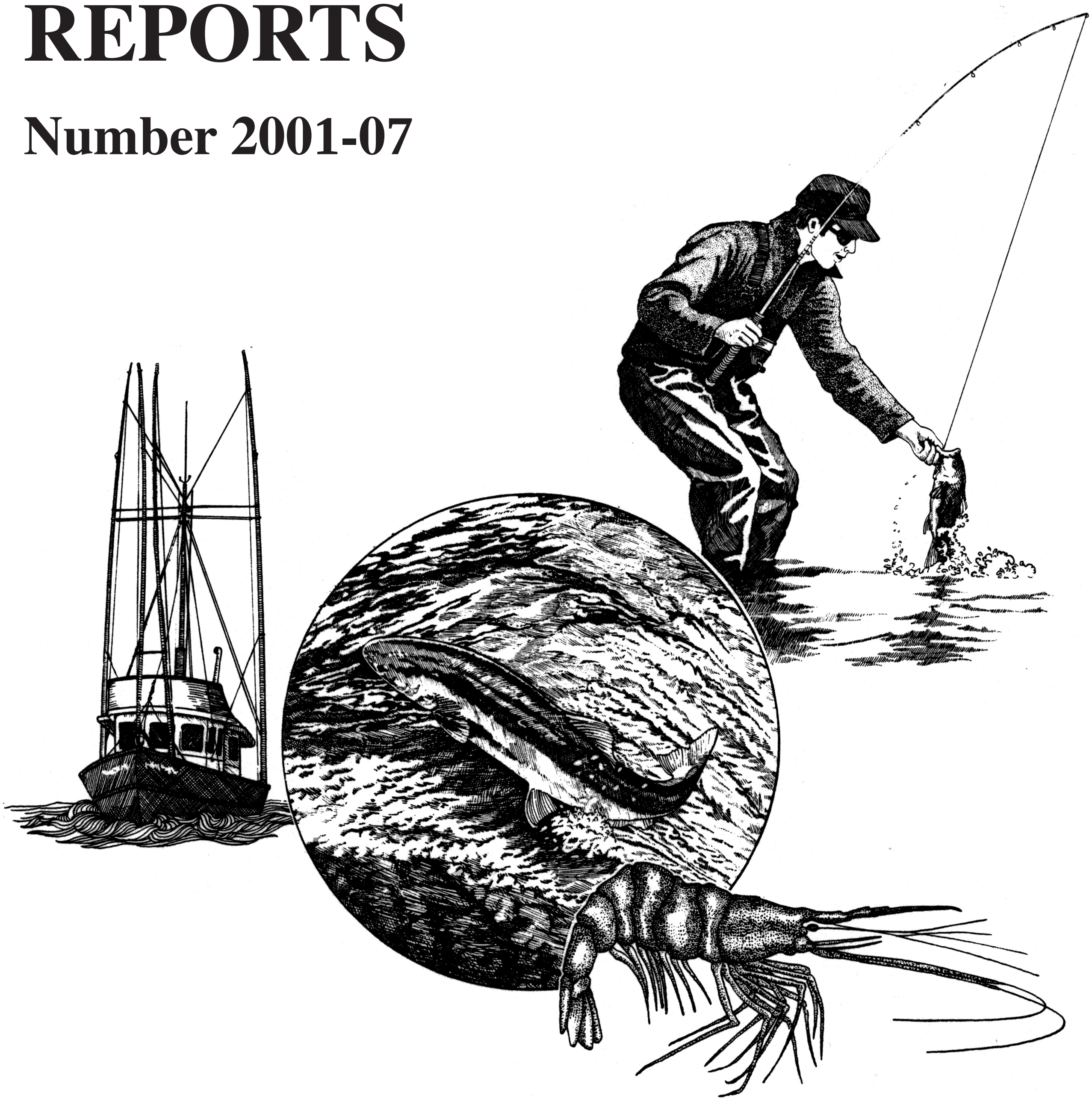
INFORMATION REPORTS

Number 2001-07



FISH DIVISION

Oregon Department of Fish and Wildlife

Estimating Run Size and Spawner Escapement of Chinook Salmon in Elk River, CurryCounty, for use as an Exploitation Rate Indicator for Mid Coastal Wild Chinook Stocks

Estimating Run Size and Spawner Escapement of Chinook Salmon in Elk River, Curry County, for use as an Exploitation Rate Indicator for Mid Coastal Wild Chinook Stocks

Prepared by:
Ron Williams

Oregon Department of Fish and Wildlife
2501 SW First Avenue
PO Box 59, Portland Oregon 97202

September 2001

This project was funded through the US Section of the Pacific Salmon Commission, National Marine Fisheries Service Award No. NA97FP0059

Table of Contents

Abstract

The Elk River hatchery stock of fall chinook is proposed as an exploitation rate indictor for several Oregon mid-coast wild stocks of chinook salmon. Exploitation rate indicators are necessary for modeling effects of ocean mixed stock fisheries on the wild salmon produced in rivers in North America as specified in the Pacific Salmon Treaty. Currently, Oregon has designated only the Salmon River hatchery chinook stock as an exploitation rate indicator for all 16 natural fall chinook stocks produced in coastal rivers that show northern migration patterns. The ocean catch pattern of the Elk River stock more closely resembles the distribution of the Coos, Coquille, and Umpqua fall chinook than does the Salmon River indicator. It is therefore proposed that the Elk River hatchery fall chinook stock be designated as the exploitation rate indicator stock for these mid-coast populations of fall chinook salmon. To implement this program, estimates of returning coded microwire (CW)-tagged fish must be made. The Elk River hatchery stock has a continuous history of CW-tagged fish released and a continuous monitoring program to estimate the terminal run. A mark-recapture experiment conducted in 1970-80 serves as the calibration for development of 2 predictive models to estimate the run for both wild and hatchery origin chinook. From these estimates it is possible to derive expansion factors to apply to sampled fish to estimate the total return of CW-tagged groups. These models were reviewed and alternative models are proposed to improve prediction, especially at low abundance levels.

Introduction

Harvest management framework

The fishery management program agreed to under the Pacific Salmon Treaty (PST), specifies a chinook conservation program. This program requires that intensive stock assessment monitoring be provided for naturally producing populations of chinook from the North American continent. One vital component of the stock assessment program is to define the age and stock specific exploitation rate of chinook populations that contribute to PST regulated fisheries. This information is used by the Chinook Technical Committee (CTC), in their evaluation of fisheries impacts on chinook stocks. The CTC uses a harvest and simulation model called the Coast Model to determine the post season distribution of catch and harvest impact, and as a preseason tool to determine an appropriate harvest regime for the forthcoming recruitment of chinook stocks. Exploitation rate information is a primary input variable to this model, and to post season evaluation of the harvest of specific stocks in the PST fisheries.

Exploitation Rate Indicator Stocks (ERIS)

The PST specified that the parties maintain an exploitation rate indicator stock program to provide the CTC with information from each production area for the annual evaluation of fisheries and to forecast future harvest impacts. The mechanism to provide this information was to use the coded microwire tag (CWT) along with removal of the adipose fin to identify target fish for field sampling. In 1986 Oregon began to implement this program and chose to use hatchery groups to represent both natural populations along the Oregon Coast, and hatchery production in the lower Columbia and Willamette Rivers.

<u>Qualifications</u>

Because the assessment performed by the exploitation rate analysis and the coast model standardizes current abundance and exploitation rates to the period prior to PST imposed harvest restrictions, the CTC requires that Exploitation Rate Indicator (ERI) stocks have a tagging history that includes brood years in the range of 1976-80. The assessment statistics are therefore indexes of current conditions as compared to conditions prior to implementation of the Pacific Salmon Treaty.

ERI stocks should be chosen based on their ability to represent the wild stocks in the region. This includes consideration of the life history and migration characteristics of the ERI and the stocks it represents. ERI stocks should exhibit similar age at maturity and ocean catch distributions as the wild stock for which it serves as a representative. For domesticated stocks, the ERI needs to represent the "normal" production from that artificial propagation facility, rather than experimental or a group of fish treated in a transient mode, ie. a short term off-station release.

The CTC requires that 200,000 smolts per ERI stock be adipose fin marked and CW tagged and reported in a timely manner to the PSMFC database in the PSC format. Reporting to the database should be completed by November of the year following return of the fish to freshwater (November 2001 for the fish returning in run year 2000). The run year of some late returning stocks extend beyond the calendar year. Once the agency implements an ERIS it is obligated under terms of the treaty to maintain this program for the duration of the treaty for those stocks representing wild stocks. For the ERIS representing only hatchery production, if that hatchery production ceases the ERIS program naturally will no longer be needed, and there is no need to continue with any ERIS for that defunct production.

Monitoring program requirements

When an agency implements an ERIS program it is obligated under the treaty to not only assure the tagging and tag reporting requirements are met, but a recovery program is needed to account for fish being caught in ocean fisheries, and those mature fish returning to their natal stream. Generally the Northwest states and Canada have been providing offshore fishery recovery tag information through a program implemented prior to the treaty. For Columbia River ERI stocks, agency ongoing fishery and escapement monitoring has been implemented through state or other federal programs prior to the treaty. However, for coastal natural stocks freshwater recovery programs for ERI stocks have only been implemented after the treaty.

Generally as fish return to their natal streams they are either caught in sport fisheries, trapped for broodstock, or escape to spawn naturally. An ERIS recovery program needs to annually sample each one of these events and provide systematic sampling procedures to assure a statistically valid estimate of all returning ERIS fish. Sampling fraction statistics are generated through statistically designed random sampling of fisheries and spawning ground escapement. Broodstock collections are a complete census. Spawning ground escapements pose a particularly difficult challenge when estimating total escapement from sampling only a small fraction of the total during foot or boat surveys. In many cases it is necessary to conduct annual mark and recapture experiments to obtain the correct sampling fraction for expanding the spawning ground samples. In other cases, previous studies may have provided information necessary to obtain a predicted sampling fraction. This is often an average sampling fraction derived from former mark and recapture studies. Studies that establish these sample fractions are considered a calibration test, and they may continue to occur annually or have terminated, and the older data continues to be used. It should be noted that calibration needs to be made periodically as the fish populations, and environmental conditions change over the course of decades. Additionally, sampling plans are often not recorded well during the former experiments used in the calibration and it is difficult to maintain similar sampling protocol today without adequate records of the former procedures.

Current status of Oregon's Coastal chinook ERIS program

<u>Salmon River domestic stock as ERIS for the NOC group</u>

In 1986 the ODFW designated the Salmon River hatchery stock as the ERI stock to represent naturally producing stocks from Oregon coastal rivers. This domestic stock has been Ad+CW tagged beginning with the 1976 brood. Tagging was consistent except for the 1981 brood which, unfortunately, was not tagged. Tagging rate was increased to the required 200,000 smolts with the 1986 brood and has remained so until the present. In 1986 a comprehensive freshwater recovery program was implemented to recovery tagged fish from the fishery, broodstock collection and the natural spawning escapement. Annually a statistical creel survey and a mark and recapture experiment is conducted to establish sampling fractions for the CW tagged fish observed at these locations. The hatchery operations take a complete census of the CW tagged fish used for reproduction.

Through the comprehensive hatchery production monitoring program called the stock assessment project, see Lewis, (2000) for example, it was apparent that the natural stocks from the mid-coast and south coast rivers have very different ocean catch distributions (Figure 1). In a review of coastal natural stocks of chinook, Nicholas and Hankin (1988) determined that north coast and mid to south coast stocks had different maturity, and sex ratio at age patterns. Consequently in 1989 the ODFW recognized that an additional ERIS would be needed to represent the natural stocks produced in the mid-coast rivers.

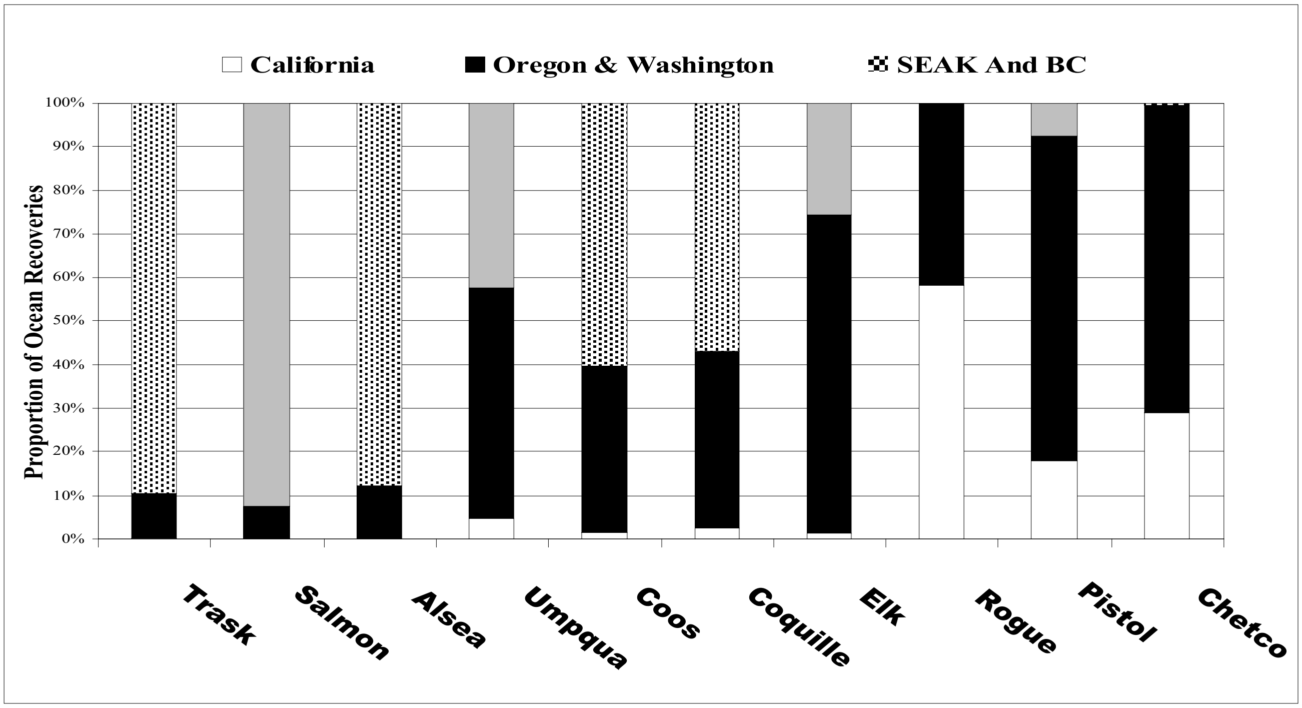


Figure 1. Distribution of the ocean catch of 10 Oregon coastal stocks of hatchery Fall Chinook. These are assumed to represent the catch distributions of wild stocks from each of these 10 coastal rivers. SEAK denotes Southeast Alaska, BC is all of British Columbia. Adapted from Lewis (2000).

<u>Elk River domestic stock as ERIS for MOC group</u>.

The only group of chinook with the proper qualifications to serve as a mid-coast stock ERI was the Elk River hatchery stock. The catch distribution shown in Figure 1 is more similar to the adjacent stocks of the Coos, Coquille, and Umpqua rivers than is the catch distribution of the Salmon River ERIS. The mid-coastal stocks do not show the same proportionate catch in far-northern fisheries as the Oregon north coastal stocks represented by the Salmon River ERIS. Therefore, when modeling the harvest impacts with the Coast Model erroneous conclusions would result if we were not able to separate these stocks from the catch distributions of the Salmon River ERIS.

The Elk River stock has been CW- tagged during the base period (1976-80) and has had nearly continuous tagged groups released over the years. There has been continuous annual monitoring of the return to river to maintain an annual estimation of run size. Most importantly, there was an historic mark –recapture study to serve as a calibration necessary to establish the sampling fraction to estimate annual recoveries of tagged fish in the fishery and on the spawning grounds. This calibration work took place from 1970 –80 and consisted of a mark recapture experiment during these 11 years and a statistical creel survey for 9 years (1972-80). Based on these attributes the ODFW increased the number of tagged hatchery chinook from the Elk River hatchery beginning with the 1990 brood to meet the CTC's requirement of 200,000 tagged fish. Increased recovery sampling began in 1992 as the first of the 1990 progeny returned as jacks. This monitoring began with a statistical creel survey, and through cooperation with other agency programs have provided for spawning surveys and hatchery recovery operations.

Objectives of this report

1) Introduce the Elk River hatchery stock as an exploitation rate indicator stock for the PSC assessment.

2) Collate, and document the historical information on run size of Elk River chinook salmon.

3) Review previous run size estimation methods to verify the correct data set and,

4) Explore an alternate run estimation methods and derive an expansion factor to estimate the total number of coded wire tagged chinook returning to the spawning grounds in Elk River.

The mark-recapture work provided a means to estimate the annual ocean escapement of chinook into the Elk River based on wild or hatchery origin (Nicholas and Downey , 1983). However, the components of the terminal run do not have specific sampling fractions associated with them in that analysis. Estimation of the spawning escapement would be by subtraction of the catch and hatchery take, without a specific sampling fraction available from spawning ground sampling. To fulfill the requirements of the ERIS program annual monitoring should sample each of the event strata in the terminal run and through use of an appropriate sampling fraction estimate the total return by tag code for each stratum. This report reviews the original model for estimating the terminal run and suggests an alternative model to estimate the spawning escapement of large chinook, and calculates the sampling fraction for spawning escapements which can be used to estimate the total Ad+CW-tagged escapement.

Methods

Data Source

Data needed to calibrate the run size estimation procedure include estimates of freshwater catch, hatchery broodstock take, and an index of the number of spawners. For the Elk River, these data are available for the calibration period from both in-river sampling and from a statewide voluntary angler punch card catch recording system. There are 2 sets of data to use for estimating the catch for the calibration procedure. The punch card estimate is available from 1970 to the present, the creel sampling program was conducted from 1972-80. Prior to 1978 punch card estimates included both large and small (jack) salmon. To make this data useful for large or small fish and apportion for wild or hatchery origin, the total punch card estimate was apportioned based upon these ratios found in the statistical creel sampling. Consequently, this made the 1970-71 data unusable as no creel sampling occurred during those years. Comparisons of the 2 catch estimates is made to see if they correspond in any manner.

Data from the early mark-recapture experiment is not readily available in summary form in published documents, therefore several of the biologist that worked on the study were contacted and asked to provide this data from their records (J. Nicholas, and G. Susac, personal communication). These data were modified to corroborate with published reports on the studies (McGie, 1977, Reimers, et al. 1978, 1979,1981, and Nicholas et al., 1985). These data are presented in Appendix1.

Estimation procedures

Linear regression model in 1983 report

The procedures developed by Nicholas and Downey (1983) use a linear model to relate indices of either hatchery or wild origin large spawners to the total estimated run of chinook as determined by the mark-recapture experiment from in-river samples of chinook salmon:

$$W_t = 1{,}139 + 3.26\,(w_s + W_h) \qquad 1.0$$

Where:

W_t = Estimate of the ocean escapement of large sized (>55 cm) wild origin chinook.

w_s = The cumulative total number of large wild origin chinook counted on all spawning surveys throughout the survey season.

W_h = The total number of large wild origin fish counted in the hatchery trap.

$$H_t = (457.6 + 6.4h_s) + (H_h + H_c) \qquad 2.0$$

Where:

H_t = Estimate of the ocean escapement of large sized (>55 cm) hatchery origin chinook.

h_s = The cumulative total number of large hatchery origin chinook counted on all spawning surveys throughout the survey season.

H_h = The total number of large hatchery origin fish counted in the hatchery trap.

H_c = Estimated sport catch of large sized (>55 cm) hatchery origin fish.

During the calibration period all fish released from the hatchery had been fin marked as juveniles so determination of the origin of returning adults was possible by examination of the sampled fish for missing fins. In this paper these models were applied to the data provided by Nicholas and Susac, and analyzed by regression to check on the similarity of the database to that used in 1983.

District techniques of combining linear models

In practice district management biologists have used a second set of linear equations and calculated the average values of these two sets of equations to derive the annual ocean escapement estimate of wild and hatchery origin chinook into Elk River (Appendix 2). Reduced monitoring of the run occurred after the calibration work ceased in 1980 until the ERIS recovery project began in 1992. Each component of the run was sampled annually to provide some measure for each of the parameters required for the estimation models, however this sampling was not as intensive as during the calibration phase.

Estimation of spawning escapement and expansion factors for observed CW-tagged recoveries.

This analysis looked at several aspects of the data set. In-river sport catch can be estimated during the calibration period by either the voluntary angler report ticket (Punch Card) or by the statistical creel survey conducted from 1972-80. Prior to 1978, the punch card data set included both adult (>55cm) and jack (<55 cm) sized salmon. To apportion this dataset for these 2 size groups the proportion of jacks as determined from the creel sample program was used. To determine if the catch estimation procedures used during the calibration period were related a comparison of the estimates derived from punch card records and creel sampling is made.

Relationships between various sampling indices and the independently estimated run size were explored by running a correlation analysis between the Mark-Recapture run size estimate and the following variables: 1) catch estimate from the punch card records, 2) catch estimate from the creel survey, 3) cumulative total number of chinook carcasses recovered throughout the season on spawning ground surveys, and 4) number of fish taken at the hatchery trap. Those variables with acceptable correlation coefficients then were used as predictors in a linear model suggested by Nicholas and Downey (1983). Those same data were fit by a power function as an alternative. A power function provides a convenient management model because the intercept runs through zero. By use of this model when few fish are observed few fish will be estimated in the run or spawning escapement. By contrast use of the linear models will not allow estimates of run size less than 1,139 wild and 457 hatchery fish, which we are left to assume were caught (wild fish) or unseen during spawning surveys (hatchery fish).

Because the ERI stock accounting must estimate the number of CW-tagged fish escaping to spawn naturally, an estimate of the spawners was first obtained by:

$$W_s = W_t - W_c - W_h \quad (3.0) \quad \text{and} \quad H_s = H_t - H_c - H_h \quad (4.0)$$

Where:
W_s = estimated number of large wild origin chinook spawners.
W_c = the total number of large wild origin fish estimated to have been caught in river sport fisheries.
H_s = estimated number of large hatchery origin chinook spawners.

Second a power function was established between W_s or H_s and a corresponding spawning index:

$$W_s = a(w_s)^b \quad (3.1) \quad \text{and} \quad H_s = a(h_s)^b \quad (4.1)$$

Coefficients were derived by regression analysis on the log transformed equations:

$$\ln W_s = \ln a + b^* \ln(w_s) \quad (3.2) \quad \text{and} \quad \ln H_s = \ln a + b^* \ln(h_s) \quad (4.2)$$

Sampling fractions will be used to expand the observed number of CW-tagged fish as observed during spawning surveys. Sampling fractions for wild origin spawners (R_w) or hatchery origin spawners (R_h) are calculated as:

$$R_w = w_s / W_s \quad (4.0) \quad \text{and} \quad R_h = h_s / H_s \quad (5.0)$$

Total recoveries of CW-tagged spawners is estimated by: $H_{cwt} = 1/ R_h * h_{cwt}$ (6.0)

Where:
H_{cwt} = total estimated number of hatchery fish with CWT escaping to spawning grounds in Elk River.
h_{cwt} = number of fish with CWT observed on the spawning grounds in Elk River.

Compare run, spawner abundance, and sampling fractions from the two models

Because the ERIS program depends upon reliable estimates of each component of the returning run, results from the linear and power models were compared for estimates of the run size and the spawning escapement. To obtain an estimate of the spawning escapement from the linear model the run size is estimated and the catch and hatchery take subtracted to get the spawning escapement. Using the power function the spawning escapement is estimated directly. The magnitude of differences in the run and differences in the spawning escapements between these methods will be the same as the same values for catch and hatchery take are used in both models. Estimates from each model are compared by evaluating the mean difference between estimates for the calibration period (1970-80).

Results

Dataset

Catch Estimates from Punch Card reporting system were generally larger than those estimated by the statistical creel (Table 1)

Table 1. Catch of fall chinook salmon in the Elk River from 1970-80, as estimated by the punch card reporting system and a statistical creel survey.

Run Year	Total Catch Punch Card Large+Small	Total Catch of Large Fish from Creel Survey	Proportion Large Fish in Creel Sample	Proportion Wild in Creel Sample	Punch Card Estimate Large Wild	Punch Card Estimate Large Hatchery
1970	2175	Na	Na	Na	Na	Na
1971	1099	Na	Na	Na	Na	Na
1972	1685	390	0.186	0.251	79	235
1973	1118	289	0.146	0.201	33	130
1974	2144	2128	0.862	0.15	277	1571
1975	3535	2446	0.706	0.19	474	2021
1976	2290	596	0.245	0.362	203	358
1977	3961	2357	0.722	0.193	552	2308
1978 [a	2561	738	0.851	0.509	1305	1256
1979 [a	3003	1825	0.942	0.46	1382	1621
1980 [a	925	238	0.411	0.651	602	323

[a: after 1977 small fish were designated separately on punch cards.

Generally the 2 catch estimates were similar for 6 of the 9 years they were recorded congruently (Figure 2). For 1978-80 the 2 estimates were very different, and reasons for this discrepancy could be related to the inclusion of jacks prior to 1978 and the adjustment to that series of data to exclude jacks. After 1978 when jacks were no longer recorded on the punch cards, the 2 estimates are very dissimilar. Given this problem the punch card data are very suspect and may not be suitable for using in the estimation of run size and spawner escapements.

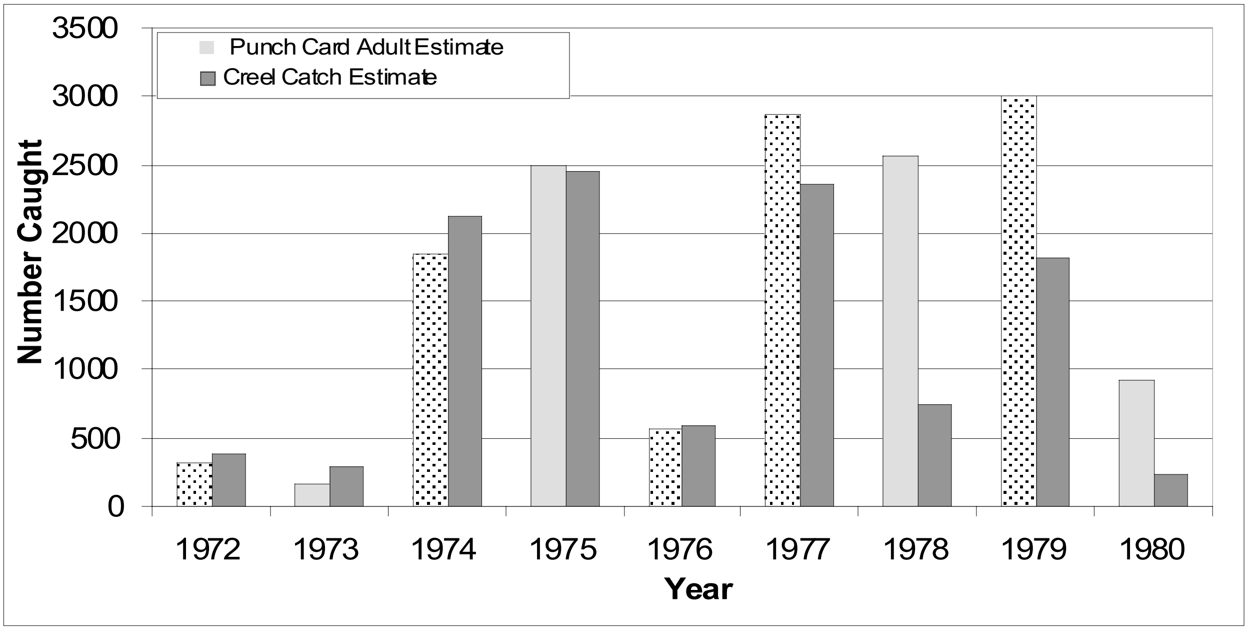


Figure 2. Comparison of Punch Card and Creel Survey Catch Estimates in the Elk River, 1972-80. Adjustments were made to the Punch Card Estimates prior to 1978 removed Jacks from the data.

Data from the mark- recapture experiments including run size estimates, spawning ground indices and hatchery trap census used in this analysis are as follows (Table 2).

Table 2. Estimated and counted large chinook salmon during the calibration period with mark and recapture experiment (Nicholas and Susac, Appendix 1).

Run Year	Poplulation Estimate Wild Fish	Poplulation Estimate Hatchery Fish	Spawner Index Wild Fish	Spawner Index Hatchery Fish	Hatchery Take Wild Fish	Hatchery Take Hatchery Fish
1970	3355	0	567	0	60	0
1971	1421	1929	122	258	32	650
1972	1392	5154	168	403	74	2199
1973	2029	5930	151	338	122	2991
1974	2110	5790	144	329	27	619
1975	1714	9237	80	330	53	945
1976	1475	1278	92	127	18	53
1977	2555	9196	430	785	110	2263
1978	2700	5068	461	545	39	512
1979	3005	4719	449	400	66	819
1980	2461	1729	255	204	29	177

The return of hatchery and wild origin chinook to Elk River showed very different trends during the calibration period (Figure 3), thus warranting the separation of these 2 components for the estimation procedure.

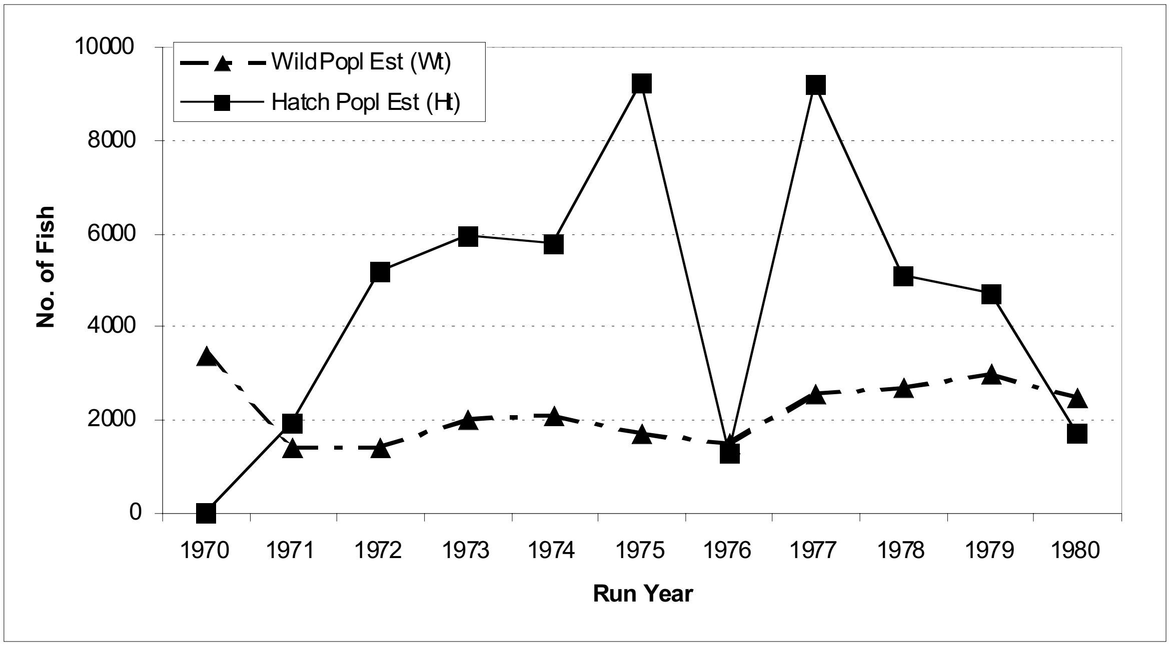


Fig 3. Comparison of the run size estimates of wild and hatchery origin Chinook Salmon in Elk River, 1970-80.

A regional drought was known to have occurred in 1976-77 and affected the 1976 returns. This was dramatically seen in the hatchery origin fish but showed little affect on the wild origin fish. The mouth of Elk River is bar bound at low flows. When substantial rains occur the bar is breached and fish can readily enter the river. Even with the bar intact fish can periodically enter the river when extreme high tide series allows ocean water to enter the lower estuary. In 1976 the drought prevented river flows substantial enough to provide easy access to the returning fish, a combination of high tides and some higher flows must have occurred as some fish obviously entered the river. Published accounts all speak of the drought impeding regular migration patterns and the difficulty of chinook in reaching their preferred up-river spawning sites (McGie, 1977). It appears that the hatchery fish were most affected by this condition.

Correlation analysis of variables

There are two time series of data to evaluate. The first one was from 1970 to 1980 when the mark-recapture experiment took place, and the second was from1972 to 1980 when both the mark-recapture and the statistical creel survey took place. Unfortunately, for the longer period there were no reliable catch estimates of large fish available. Therefore, only the hatchery return or the spawner index can be used as indicator variables for the run size. Because the 1983 analysis used this time period to derive the prediction model for wild origin fish I evaluated the correlations for this dataset also. The relationship of the various in-river indices- catch, hatchery return, and spawning survey carcass counts- to the independently estimated run size was best for the spawner index for both wild and hatchery origin chinook for the period 1970-80 (Table 3). However, for the 9 year period 1972-80 when the creel catch estimates were available, the catch estimates were better correlated with the independent estimate of the run for hatchery fish than were the spawner indices.

Table 3. Correlation coefficients between the population estimates and return indices for wild or hatchery origin Fall Chinook in Elk River

	---- 1970-1980 ----		---- 1972-1980 ----	
Variable	Wild	Hatchery	Wild	Hatchery
Year	0.28	0.21	0.75	-0.31
Catch (punch card)	na	na	0.83	0.73
Catch (creel survey)	na	na	0.63	0.76
Hatchery Broodstock	0.18	0.62	0.11	0.54
Spawner Index	0.92	0.78	0.88	0.69

For both time series the spawner index (cumulative sum of dead fish found), correlated best with the independent population estimates for the wild origin fish. This reaffirms the analysis made in 1983 by Nicholas and Downey. On the other hand, this analysis indicates that for the shorter time period when creel catch data were available, using harvest rate to predict the hatchery run may be better than using the spawner index.

Established linear model results with current dataset.

Because the entire database has never been summarized and published, and the current dataset is a re-creation of the data by the staff that had worked on the project, I recalculated the parameters using the 1983 linear models to check if the data were similar to the original data used in 1983. There were some differences in the parameter estimates but these were not especially large (Table 4). The hatchery fish model varied the greatest with the y-intercept. Although no P-values were given in the 1983 document, current data result in the intercept of the hatchery fish model as not significantly different from zero. I was satisfied that the data is similar enough to represent information that was analyzed in 1983. Consequently, the current data should serve as a comprehensive summary of all the data collected during the calibration period and can be relied upon for future stock assessments.

Table 4. Comparison of parameter and statistical values of linear models used for calibrating run size estimates of Elk River fall chinook from wild and hatchery origins, based on 1983 analysis and re-creation of the analysis with currently available data.

Model	$W_t=a+b(w_s+W_h)$		$H_t=a+b(h_s)+(H_h+H_c)$	
Analysis date	1983	Current	1983	Current
Parameter	Value	Value	Value	Value
a	1,139	1,167	457.6	435.8
P-value	na	0.0002	na	0.29
b	3.26	3.21	6.4	7.43
P-value	na	0.0002	na	0.0003
R-sq	0.822	0.898	0.905	0.899
N	11	11	8	8

Alternative model results

Due to the incomplete accounting of catch prior to 1972 and the questionable value of the punch card data from those earlier years, I used the creel catch estimate for testing new models (3.1 and 4.1), to estimate the number of spawning fish and derive a sampling fraction for observed spawners. For wild fish the correspondence of the spawner index and independently estimated number of spawners showed some correlation (Figures 4 and 5).

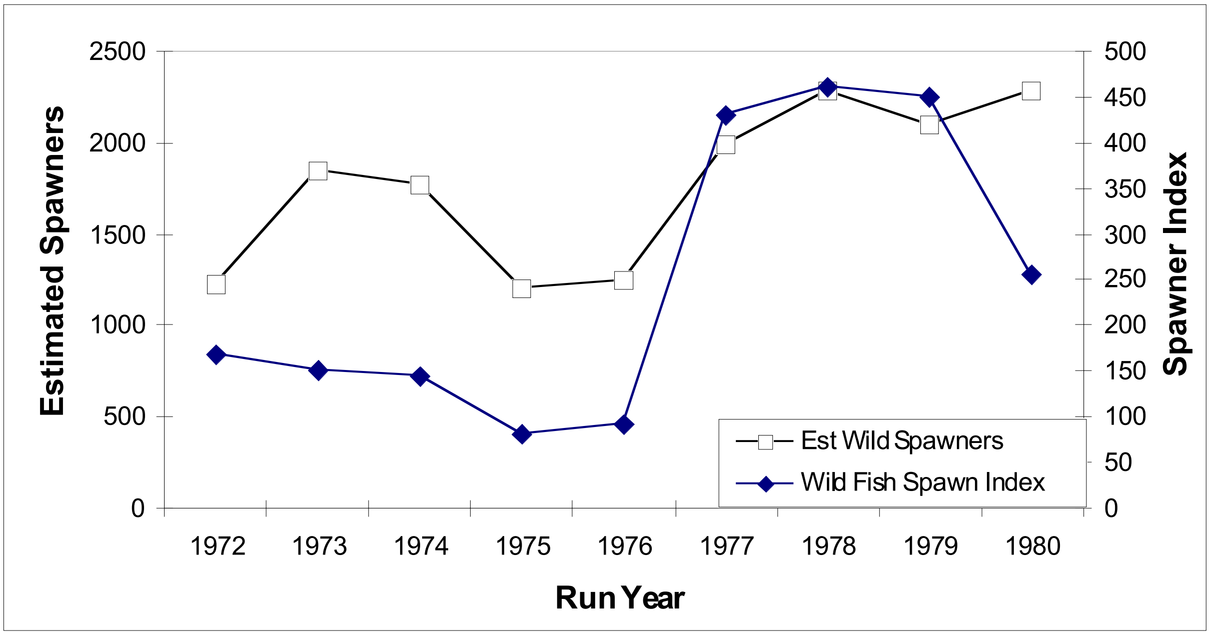


Figure 4. Estimates of the total number of wild origin chinook spawners and the wild fish spawner index in Elk River, 1972-80.

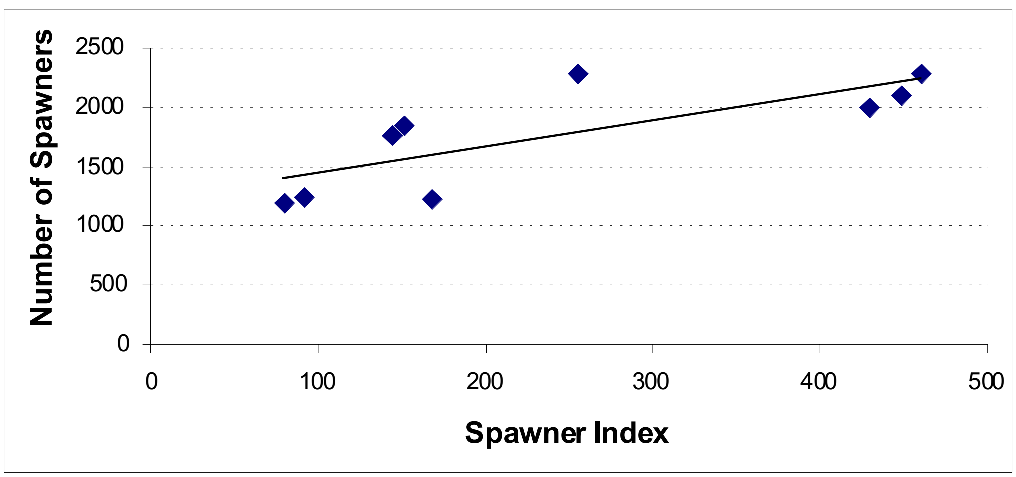


Figure 5. Correlation of the total number of wild origin chinook spawners and the spawner index in Elk River, 1972-80. Correlation coefficient =0 .774.

For hatchery origin chinook the correlation of the spawner index and the total estimated spawners was high except for 1975 (Figures 6 and 7).

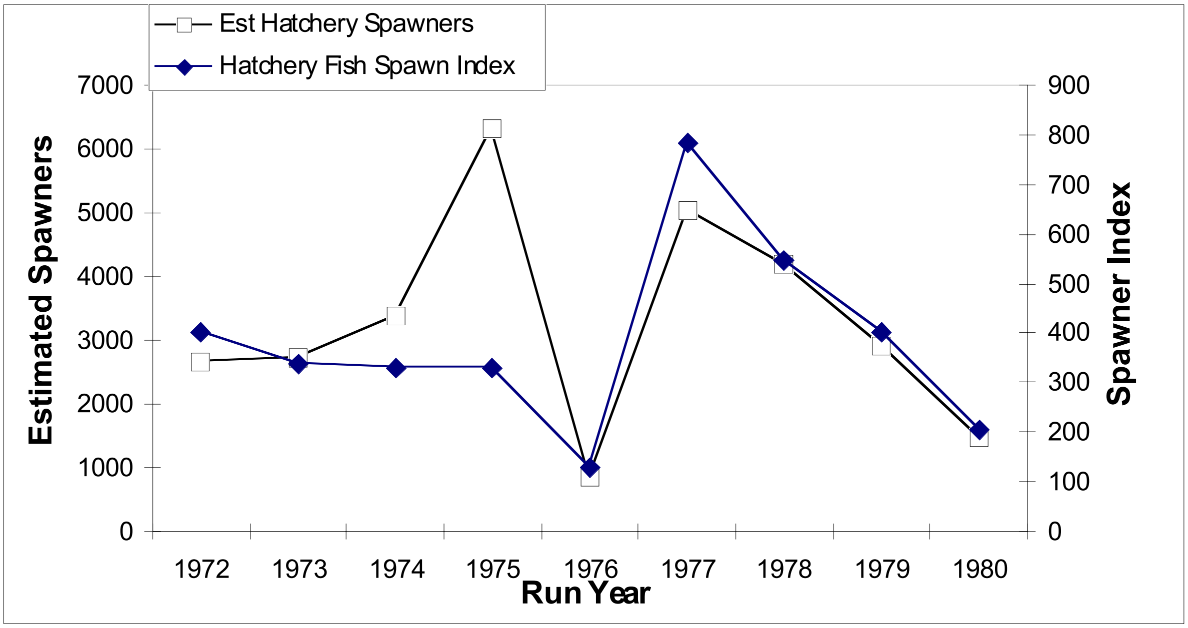


Figure 6. Estimates of the total number of hatchery origin chinook spawners and the hatchery fish spawner index in Elk River, 1972-80.

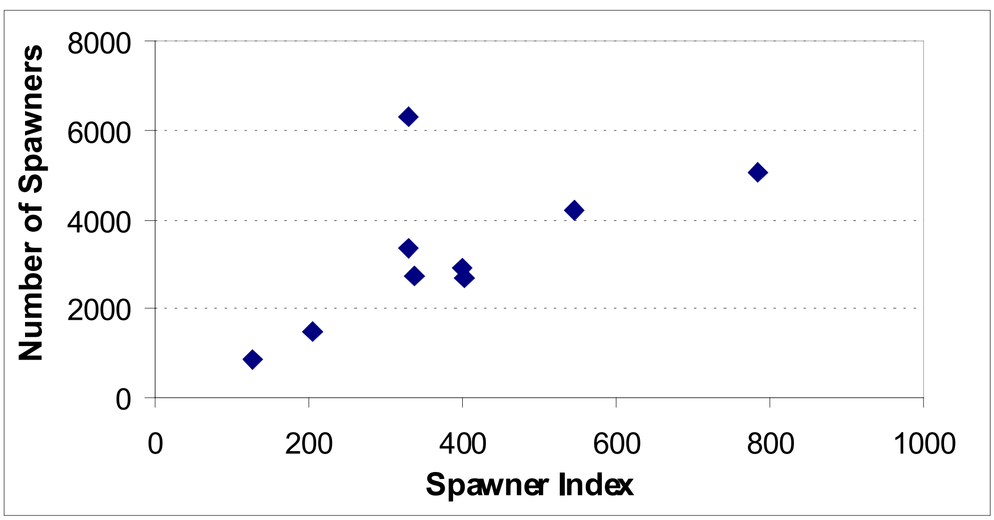


Figure 7. Relationship of the total number of hatchery origin chinook spawners and the hatchery fish spawner index in Elk River, 1972-80. Correlation coefficient = 0.396.

Because there may be an underlining correlation but the 1975 data point is very anomalous, 1975 was eliminated from the analysis. With 1975 removed the correlation coefficient improved substantially (Figure 8). Although the authors did not state which year was eliminated for the linear model developed in 1983 they used only 8 years of the 9 year data series.

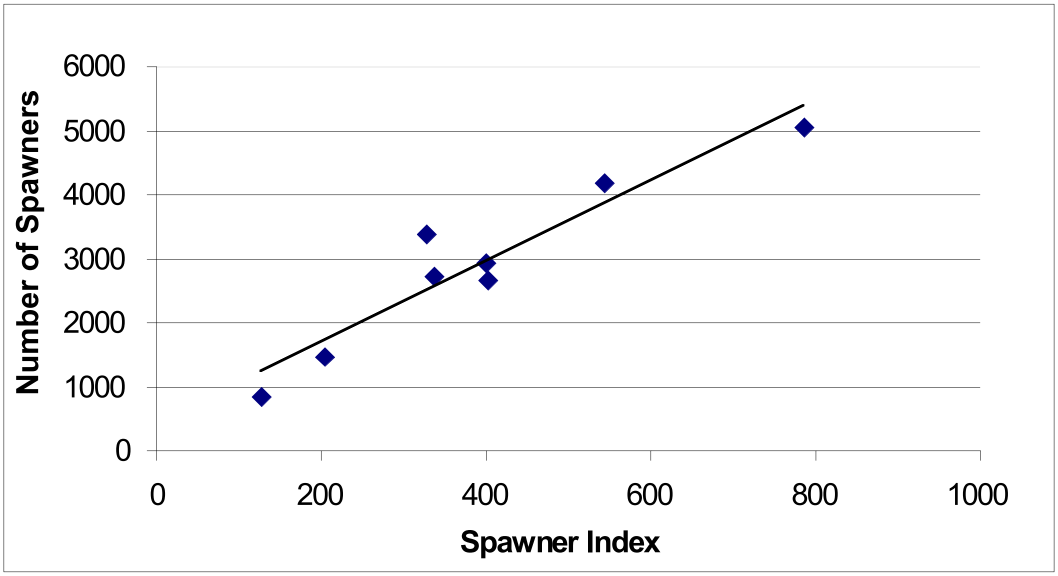


Figure 8. Relationship of the total number of wild origin chinook spawners and the spawner index in Elk River, 1972-80 excluding 1975. Correlation coefficient = 0.899.

Regression analysis on the log transformed models (3.2 and 4.2) resulted in parameter estimates that can be useful in estimating the total number of spawners from the spawner index by use of the power functions (Table 5).

Table 5. Comparison of Parameter and Statistical values of power models used for calibrating spawning fish estimates of Elk River fall chinook from wild and hatchery origins.

Model –	$\ln W_s = \ln a + b^* \ln(w_s)$	$\ln H_s = \ln a + b^* \ln(h_s)$
Parameter	Value	Value
Ln a	5.706	2.0496
P-value	0.00001	0.0185
b	0.327	0.993
P-value	0.007	0.001
R-sq	0.672	0.932
N	9	8

Transforming the logs yields the following equations for estimating the number of spawners from the spawner indices of chinook in the Elk River.

$W_s = 300.59(w_s)^{0.327}$ and $H_s = 7.76(h_s)^{0.9925}$

Comparison of results from the linear model and the power function.

Comparison of the estimates of spawners using the two predictive models show very similar results for the data collected during the calibration period (Table 6).

Table 6. Comparison of the estimated spawners using two predictive models for Chinook salmon escaping to the spawning grounds in Elk River, 1972-80.

	Wild Origin Chinook			Hatchery Origin Chinook		
Year	Linear Model	Power Model	Difference	Linear Model	Power Model	Difference
1972	1756	1606	150	3037	2991	45
1973	1849	1551	298	2621	2512	109
1974	1350	1527	-177	2563	2446	117
1975	1055	1260	-206	2570	2453	116
1976	1264	1319	-55	1270	951	320
1977	2334	2184	150	5482	5798	-316
1978	2354	2234	120	3964	4036	-91
1979	1912	2215	-303	3018	2969	48
1980	1881	1841	40	1763	1522	241
Average			2			66

The expansion factors (1/sampling fraction) for wild origin spawning fish for the period 1972-80 ranged from 4.26 to13.73 using the linear model, and 4.85 to 15.75 using the power function (Table 7). For hatchery origin fish the expansion factors ranged from 6.98 to 10.0 or the linear model, and 7.39 to 7.46 for the power model.

Table 7. Expansion factors for adult aged chinook salmon applicable to recovered by sampling the spawning grounds on the Elk River from 1972-80.

	Wild Origin Chinook			Hatchery Origin Chinook		
Year	Linear Model	Power Model	Difference	Linear Model	Power Model	Difference
1972	10.45	9.56	0.89	7.54	7.42	0.11
1973	12.24	10.27	1.97	7.75	7.43	0.32
1974	9.38	10.61	-1.23	7.79	7.43	0.36
1975	13.18	15.75	-2.57	7.79	7.43	0.35
1976	13.73	14.34	-0.60	10.0	7.49	2.52
1977	5.43	5.08	0.35	6.98	7.39	-.40
1978	5.11	4.85	0.26	7.24	7.41	-0.17
1979	4.26	4.93	-0.68	7.54	7.42	0.12
1980	7.38	7.22	0.16	8.64	7.46	1.18
Average			-0.16			0.49

Discussion

In order to use this stock for the ERIS program an expansion factor is needed for observed CW-Tagged fish recovered on the spawning grounds. Either predictive model will result in very similar run size estimates and expansion factors over the range of the data that was collected during the calibration period. Because no data were observed at spawner index of less than 80 wild fish or 127 hatchery fish these models perform equally well for deriving spawner estimates and expansion factors. However, at very low stock sizes the power function would be able to predict lower abundance whereas the linear model cannot because it has an intercept that is much larger than zero. For hatchery fish, both models show that about 7.5 more fish are actually on the spawning grounds than are observed. The linear model intercept will result in escapement estimates no lower than 443 fish if 1 fish is sampled, whereas for the power function the lowest estimate is less than 10. For wild fish the linear estimate intercept is at 1,139 meaning that if no fish were seen on the spawning grounds nor in the hatchery, the 1,139 must have gone either to the fishery or were unseen on the spawning grounds. On the other hand, the power function will predict no fish in this circumstance. This latter prediction would be more favorable for risk adverse management of the stock.

One factor that determines to a great extent the validity of these predictive models is the accuracy of the catch accounting procedure. In the case of the punch card system, especially for the older data there is much uncertainty as to what sized fish were actually recorded. In addition, a non-response bias factor is applied to expand the voluntary returns of the punch cards, and this factor may have changed over the years due to changes in behavior of the anglers. For example in the 1990's the agency offered a chance to win prizes for those anglers that turned in the cards. This surely changed the behavior of the angler yet there was no change in the response factor for expanding the returned cards. For an ERIS project to more accurately estimate the catch it would be preferable to conduct annual catch surveys. Unfortunately, for the period 1980-92 no creel surveys were made and the punch card system will have to be relied upon to provide the catch estimates for the ERIS evaluation of return to river tag recoveries for that period.

The second factor that is important to this evaluation is the ability to determine the origin of the sampled fish, either of wild or hatchery origin as the models are structured on this stratification. During the calibration period all hatchery fish were fin marked. Since that time not all hatchery production has been marked. Annual Ad+CWT marking has occurred for a select number of hatchery production for general hatchery evaluation. Additionally, numerous experiments or identification for broodstock selections has been made by fin marking groups. In 1990, the majority of the production began to be marked for inclusion in the ERIS program. Typically full production at the hatchery is about 325,000 chinook smolts annually, of which at least 200,000 are Ad+CWT marked for the ERIS project. Determination of unmarked hatchery origin fish is made by means of scale analysis. ODFW scale analysts have developed techniques to separate hatchery from wild fish based on differences in circuli patterns in the freshwater phase, which are unique for the Elk and Chetco River. These rivers in southern Oregon, have no estuaries and migrating smolts reside either in the river or go directly to sea. This leads to unique scale pattern differences in hatchery and wild fish from these systems.

The third important factor in application of these predictive models is that the spawning survey must be conducted in a similar manner as during the calibration period. The spawner index is the total number of dead fish found on surveys throughout the spawning period. Therefore, if the survey effort is substantially changed in time or place then different index values would result from changes in the sampling plan rather than changes in the abundance. For the period between 1981 and the present the spawning survey protocol has been maintained similar to the calibration period surveys.

The mark-recapture study was conducted over 25 year ago, it was not designed to serve as an estimation procedure for predicting annual abundance of spawners, and much of the original data is no longer accessible. Therefore, it is advisable to conduct a new study designed specifically for the purpose of estimating the run size and spawner escapement of ERI stock fish. An independent population estimate of either the run or the spawner abundance is needed. Simultaneously a sampling plan to collect spawning fish indices is needed as well as continuation of the statistical creel survey. These data can then be calibrated for development of a predictive tool for longer term monitoring of the indicator stock.

Recommendations

For use as an ERI stock the following procedures are recommended:

1) Continue marking at least 200,000 smolts annually.
2) Continue annual statistical creel surveys to recover CW-tagged fish and provide reliable expansion factors for the fishery as well as variance estimates.

3) Continue intense spawning surveys that will match the sampling protocol used in the calibration period.
4) Adopt the power function models to estimate total spawner escapement of wild and hatchery fish, and use the resultant expansion factors from these models to estimate total escapement by tag code for the ERI stock.
5) Conduct new studies to recalibrate the estimation models.

Acknowledgements

I'd like to thank Jay Nicholas and Gary Susac for their diligence in collecting the data base for this analysis, and for their thoughtful insight into the fall chinook runs in the Elk River. I'd like to thank Mary Buckman, and Jody White for their thoughts on analysis and Shijie Zhou for editing assistance. I'm very appreciative of the time they took and the useful comments provided to improve the information.

References

Lewis, M.A. 2000. Stock Assessment of Anadromous Salmonids, 1999. Monitoring Program Report Number OPSW-ODFW-2000-4, Oregon Department of Fish and Wildlife, Portland, Oregon.

McGie, A.M. 1977. Anadromous fish research in Oregon's Coastal Watershed's. Annual Progress Report AFC-76. Oregon Department of Fish and Wildlife, Portland Oregon.

Nicholas, J.W. and D.G. Hankin, 1988. Chinook Salmon Populations in Oregon Coastal River Basins: Description of Life History and Assessment of Recent Trends in Run Strength. Informational Report Series Number 88-1. Oregon Department of Fish and Wildlife. Portland, Oregon.

Nicholas, J.W. and T. W. Downey , 1983. Coastal Chinook Salmon Studies, 1980-83. Annual Progress Report. Oregon Department of Fish and Wildlife. Portland, Oregon.

Nicholas, J.W., T. W. Downey, and L.A. van Dyke, 1985. Research and Development of Oregon's Coastal Chinook Stocks. Annual Progress Report. Oregon Department of Fish and Wildlife. Portland, Oregon.

Reimers, P.E. , J.W. Nicholas, T.W. Downey, R.E. Halliburton, and J.D. Rodgers, 1978. Fall Chinook Ecology Project. Annual Progress Report AFC-76-2. Oregon Department of Fish and Wildlife. Portland, Oregon.

Reimers, P.E. , J.W. Nicholas, D. L. Bottom, T.W. Downey, K.M. Maciolek, J.D. Rodgers, and B.A. Miller, 1979. Coastal Salmon Ecology Project. Annual Progress Report AFC-76-3. Oregon Department of Fish and Wildlife. Portland, Oregon.

Reimers, P.E., T.W. Downey, and K.M. Downey, 1981. Studies of fall chinook salmon in Elk River. Annual Progress Report AFC-102. Oregon Department of Fish and Wildlife. Portland, Oregon.

Susac, Gary. Personal communication. Regional ODFW fish biologist assigned to conduct annual sampling of chinook salmon returns to Elk River, 1985-96.

Appendices

Appendix 1.
Memo from J.W. Nicholas and G. Susac listing currently available data from the mark-recapture study during 1970-890 in Elk River, Curry County, Oregon.

Date: November 6, 1992
To: Distribution
From: Jay Nicholas
Subj: Elk River Data Base

I worked with Tim Unterwegner and Gary Susac at Elk River Hatchery on 5 November and compiled the attached data tables. These represent our assessment of the "best" numbers presently available from the base period 1970-1980 from the Elk River study. Ron Williams picked up a set of these tables on 6 November before the ink was dry and will explore alternative hindcasting approaches before we confer as a group. Please contact me if you have questions regarding this material.

Table 1. Population[a] estimates for wild and hatchery chinook that entered Elk River

	Population Estimate for wild fish		Population estimate for hatchery fish	
Return Year	Adults	Jacks	Adults	Jacks
1970	3,355	2,457	0	3,826
1971	14,21	1,040	1,929	2,121
1972	1,392	747	5,154	5,240
1973	2,029	1,059	5,930	3,405
1974	2,110	1,150	5,790	432
1975	1,714	1,750	9,237	495
1976	1,475	2,800	1,278	3,975
1977	2,555	600	9,196	2,063
1978	2,700	750	5,068	250
1979	3,005	83	4,719	172
1980	2,461	972	1,729	333

[a] These values represent the number of fish entering Elk River from the ocean. Estimates were based on mark-recapture studies.

Table 2. Adult chinook salmon sampled in spawning areas throughout Elk River during an entire run year.

	All recoveries -surveys from entire basin		Recoveries from only 4 survey areas[a]	
Run Year	Hatchery	Wild	Hatchery	Wild
1970	0	567	0	366
1971	258	122	21	68
1972	403	168	91	150
1973	338	151	38	125
1974	329	144	301	119
1975	330	80	260	64
1976	129	94	16	13
1977	785	440	626	340
1978	545	460	335	244
1979	398	449	265	213
1980	204	255	167	194

[a] Anvil creek, Rock Creek, Bald Mountain Creek, mainstem from Anvil Creek to Reynolds
.[b] Drought in 1976 inhibited upstream migration of spawners

Table 3. Chinook salmon sampled at Elk River Hatchery

	Wild [a]		Hatchery	
Run Year	Adult	Jack	Adult	Jack
1970	60	30	0	1,336
1971	32	41	650	538
1972	74	69	2,199	68
1973	122	162	2,991	2,378
1974	27	25	619	53
1975	53	53	945	95
1976 [b]	18	10	53	233
1977	110	31	2,263	486
1978	39	13	512	13
1979	66	5	819	33
1980	29	41	177	109

[a] These fish were classified "wild" because they had no marked fins. Apparently some hatchery fish were not marked during the 100% mark era at Elk River Hatchery. If so, the numbers of wild fish sampled at the hatchery is inflated to some degree.
[b] Drought in 1976 inhibited upstream migration of spawners

Table 4. Peak count (live and dead) of chinook salmon for 4 standard survey areas.

	Rock Creek	Anvil creek	Bald Mt. Creek	Panther Creek
1970	18	28	31	96
1971	13	31	18	
1972	27	247	47	26
1973	52	357	17	42
1974	82	122	36	10
1975	65	138	23	B
1976 [a]	0	0	0	0
1977	83	212	16	8
1978	83	135	14	2
1979	33	73	14	13
1980	21	85	9	1

[a] Drought year not surveyed
[b] Not surveyed

Table 5. Various estimates of catch of adult chinook salmon.

	From Punch Cards	Punch Card adjusted by % wild (from ratio observed in statistical creel)		Punch Card adjusted by % wild (from ratio observed at hatchery and all spawning surveys)		Catch estimate based on statistical creel survey	
Run Year		H	W	H	W	H	W
1970	2,175	--	--	0	2,175	--	--
1971	1,099	--	--	940	259	--	--
1972	1,685	1,262	423	1,542	143	292	98
1973	1,118	894	224	1,005	113	231	58
1974	2,144	1,822	322	1,816	328	1,809	319
1975	3,535	2,863	672	3,201	334	1,981	465
1976	2,290	1,466	824	1,418	872	380	216
1977	3,961	3.208	752	3.356	605	1,902	455
1978	2,561	1,255	1,306	1,740	821	362	376
1979	3,003	1,622	1,382	2,110	893	985	840
1980	925	601	324	530	395	83	155

General comments: prior to 1978, adults were designated on punch cards as being >= 20 inches; starting in 1978 the size was changed to 24 inches (total length). Catch estimates based on statistical creel used biological criteria (i.e. age) to distinguish jacks (age 2) from adults (ages 3 and older).

Appendix 2. Models used by district fishery management biologist for estimating run size in Elk River, Curry County, Oregon.

In practice the local district biologist used two linear equations to calculate the estimated run of fall chinook and took the average between the estimates as the point estimate for the year. The linear equations used are as follows:

Wild Adult chinook: W_a
Method 1: $W_a = 1{,}139 + 3.26\ (A_{ws} + A_{wh})$

Method 2: $W_a = 1{,}280.8 + 3.46\ (A_{ws})$ $R^2 = 0.838$, N = 11 years

Where: Wa = Estimated run of adult chinook
A_{ws} = cumulative sum of wild adult carcasses sampled on spawning grounds
A_{wh} = wild adult sampled at hatchery

Hatchery Adult Chinook: H_a

Method 1: $H_a = (457.6 + 6.4(A_{hs}) + A_{hh} + C_{ha}$

Method 2: $H_a = 1{,}206.2 + 1.7(A_{hs} + A_{hh} + C_{ha})$ $R^2 = 0.803$, N = 8 years; 1975 deleted

Where: A_{hs} = cumulative sum of hatchery adult carcasses sampled on spawning grounds
A_{hh} = wild adult sampled at hatchery
C_{ha} = estimated sport catch of hatchery adults

Taken from memo dated 1992, from Gary Susac- Elk River biologist. The source of the second set of equations is not documented.

OREGON
Fish & Wildlife

3406 Cherry Ave. NE
Salem, Oregon 97303