	0.0%	14.5%	10.1%	5.8%	1.4%	0.0%
Male	0.0%	46.4%	17.4%	2.9%	1.4%	0.0%
Combined	0.0%	60.9%	27.5%	8.7%	2.9%	0.0%

Estimated number of Chinook harvested = 1231

Table 5A-04. Summary of the estimated number of fall chinook by age escaping into the South Fork Umpqua River in the year 1998.

	Age						
Gender	2	3	4	5	6	7	Total
Female	0	178	125	71	18	0	392
Male	0	571	214	36	18	0	839
All Chinool	0	749	339	107	36	0	1231

Table 5A-05. Confidence intervals (95%) for the age classes of the estimated fall chinook escapement in the South Fork Umpqua River,

Age-	2	3	4	5	6	7
Lower CI	0	607	208	25	-13	0
Upper CI	0	892	470	189	85	0
SE of All C	0.0	72.4	66.8	41.8	25.0	0.0
1/2 95% C	0	143	131	82	49	0

Module 5B. Analysis of fall chinook salmon age composition from the South Fork Umpqua River mark-recapture study, 1999.

Table 5B-01. Summary of scale readers analysis of fall chinook salmon tagged at the Happy Valley weir, 1999.

Count of A	Age						
Gender	2	3	4	5	6	7	Total
F	0	16	243	26	0	0	285
M	2	34	164	5	0	0	205
U	0						0
Total	2	50	407	31	0	0	490

Std Error of the proportion by age for each sex

	Age					
Gender	2	3	4	5	6	7
Female	0.0%	0.8%	2.3%	1.0%	0.0%	0.0%
Male	0.3%	1.1%	2.1%	0.5%	0.0%	0.0%
Combined	0.3%	1.4%	1.7%	1.1%	0.0%	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	0.0%	1.7%	45.2%	3.3%	0.0%	0.0%
Female Upper Ci	0.0%	4.8%	54.0%	7.3%	0.0%	0.0%
Male Lower CI	-0.2%	4.7%	29.3%	0.1%	0.0%	0.0%
Male Upper CI	1.0%	9.2%	37.7%	1.9%	0.0%	0.0%
Combined Lower CI	-0.2%	7.5%	79.7%	4.2%	0.0%	0.0%
Combined Upper CI	1.0%	12.9%	86.4%	8.5%	0.0%	0.0%

Table 5B-02. Summary of the proportion within age by gender of fall chinook salmon carcasses tagged at the Happy Valley weir, 1999.

	Age					
Gender	2	3	4	5	6	7
Female	0.0%	32.0%	59.7%	83.9%	0.0%	0.0%
Male	100%	68.0%	40.3%	16.1%	0.0%	0%

Table 5B-03. Summary of the proportion of fall chinook in the year 1999 South Fork Umpqua River as percent of total sample by gender and by

	Age					
Gender	2	3	4	5	6	7
Female	0.0%	3.3%	49.6%	5.3%	0.0%	0.0%
Male	0.4%	6.9%	33.5%	1.0%	0.0%	0.0%
Combined	0.4%	10.2%	83.1%	6.3%	0.0%	0.0%

Estimated number of Chinook harvested = 1980

Table 5B-04. Summary of the estimated number of fall chinook by age escaping into the South Fork Umpqua River in 1999.

	Age						
Gender	2	3	4	5	6	7	Total
Female	0	65	982	105	0	0	1152
Male	8	137	663	20	0	0	828
All Chinook	8	202	1645	125	0	0	1980

Table 5B-05. Confidence intervals (95%) for the age classes of the estimated fall chinook escapement in the South Fork Umpqua River, 1999.

Age-	2	3	4	5	6	7
Lower CI	-3	149	1579	83	0	0
Upper CI	19	255	1710	168	0	0
SE of All C	5.6	27.0	33.7	21.4	0.0	0.0
1/2 95% C	11	53	66	43	0	0

Table 5C-06. Summary of scale readers analysis of ages of fall chinook salmon in							
Count of A	Age						
Gender	2	3	4	5	6	7	Total
F	0	27	63	40	0	0	130
M	0	33	24	18	0	0	75
U	0						0
Total	0	60	87	58	0	0	205

Std Error of the proportion by age for each sex						
	Age					
Gender	2	3	4	5	6	7
Female	0.0%	2.4%	3.2%	2.8%	0.0%	0.0%
Male	0.0%	2.6%	2.3%	2.0%	0.0%	0.0%
Combined	0.0%	3.2%	3.5%	3.2%	0.0%	0.0%
95% Confidence Interval of Proportions by age for each sex						
Female Lower CI	0.0%	8.5%	24.4%	14.1%	0.0%	0.0%
Female Upper Ci	0.0%	17.8%	37.1%	25.0%	0.0%	0.0%
Male Lower CI	0.0%	11.1%	7.3%	4.9%	0.0%	0.0%
Male Upper CI	0.0%	21.1%	16.1%	12.7%	0.0%	0.0%
Combined Lower CI	0.0%	23.0%	35.7%	22.1%	0.0%	0.0%
Combined Upper CI	0.0%	35.5%	49.2%	34.5%	0.0%	0.0%

1.96 = t value at P=5%

Table 5C-07. Summary of the proportion within age by gender of fall chinook sampled in the year 2000 South Umpqua River spawning ground						
	Age					
Gender	2	3	4	5	6	7
Female	0.0%	45.0%	72.4%	69.0%	0.0%	0.0%
Male	0%	55.0%	27.6%	31.0%	0.0%	0%

Table 5C-08. Summary of the proportion of fall chinook sampled in the year 2000 Umpqua carcass recovery as percent of total sample as gender						
	Age					
Gender	2	3	4	5	6	7
Female	0.0%	13.2%	30.7%	19.5%	0.0%	0.0%
Male	0.0%	16.1%	11.7%	8.8%	0.0%	0.0%
Combined	0.0%	29.3%	42.4%	28.3%	0.0%	0.0%

Estimated number of Chinook harvested = 2697

Table 5C-09. Summary of the estimated number of fall chinook by gender and age in the South Umpqua/Cow Creek subsystem in 2000.							
	Age						
Gender	2	3	4	5	6	7	Total
Female	0	355	829	526	0	0	1710
Male	0	434	316	237	0	0	987
All Chinool	0	789	1145	763	0	0	2697

Table 5C-10. Confidence intervals (95%) for the age classes of the estimated chinook spawners in the South Umpqua/Cow Creek subsystem						
Age	2	3	4	5	6	7
Lower CI	0	621	962	596	0	0
Upper CI	0	958	1328	930	0	0
SE of All C	0.0	85.7	93.4	85.2	0.0	0.0
1/2 95% CI	0	169	183	167	0	0

Table 5D. Analysis of the age composition of fall chinook salmon in 2001 from the South Umpqua/Cow Creek portion of the Umpqua River.

Table 5D-01. Summary of scale readers analysis of fall chinook salmon tagged at Happy Valley in the South Umpqua in 2001

Count of A	Age						
Gender	2	3	4	5	6	7	Total
F	0	124	261	14	2	0	401
M	8	283	171	3	0	0	465
U	0						0
Total	8	407	432	17	2	0	866

Std Error of the proportion by age for each sex

	Age					
Gender	2	3	4	5	6	7
Female	0.0%	1.2%	1.6%	0.4%	0.2%	0.0%
Male	0.3%	1.6%	1.4%	0.2%	0.0%	0.0%
Combined	0.3%	1.7%	1.7%	0.5%	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	0.0%	12.0%	27.1%	0.8%	-0.1%	0.0%
Female Upper Ci	0.0%	16.7%	33.2%	2.5%	0.6%	0.0%
Male Lower CI	0.3%	29.6%	17.1%	0.0%	0.0%	0.0%
Male Upper CI	1.6%	35.8%	22.4%	0.7%	0.0%	0.0%
Combined Lower CI	0.3%	43.7%	46.6%	1.0%	-0.1%	0.0%
Combined Upper CI	1.6%	50.3%	53.2%	2.9%	0.6%	0.0%

Table 5D-02. Summary of the proportion within age by gender of fall chinook tagged in the year 2001 at Happy Valley weir.

	Age					
Gender	2	3	4	5	6	7
Female	0.0%	30.5%	60.4%	82.4%	100.0%	0.0%
Male	100%	69.5%	39.6%	17.6%	0.0%	0%

Table 5D-03. Summary of the proportion of fall chinook tagged in the year 2001 South Umpqua as percent of total sample by gender and by age.

	Age					
Gender	2	3	4	5	6	7
Female	0.0%	14.3%	30.1%	1.6%	0.2%	0.0%
Male	0.9%	32.7%	19.7%	0.3%	0.0%	0.0%
Combined	0.9%	47.0%	49.9%	2.0%	0.2%	0.0%

Estimated number of Chinook harvested = 5402

Table 5D-04. Summary of the estimated number of fall chinook escaping intothe South Umpqua/ Cow Creek subsystem in year 2001.

	Age						
Gender	2	3	4	5	6	7	Total
Female	0	773	1628	87	12	0	2500
Male	50	1765	1067	19	0	0	2901
All Chinool	50	2539	2695	106	12	0	5402

Table 5D-05. Confidence intervals (95%) for the age classes of the estimated fall chinook tagged at the South Umpqua Happy Valley weir.

Age-	2	3	4	5	6	7
Lower CI	15	2359	2515	56	-5	0
Upper CI	84	2718	2875	156	30	0
SE of All C	17.9	91.8	91.8	25.5	8.7	0.0
1/2 95% C	35	180	180	50	18	0

number of returning spawners in each basin). Most female chinook spawners in the Umpqua system are returning as age 4 individuals.

Analysis of chinook salmon lengths at tagging and carcass recovery through Kolmogorov-Smirnov and chi-square tests resulted in us consistently rejecting the null hypothesis of similar size distribution between events in this experiment. When the null hypothesis of similar size distribution is rejected for both tests, it is recommended that sexes and ages only from the second capture event be used in estimating spawner escapement composition (Bernard 1991). Unfortunately, ODFW has scale data from spawning ground recoveries only for 2000. In the other years of the study, we are limited to scale data from the initial tagging event at Happy Valley weir for making our estimates of run composition.

SPAWNING SURVEY CALIBRATION

The time series of fall chinook spawner surveys has been by aerial counts of redds made at two times during the spawning season. Generally, flights are made once in late October and once in the third week of November. During each flight, chinook redds are identified and counted. An annual index is derived from the peak number of redds between the two flights. This series of survey flights has been financed by Douglas County, OR. Due to sharp county funding reductions, no aerial redd counts were made during 2002, but we expect that they will be resumed in 2003.

The Coastal Chinook Research and Monitoring project is able to provide a preliminary calibration of redds to spawner escapement estimate based on the years 1999 through 2001. The mean number of fish per redd estimated from these three years is 3.2 with a coefficient of variation of 15.7%. (Table 6). 1998 is excluded from this analysis as the precision of the population estimate is unacceptable. Figure 3 depicts the predicted relationship between redds and spawner escapement number for the South Fork Umpqua basin with 95% confidence limits.

Table 6. Aerial redd counts in relation to estimated spawner escapement in the South Umpqua basin: 1999 - 2001.

Year	Estimated Population	Total Redds	Fish/Redd	Mean	St Dev	Var
2002	10,477			3.20	0.5052	0.8177
2001	**5402**	**1887**	**2.86**			
2000	**2697**	**910**	**2.96**	CV		
1999	**1979**	**523**	**3.78**	15.77%		
1998	1231	319	3.86			

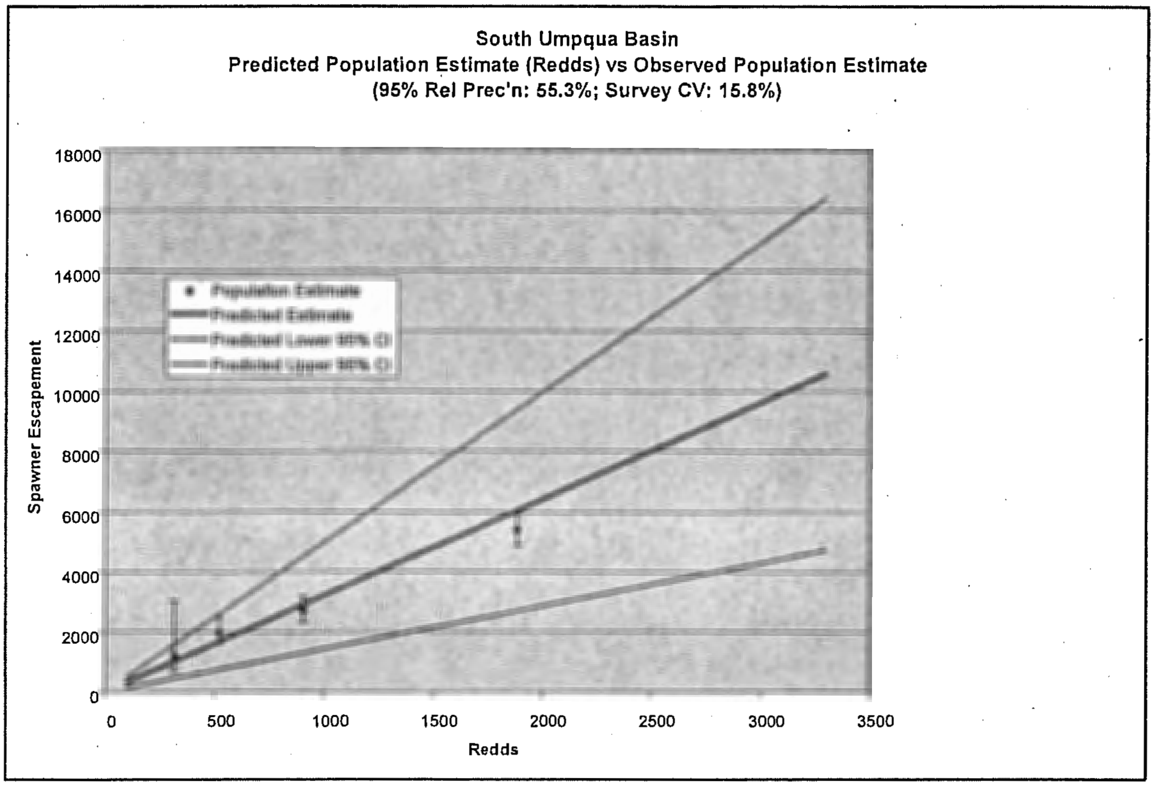

Fig. 3. Predicted to actual spawner escapements for the South Umpqua River

RADIO TELEMETRY

In 2001, 31 of the 169 chinook marked during tangle net operations had esophageal radio transmitters placed in them. Daily tracking began upon placement of the first tag and continued into December. Fourteen radio tags were tracked into the South Umpqua: six fish spawned in Cow Creek, six spawned in mainstem South Umpqua between Happy Valley and Cow Creek, and two spawned below Happy Valley trap. Three of the fourteen radio tagged fish that passed Happy Valley were captured in the trap. One fish, after handling at the trap, fell back and spawned at RM 4 on the South Umpqua.

Three radio tagged chinook entered and spawned in the North Umpqua. Five radio tags remained in mainstem Umqua from RM 53 to RM 108.6. Two of these fish were still actively moving when their signals were lost. Anglers harvested two radio tagged chinook and the radio tags were returned to ODFW. Three radio tagged chinook, after tagging moved downstream into the upper Umpqua estuary and moved into Mill Cr (RM 24.3) to spawn. Two radio tags were regurgitated one day after the fish were tagged, one fish moved upstream four miles before regurgitating the tag. One fish was never found after being radio tagged.

In 2002, tagging crews implanted esophageal radio transmitters into 72 of the 204 chinook marked at this station. As in 2001, daily tracking began after placement of the first tag and continued into December. Twenty seven of these fish spawned in the South Umpqua/Cow Creek subsystem. Eight remained in the lower South Umpqua below

Happy Valley trap. Sixteen remained in the mainstem Umpqua and four crossed Winchester Dam and spawned in the North Umpqua.

Table 7. Chinook spawner distribution in the Umpqua River system based on radio telemetry.

	2001		2002	
	Transmitters	% Distribution	Transmitters	% Distribution
South Umpqua	6	24%	20	36%
Cow Creek	6	24%	7	13%
Lower S. Umpqua	3	12%	8	15%
North Umpqua	3	12%	4	7%
Lower Umpqua R	7	28%	16	29%

IN-RIVER HARVEST

We estimate that 1436 fall chinook were taken in Umpqua recreational fisheries in 2001, and 948 were taken in 2002. Unfortunately, our creel surveys overlap for only one year with our available estimates of recreational harvest through punch cards (Table ~~10~~ 8).

DISCUSSION

Spawner escapement estimates

The Umpqua Basin Escapement Stock Indicator project has demonstrated the capability to develop precise estimates of spawner escapement in the South Umpqua basin, and a less well-developed capability to estimate escapements for the entire basin based on mark-recapture methods. Construction of a floating weir (with CTC funds) on the South Fork Umpqua at Happy Valley, the feasibility work in 2000 to develop mainstem Umpqua River tangle-netting and marking sites, and subsequent adaptation of the project based on field experience has led to annual improvements in the numbers of marked and inspected chinook. This field performance has also contributed to increasing numbers of recaptures of marked individuals, and resulting improved precision in the spawner escapement estimate.

Project work also shows a clear increasing trend in spawner escapement numbers over the course of the study. The increase in estimated spawner escapement into the South Umpqua/Cow Creek subsystem from 1231 in 1998 and 10,477 in 2002 goes beyond field technique. We have noted in other basin projects funded through the U.S. Section of the Chinook Technical Committee an increasing trend in numbers of spawners escaping. We suspect that this is due to a combination of estuarine and oceanic conditions conducive to fall chinook survival and growth as well as increasingly conservative harvest regimes in the North Pacfic.

Table 8. Estimated recreational catch of fall chinook salmon in the Umpqua River system, 1987-2001, based on angler punch cards and project creel surveys (2001 and 2002 only).

Stream	Run Year 1978	1979	1980	1981	1982	1983	1984	1987-88	1988-89	1989-90	1990-91	1991-92
Umpqua River & Bay	198	81	122	121	343	244	373	498	626	638	578	2,108
N. Umpqua River, Lower	87	19	15	43	22	18	21	17	23	6	28	19
N. Umpqua River, Upper	--	--	--	--	--	--	16	26	14	11	19	55
S. Umpqua River	66	72	160	95	104	6	29	10	16	7	0	3

Stream	Run Year 1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Umpqua River & Bay	1,530	2,440	1,447	3,014	3,605	1,022	1,744	1,345	1,815	1,876	n/a
N. Umpqua River, Lower	5	2	20	11	12	5	12	7	60	36	
N. Umpqua River, Upper	32	3	17	11	8	4	40	7	94	98	
S. Umpqua River	0	0	6	9	0	0	6	15	4	9	
Creel Survey Harvest Estimates										1,436	948
% of Punchcard Estimate										76.55%	

While we have high confidence in our estimates of spawner abundance in the South Umpqua/Cow Creek portion of the basin, our estimates of spawner abundance in the basin as a whole is less clear. First, our netting operations in the mainstem Umpqua are constrained encounters with ESA-listed coho salmon. The terms and conditions for our operations require us to limit interactions with coho. Consequently, we are fairly certain that we are not netting and tagging over the course of the entire run when we operate in the mainstem Umpqua.

Radio telemetry results also suggest our understanding of fall chinook salmon in the Umpqua system is incomplete. Entering into this study, we would have estimated that 85 to 90 percent of the Umqpua fall chinook are in the South Fork/Cow Creek portion of the system. Our abundance estimates based on mark-recapture methods are consistent with this hypothesis. However, the distribution of radio-tagged chinook suggest that something else may be going on, and that there may be substantial numbers of fish spawning in the lower South Umpqua and the mainstem Umpqua where we are unable to effectively survey and recovery carcasses for inspection. This uncertainty is unresolved, and will be a focus of attention during the 2003 field season.

Another problematic area for this project in its understanding of fall chinook abundance is the noted regrowth of tissue over the operculum punches used for marking. We adopted the opercular punch as a cosmetic mutilation mark as a means of checking for tag loss earlier in the study, and the working presumption was (and is) that this mark cannot be lost. While close inspection of fish at Happy Valley weir, or carcasses on spawning grounds, generally will reveal whether the operculum has been punched, the observation of this regrowth suggests that some marked fish may be missed leading to an inflated abundance estimate. In assessments of tag loss in previous years, we noted only a single instance of a tag being recorded by a surveyor, but no operculum punch being recorded.

Aerial Survey Calibrations

Estimates of spawner escapement are used to calibrate the time series of aerial redd counts performed annually with funding from Douglas County. The project has three years of escapement estimates that it can match to redd counts (1999, 2000 and 2001). The estimated number of spawners per redd observed has a mean of 3.2 and a cv of 15.8% (Table 8). This close association allows us to prepare estimates of spawner escapement numbers in past years based on this mean and the observed numbers of redd counts. (Table 1)

Angler Harvest

Fall chinook harvest by recreational anglers was estimated as 1436 individuals in 2001, and 948 in 2002. We are reluctant to apply a great deal of significance to this result at this time given the lack of variance estimates, and the minimal overlap with punch card estimates of angler harvest. We will note, for comparison, that longer time series in the

Salmon River and Elk River allow some comparison of creel surveys with punch card estimates. In each of these cases we can see a strong correlation between punch card and creel survey estimates of recreational harvest, with regressions between the two explaining approximately 63% to 70% of the variance (ODFW, unpublished data). However, these time series are also without estimates of variance, and we are unable to determine whether or not they are statistically distinct.

CONCLUSIONS AND RECOMMENDATIONS

Our understanding of Umpqua River fall chinook would be increased most strongly be increased mainstem tagging that covers the entire run of fall chinook. As our operations are constrained by limited interactions with ESA-listed coho, it is unlikely that we will be able to continue mainstem netting operations later into the year.

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Appendix B: Chi Square Tests of Random Mixing on Spawning Grounds

1999

Space

	untagged	tagged	
S. Umpqua	80	19	99
Cow Crk	183	38	221
	263	57	320
	81.37	17.63	
	181.63	39.37	
		p	df
Chi-Square=		0.666	1

Sex

	Males	Females	
S. Umpqu	76	83	159
Cow Crk	93	127	220
	169	210	379
	70.90	88.10	
	98.10	121.90	
		p	df
Chi-Square=		0.286	1

Time

Cow Creek

	untagged	tagged	
early	69	18	87
late	113	20	133
	182	38	220
	71.97	15.03	
	110.03	22.97	
		p	df
Chi-Square=		0.2782	1

South Umpqua

	untagged	tagged	
early	49	12	61
late	31	7	38
	80	19	99
	49.29	11.71	
	30.71	7.29	
		p	df
Chi-Square=		0.87783	1

Appendix B (continued)

2000

Sex

	M	F	Total
			Tot
Cow Crk	140	190	330
S. Umpqua	129	147	276
	269	337	606
	expected		
	146.5	183.5	
	122.5	153.5	
		p	df
Chi Square=		0.28701	1

Marked/unmarked

	Mrk	UnMrk	Total
Cow Crk	67	263	330
S. Umpqu	39	237	276
	106	500	606
	expected		
	57.7	272.3	
	48.3	227.7	
		p	df
Chi-Square=		0.04638	1

Time

	Cow Crk				S. Umpqua		
	Mrk	UnMrk	Total		Mrk	UnMrk	Total
early	31	133	164		24	134	158
late	36	130	166		15	103	118
	67	263	330		39	237	276
	expected				expected		
	33.3	130.7			22.3	135.7	
	33.7	132.3			16.7	101.3	
		p	df			p	df
Chi Square=		0.52955	1	Chi Square=		0.55876	1

Appendix B (cont'd): Chi Square Tests of Random Mixing on Spawning Grounds

2001

Mixing by Sex

	M	F	
Cow	302	247	549
Lwr SU	211	195	406
Uppr SU	25	34	59
	538	476	1014
	Expected		
	291.28	257.72	
	215.41	190.59	
	31.30	27.70	
	p	df	
chitest=	0.1544	2	

Spatial Analysis

sexes combined

	Cow Creek	Lower SU	Upper SU	Total
marked	127	120	13	260
unmarked	422	286	46	754
total	549	406	59	1014
	expected			
	140.77	104.10	15.13	
	408.23	301.90	43.87	
	p	df		
chitest =	0.0646	2		