Evaluate Spawning of Fall Chinook and Chum Salmon just Below the Four Lowermost Columbia River Mainstem Dams

Project # 199900301

Question # 1: The background statement should be enlarged to establish an understanding of the broader regional needs for flow and water management in the mainstem Columbia River. For example, it should be made clear that the investigators understand the tradeoffs that are involved in providing water to enhance spawning effectiveness in this area with use of water later to provide flow volumes to enhance outmigrations of upriver juvenile salmon.

The second paragraph could be modified to read:

We are proposing to continue implementation of this project during FY 2003 through 2005. The primary goal of the project remains unchanged and that is to collect data concerning fall chinook and chum spawning below Columbia River mainstem dams so that the FCRPS can be managed in a manner to protect and enhance these important populations. Data from this project will be provided to the agencies involved in the management of the FCRPS as they try to balance the needs of fall chinook and chum spawning below Bonneville Dam with other management objectives upriver. Some of upriver management objectives could include the Vernita Bar agreement for spawning fall chinook, providing adequate reservoir levels in Lake Roosevelt so kokanee can access the tributaries to spawn in the fall and storing enough water in the upper Columbia and Snake River reservoirs to augment spring-time mainstem flows as upriver juvenile salmon migrate downstream past the hydro projects.

Question # 2: An enlarged background statement would help identify key questions that need to be answered and the tradeoffs that must be addressed as more and more salmon are observed to be adapting to the FCRPS.

Data collected from this project could provide important information to the managers of the FCRPS as they balance the needs of the fish below Bonneville Dam with those from upstream. With general abundance, distribution, and biological/genetic makeup of the non-index chum spawners, it may be better understood the relative importance of the Ives Island population in the context of the entire ESU. With the proposed feasibility study to estimate juvenile chum production in the Ives Island, it would allow survival rate and total abundance comparisons with the adjacent tributaries. In addition it may be possible to estimate loss from dewatering of redds or juvenile stranding. With continued CWT of the juvenile wild fall chinook in the Ives Island area, it may be possible to determine survival rates under various flow scenarios.

Question # 3: It would seem to be appropriate to include in this proposal, either as background or as a specific task, exploration of the feasibility of opening up additional spawning area at the mouth of tributaries in the lower river.

We would be willing to explore this opportunity with additional funding. The specific tasks would determining the effects of stream flows and tides on the spawning habitat, determining the quantity and quality of the spawning habitat, and identifying the extent of ground water (seeps). It will also be important to continue the spawning ground counts in those areas to determine spawner abundance and profile the biological and genetic makeup of the population.

There is insufficient justification of the need for the effort to determine the "feasibility" of estimating the juvenile chum salmon production from the mainstem Columbia in the Ives/Pierce Island area, as proposed

Without survival rates for each life stage (Egg to Fry, Fry to Adult) we cannot quantify the extent to which management strategies are working. Additionally, the salmon managers have voiced interest in the data to document the level of take that occurs from stranding and the dewatering of redds. In the Ives Island complex, current management practices hold spawning flows to approximately 130 kcfs for much of the spawning season. This does provide habitat for spawning but with high levels of redd superimposition. Without a measure of production we have no way to qualify this management activity or propose an alternative one.

Furthermore, the proposed method, to employ a mark recapture estimation procedure, would need to be described in more detail before it could be considered to be likely to succeed. The investigators need to give more thought to the problem of meeting the necessary assumptions in employing such methods, i.e. that emigration and immigration are negligible under the circumstances to be expected with chum salmon juveniles.

Estimates of Ives/Pierce Island chum production can be made by using traps in two different locations. The first trap (probably a screw trap) would be placed in Hamilton Creek, and would be used to capture and mark fry leaving the stream. Estimates of trap efficiency and population size leaving Hamilton Creek could be made by re-releasing marked fish above the trap. The second trap would be in the mainstem Columbia below the mouth of Hamilton Creek, and may be a fyke net or screw trap. Both unmarked and marked fry would be captured in the Columbia trap. The ratio of marked to unmarked fish captured will depend on the number of fry outmigrating from the Ives/Pierce Island complex relative to the number of fish migrating from Hamilton Creek. This ratio will allow estimation of the fry population originating from the Columbia River. The precision of the Ives/Pierce abundance estimate will depend on the relative sizes of the two populations, the absolute number of fish, and the trap efficiencies.

The fish will be captured, marked, released, and recaptured within different periods, during which capture efficiency may be changing due to flow conditions. Consequently, it can be considered a stratified mark-recapture experiment. Each trap efficiency trial will be uniquely paired with one capture period (stratum). This can be accomplished by releasing marked smolts at relatively short intervals (e.g. a few days) so that there is little chance that fish will be recaptured in later strata. Carlson et al. (1998) describe the problem of estimating smolt populations through stratified mark-recapture with either one or two sampling locations.

We have done some simulation studies to estimate the number of marks needed for different levels of precision of the estimate of Ives/Pierce Island fry, over a range of assumptions. The target precision levels we used are measures of "relative error" (*r*) used by Carlson et al. (1998) and first proposed by Robson and Regier (1964). These are based on the confidence interval around the estimate of the parameter of interest (in this case, Ives/Pierce fry population size) for a given confidence level. For instance, for a 95% confidence level ($\alpha = 0.05$), relative error bound is defined as

$$r = 2\frac{\sqrt{V(\hat{q})}}{q}$$

where q is the parameter of interest. Robson and Regier (1964) suggest using $\alpha = .05$ and r = 25% for management studies and r = 10% for research.

Stochastic simulations of the mark-recapture experiment were done with the following assumptions about study design or parameter ranges:

- 5 marking/recapture periods assumed, which are identical for both Hamilton trap and mainstem trap. Each period may consist of 1 or multiple weeks
- The fraction of the Hamilton population migrating into the trap in different periods was allocated to approximate a normal distribution over the season, with random variation in the allocation
- Hamilton trap and mainstem trap efficiencies varied randomly over season, with means of 35% or 20%, and 10% or 5%, respectively
- CV of 25% assumed for variation in period fraction and capture efficiency
- Simulations were done with 50, 100, or 150 females spawning in Hamilton
- 50, 100, 150, and 250 females spawning were used for mainstem areas.
- 1000 smolts per female were assumed produced in both spawning areas
- Marking assumed to occur only on first capture in Hamilton.
- Number of marks in a stratum assumed proportional to total population in that stratum
- Number of marked fish known without error
- All Hamilton fish, both marked and unmarked, captured at the Hamilton trap, assumed to survive and be re-released.
- Emergence and migration timing is similar for both groups of fish
- The groups are equally susceptible to being captured in the mainstem trap.

Curves relating the relative error in the Ives/Pierce smolt abundance estimate to the number of marked fish released from Hamilton Creek were generated for the different permutations of assumed spawner abundance in the two areas and capture efficiencies. Results showed that with 20,000 total marks, the resulting *r* was close to or less than 25%

for all assumptions, and often less than 10% (especially if mainstem abundance is high). With 10,000 marks, *r* was less than 25% for most combinations of assumptions about spawner size and trap efficiency, and for some combinations was close to or less than 10%. With 5,000 marks, *r* was generally less than 25% if trap efficiency means were set at the optimistic values.

References

Carlson, S.R., L.G. Coggins, and C.O. Swanton. 1998. A simple stratified design for mark-recapture estimation of salmon smolt abundance. Alaska Fishery Research Bulletin 5: 88-102.

Robson, D.S. and H.A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Trans. Am. Fish. Soc. 93: 215-226.

Under Task 3.b Analysis, it is said that "Regression analysis will be used to determine in a statistically rigorous manner the extent to which each habitat metric plays in predicting habitat". This statement needs to be enlarged upon for clarification and to establish credibility.

Logistic regression

We will be constructed a logistic regression model to predict the probability, P_i, of Chum Salmon and Fall Chinook Salmon redd presence in i habitat cells given habitat characteristics of each cell. P_i can be expressed as:

$$P_i = \frac{e^{g(x)}}{1 + e^{g(x)}}$$

where g(x) is the linear combination of parameter estimates of the predictor variables.

Model development will began by regressing redd presence against each habitat variable separately to determine if each one-variable model was significantly different from a constant-only model. This will be done using the likelihood ratio test, whose statistic, G, is equal to minus twice the difference between the log likelihoods of the two models. This statistic will be compared to the chi-square distribution with 1 df at a=0.05 (Hosmer and Lemeshow 1989). We also considered habitat variables with P values <0.25 as candidates for multivariate analyses.

One of the assumptions of logistic regression regarding continuous variables is that the relationship between a predictor and the logit will be linear. We will examine this assumption following the methods of Demaris (1992) for velocity, substrate and depth.

We will evaluate the performance of our logistic regression models using cross-validation. Cross-validation involves removing one observation from the data set and estimating the logistic model using the remaining observations. The probability of redd presence in the excluded observation is then estimated according to this model. This process is repeated for each observation in the data set, and classifications of redd presence and absence is then tabulated. Probabilities =0.5 will be used to define fish presence. Statistical analyses will be performed using SAS software (SAS 1998).

References

Demaris, A. 1992. Logit modeling. Sage Publications, Series 7-86, Newbury Park, California.

Hosmer, Jr., D.W., and S. Lemeshow. 1989. Applied logistic regression. John Wiley and Sons, New York, New York.

SAS. 1998. SAS/STAT user's guide, release 7.0. SAS Institute, Cary, North Carolina.

Question # 4: The proposal calls for the CWT implantation of Ives/Pierce Island fall chinook. It is not clear how these will be discriminated from other stocks that may move downstream and inhabit those locales. Clarifying this would be helpful.

Identification of locally produced fall chinook will be based on a combination of size at capture and time of capture. CWT implantation occurs during the spring when juvenile fall chinook rearing in the Ives Island study area are at a size that allows separation of local chinook using the area for rearing purposes from non-local chinook using the area for outmigration purposes based on size. Early in the collection period, prior to June, local rearing juvenile fall chinook are significantly smaller than non-local outmigrating fall chinook and therefore can be separated based on size. This separation technique has been corroborated based on data collected from fall chinook released from Spring Creek Hatchery. Since releases from Spring Creek Hatchery occur only a few miles upstream of the survey area, and migration time to the study area is short, it is easy to determine when these fish arrive at the study area. When the Spring Creek releases arrive in the study area they are easily identifiable based on size alone. The origin of the larger size fish was further documented by the appearance of larger-sized adipose fin-clipped fall chinook in the study area and a peak in juvenile passage over Bonneville Dam just prior to their arrival in the study area.

The opportunity for other non-local juvenile fall chinook rearing in the study area is unlikely for several reasons. First and foremost is that there is little suitable spawning habitat that exists between the upstream end of the study area and Bonneville Dam (located 2 miles upstream); therefore, there is limited opportunity for juvenile fall chinook to move into the study area from upstream locations. Additionally, it is unlikely that fall chinook emerging from redds built downstream of the study area would move upstream into the study area to rear. Finally, juvenile fall chinook passage is enumerated at Bonneville Dam and passage is very low, excluding full term smolts, prior to June. Based on this information it is highly unlikely that any significant amount of non-local juvenile fall chinook would move into the study area prior to June.

Implantation of CWTs is terminated in June when the abundance of outmigrating upriver fall chinook increase and separation of local stocks and non-local outmigrating upriver stocks is no longer feasible. The downstream migration of juvenile fall chinook can be tracked based on counts at dams on the mainstem Columbia and Snake Rivers. When passage increases at Bonneville Dam a portion of those juvenile fall chinook appear in the study area. In contrast to earlier in the year, by June the outmigrating upriver juvenile fall chinook are now similar in size to local juvenile fall chinook rearing in the study area. Even though additional local juvenile fall chinook are available in the study area for marking, implantation of CWT's is terminated at this time to ensure that only local stock fall chinook receive a CWT.