Preliminary Proposal for FY 2005 funding

Title: Estimating the survival of migrant juvenile salmonids through Bonneville Dam using Radio-Telemetry: 2005 evaluations

Study Codes:	SPE-P-02-1
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PROJECT SUMMARY

RESEARCH GOALS

The goal of this research is to estimate the survival of juvenile salmonids through specific routes at Bonneville Dam and to estimate survival through the entire dam.

STUDY OBJECTIVES

During 2005, we propose to use radio-tagged fish releases and radio-telemetry detection schemes to estimate the survival of yearling and sub-yearling Chinook salmon and steelhead trout at Bonneville Dam. The research activities contained in the objectives described below may be subject to change pending changes in recommended dam operations during 2005 or shifts in the priorities of management agencies after the submission of this document and the nature of the 2005 water year. As part of this study, the USGS will continue to coordinate with the ACOE and regional fish managers to provide the necessary information to them so that the objectives of the studies at Bonneville Dam meet their expectations.

Objective 1. Determine the appropriate experimental design and conduct power analyses to determine sample size requirements for estimating the survival of juvenile salmonids at Bonneville Dam using radio-telemetry.

The USGS will work with the Army Corps of Engineers and University of Washington staff to formulate the experimental design and sample size requirements of the radio-telemetry survival evaluations at Bonneville Dam during 2005. The process of prioritizing and selecting specific evaluations has been an iterative process in past years and thus, requires design flexibility within the context of existing logistical constraints. Appropriate release strategies, models, and statistical tests will be identified given the final set of objectives and hypotheses selected.

Objective 2. Estimate the survival of juvenile yearling and sub-yearling Chinook salmon and steelhead trout passing through the ice and trash sluiceway at Bonneville Dam's powerhouse 1 (B1).

Similar to evaluations in 2004, we will use releases of radio-tagged fish released directly into the B1 ice and trash sluiceway, releases into the tailrace of Bonneville Dam, and the paired release-recapture models of Burnham et al. (1987) to estimate survival of juvenile salmonids through this route.

Objective 3. Estimate the survival of juvenile yearling Chinook salmon and steelhead trout passing through a minimum gap runner turbine unit at B1.

Similar to evaluations during 2002 and 2004, we will use releases of radio-tagged fish directly into a minimum gap runner turbine unit at Bonneville Dam's B1, below the front roll immediately downstream of B1, below the B2 juvenile bypass outfall, and the paired release-recapture models of Burnham et al. (1987) to estimate the survival of fish passing via this route.

<u>Objective 4.</u> Estimate the route specific survival of juvenile yearling and sub-yearling Chinook salmon and steelhead trout passing through Bonneville Dam.

During 2005, we will use releases of radio-tagged fish at The Dalles Dam, releases below the B2 juvenile bypass outfall, and the route specific survival model (RSSM) (Skalski et al. 2002) to estimate the survival of fish passing via B1, B2, the new corner collector at B2, the B2 juvenile bypass system, the spillway, and for fish passing all routes collectively.

<u>Objective 5.</u> Estimate false-positive detection rates for radio-tagged dead fish released below Bonneville Dam.

False-positive detections from radio tags on dead fish may positively bias survival estimates (Skalski et al. 1998a). Thus, we propose to continue to monitor radio-tagged dead fish released below Bonneville Dam to evaluate false-positive detection rates.

RELEVANCE TO THE BIOLOGICAL OPINION

Per the National Marine Fisheries Service, Biological Opinion RPAs 64 (MGR), 66 (B2 CC), & 82 (spill survival) the Portland District will be evaluating survival through all juvenile salmonid fish passage routes. With the completion of the corner collector at powerhouse 2, a post construction survival program to evaluate project survival, and route specific survival data are necessary to evaluate future fish passage programs and operations at the Bonneville project. Further, two routes at the first powerhouse will be evaluated (B1 MGR & I&T) for survival to assist in future planning efforts.

PROJECT DESCRIPTION

BACKGROUND AND JUSTIFICATION

As anadromous juvenile salmonids migrate from freshwater rearing habitats to the ocean, they are vulnerable to a host of factors that affect their survival. Direct effects associated with dam passage (e.g., instantaneous mortality, injury, loss of equilibrium, etc.) and indirect effects (e.g., predation, disease, and physiological stress) contribute to the total mortality of seaward migrating salmonids. Many studies have been conducted to determine the effects of hydroelectric dams on the survival of salmonid migrants (Raymond 1979, Stier and Kynard 1986, Iwamato et al. 1994, Muir et al. 1995, Smith et al. 1998). Giorgi et al. (2002) noted that survival of salmonid migrants is variable among projects and across species. Thus, studies designed to estimate project specific survival and route specific survival (i.e. through turbines, bypass areas, and spillways) of juvenile salmon are essential to identify areas of mortality. Based on this research and studies examining migrant salmonid behavior at dams in the Columbia River Basin, management actions are currently being implemented to improve the survival of juvenile salmonid migrants.

New fish marking techniques and the development and acceptance of new statistical methodologies (see Lebreton et al. 1992) have led scientists to reevaluate past techniques used to assess survival of migrant salmonids in the Columbia River Basin. The development of the passive integrated transponder (PIT) tag allowed for the unique identification of fish (Prentice et al. 1990), and recent technological advancements in radio-telemetry equipment have decreased the size and increased the life of transmitters allowing for use with juvenile fish passage behavior and survival studies (Skalski et al. 2002, Counihan et al. 2002 and In review). Consequently, PIT-tag recoveries, radio telemetry capture histories, and release-recapture models (Burnham et al. 1987, Smith et al. 1996) have been used to assess the survival of migrant salmonid smolts through various reaches of the Columbia and Snake Rivers (Muir et al. 1995, Skalski et al. 1998b, Smith et al. 1998, Dawley et al. 1998, Skalski et al. 2002). Results from studies examining simultaneous releases of PIT-tagged and radio-tagged fish in the Snake River and mid Columbia River suggest similar trends in survival between the two groups (Hockersmith et al. 2000). Further, concurrent releases of radio- and PIT-tagged yearling Chinook salmon at The Dalles Dam also indicate that estimates from the two tagging techniques provide comparable estimates (Counihan et al. In review). Estimates of survival generated from radio-tagged sub-yearling Chinook salmon were less comparable. However, the large confidence intervals associated with both PIT- and radio-tagged fish were not conducive to a meaningful evaluation of the comparability of the estimates.

Although the two techniques have similar results, there are important considerations with each method. The use of the PIT-tag technique relies on the availability of PIT-tag detectors at hydroelectric dams, which are not present at all locations in the Columbia River Basin (e.g. The Dalles Dam). The absence of PIT-tag detectors at certain projects and areas below Bonneville Dam has precluded or confounded survival estimation in some specific reaches of the Columbia River and limited the spatial scale over which survival estimates can be made. Further, the low detection probabilities associated with this technique requires that large numbers of fish be handled (although minimally) to obtain desired levels of precision in survival estimates (Skalski 1999b). Detection rates of marked fish affect the sample size required for a given level of precision and thus, the reliability of survival estimates (Skalski 1992). The radio-telemetry technique offers high detection rates, observed in migrant salmonid studies at specific project sites and in-river sites in the lower Columbia River, suggesting that the numbers of fish necessary to generate survival estimates with similar or greater precision could be reduced using radio-tagged fish. Further, the flexibility of radio-telemetry system deployment at hydroelectric projects and in-river locations can increase the geographic area over which estimates are generated (e.g. areas below Bonneville Dam).

A primary objective of The National Marine Fisheries Service (NMFS) Federal

Columbia River Power System (FCRPS) Biological Opinion is to increase survival of juvenile salmonid out migrants through the federal hydrosystem (NMFS 2001). To help meet this goal migrant salmonids are diverted from turbine passage by turbine bypass systems and spill scenarios used to increase spillway passage. While there is a consensus that survival is greater for fish diverted from turbines, questions regarding the effectiveness of different spill patterns and other passage scenarios remain (Dawley et al. 1998). During 1999, tests of the efficacy of different spill scenarios were conducted at both John Day and The Dalles Dams. The motivation for these evaluations was to identify which spill scenario will increase fish passage efficiency and reduce predation of migrant juvenile salmonids by altering the hydraulic conditions in the forebay environment, shortening travel times through tailrace areas, and manipulating passage routes through tailrace areas to divert fish from areas with high predator densities. Ultimately, these actions are designed to increase the survival of migrant salmonids as they migrate through projects in the lower Columbia River. Thus, there is a need to estimate the survival of migrant juvenile salmonids in the lower Columbia River to evaluate the utility of these management actions.

The Columbia River Research Laboratory (CRRL) has studied the behavior of migrant salmonids in the lower Columbia River since 1995. During 2005, we propose to use radio-tagged fish releases and radio detection arrays to generate survival estimates at Bonneville Dam. Survival will be estimated through the ice and trash sluiceway and a minimum gap runner turbine unit at powerhouse 1, the corner collector and juvenile bypass system at powerhouse 2, the spillway, and through powerhouse 1 and 2, and for yearling and sub-yearling Chinook salmon and steelhead trout passing via all routes at Bonneville Dam.

CURRENT STATUS

Evaluations conducted during 1999 and 2000 demonstrated the feasibility of using radio telemetry to estimate the survival of juvenile salmonids passing through the John Day, The Dalles, and Bonneville dams. During 2000, radio-tagged yearling and sub-yearling Chinook salmon and steelhead trout were released in the lower Columbia River to evaluate FPE and estimate survival. During 2000, the evaluation of two spill conditions (12 v. 24 h spill), at John Day Dam, indicated differences in survival for groups passing the project during each operating scenario. However, further analyses suggest that other environmental conditions were variable within and between the two treatments and that the variability in conditions (including spill percent within treatments) may have affected the survival of both yearling Chinook salmon and steelhead trout and confounded the original intent of the experiment. Releases of yearling Chinook during 2000 were made above and below Bonneville Dam to assess the feasibility of estimating survival at this project. The results of the pilot study at Bonneville Dam suggested that the high capture probabilities observed during the evaluations in the impounded Columbia River were also possible in the un-impounded reach below Bonneville Dam.

During 2001, we estimated the survival of yearling and sub-yearling Chinook salmon at Bonneville Dam. The survival of paired releases of radio-tagged fish was evaluated using the paired release-recapture models of Burnham et al. (1987). The original objectives for the 2001 survival evaluation at Bonneville Dam were altered because of the low water conditions present during 2001. The scaled back objectives were to provide estimates of survival for fish passing via all routes at Bonneville Dam and to provide estimates of the relative survival of fish passing through the juvenile bypass system at powerhouse 2.

The evaluation of the assumptions associated with the survival models used during these studies indicated that, in general, the assumptions were satisfied. Similar to the survival evaluation during 1999 and 2000, the results of Burnham tests 2 and 3, which test the assumptions that upstream or downstream detections affect downstream survival and/or detection and whether upstream capture histories affect downstream survival and/or capture, were largely incalculable. We will continue to evaluate Burnham tests 2 and 3 in future years; however, the utility of these tests to discern whether these assumptions have been met is confounded by the high capture probabilities now possible with the radio-telemetry detection arrays

Few differences in the arrival times of the treatment and control groups were detected. In those cases where we observed differences, we further examined the river discharge and temperature conditions present during the passage of the treatment and control groups at the radio-telemetry arrays below Bonneville Dam and found that for most releases, the conditions were similar. The exception being a paired release group that passed Bonneville Dam on the Fourth of July that was subjected to different discharge conditions presumably due to dam operations related to decreased electricity demand on this holiday. Releases of dead radio-tagged yearling and sub-yearling Chinook salmon at Bonneville Dam indicated that it was possible that dead fish may have been detected at the downriver radio-telemetry arrays. One dead radio-tagged yearling chinook salmon was detected at all of the three radio-telemetry detection arrays below Bonneville Dam and one dead radio-tagged sub-yearling Chinook salmon was detected at the first radio-telemetry detection array below Bonneville Dam.

The survival of yearling Chinook salmon passing via all routes at Bonneville Dam was evaluated using paired releases made at Bonneville Dam (based on detections at Bonneville Dam of fish released near Hood River, OR) and in the tailrace of Bonneville Dam. The survival probabilities ranged from 0.85 to 1.05. The average dam survival at Bonneville Dam for yearling Chinook salmon was estimated to be 0.937 (SE = 0.014). Dam survival during the day was estimated to be 0.923 (SE = 0.024) and night relative survival was estimated to be 0.949 (SE = 0.016). No significant differences were detected between day and night dam survival (one-tailed t-test, P = 0.19) but the power associated with this test was low ($1 - \beta = 0.22$). No significant relations were detected (linear regression, $P > 0.10$) between the dam survival of yearling Chinook salmon and total river discharge, total turbine discharge, or total powerhouse discharge. Because of the low water year during 2001, appreciable spill at Bonneville Dam occurred during only the last seven releases during the spring migration evaluation and allowed a comparison of the relative survival of yearling Chinook passing Bonneville Dam during periods of spill and no spill. Prior to the initiation of spill at Bonneville Dam, the survival of yearling Chinook passing through all routes at the project was 0.928 (n = 8, SE = 0.023) and after spill was initiated, was 0.946 (n = 7, SE = 0.015). The survival for yearling Chinook salmon passing Bonneville Dam before and after spill was initiated was not statistically different (one tailed t-test, P = 0.27). However, the power associated with this test was low ($1 - \beta = 0.14$).

Survival for yearling Chinook salmon released at the top of the powerhouse 2 juvenile bypass system (JBS) ranged from 0.78 to 1.1. The average survival through the JBS was estimated to be 0.962 (SE = 0.023). Survival through the juvenile bypass system during the day was estimated to be 0.953 (SE = 0.039) and night survival was estimated to be 0.971 (SE = 0.027). No significant differences were detected between day and night survival through the JBS (one tailed t-test, $P = 0.35$) with power ($1 - \beta = 0.10$). Similar to the results for dam survival, no significant relations were detected (linear regression, $P > 0.10$) between the relative juvenile bypass survival of yearling Chinook salmon and total river discharge, total turbine discharge, or total powerhouse discharge.

We separated the yearling Chinook paired releases groups (e.g., released near Hood River and detected at Bonneville Dam and in the tailrace of Bonneville Dam) into turbine passed and non-turbine passed fish. The survival of turbine passed fish ranged from 0.83 to 1.07. The average survival for turbine passed yearling Chinook was 0.929 (SE = 0.02). For non-turbine passed fish, the survival ranged from 0.82 to 1.03. The average survival for non-turbine passed yearling Chinook was 0.937 (SE = 0.02). For turbine passed yearling Chinook, the average survival of fish passing during periods of spill was 0.900 (SE = 0.032) and during periods of no spill was 0.954 (SE = 0.024). The relative survival of turbine passed yearling Chinook passing during periods of spill and no spill were marginally significantly different (one-tailed t-test, $P = 0.098$) at an alpha level of 0.10. The average survival of non-turbine passed fish during periods of spill was 0.96 (SE = 0.018) and for periods of no spill was 0.91 (SE = 0.029). The difference between the average survival levels during periods of spill and no spill for non-turbine passed fish was found to be significantly different (one-tailed t-test, $P = 0.086$).

The dam survival of sub-yearling Chinook salmon passing via all routes at Bonneville Dam was based on the same release locations as those used for yearling Chinook salmon. The dam survival of sub-yearling Chinook salmon ranged from 0.73 to 1.08. The estimated average project survival was 0.902 (SE = 0.036). The average project survival during day releases was estimated to be 0.895 (SE = 0.044) and during night releases was 0.910 (SE = 0.066). No significant differences between day and night dam survival were detected (one-tailed t-test, $P = 0.42$). No significant relations (linear regression, $P > 0.10$) between total river discharge, total turbine discharge, and total powerhouse 2 discharge were detected.

Sub-yearling Chinook salmon were also released at the top of the powerhouse 2 juvenile bypass system (JBS) during 2001. Sub-yearling Chinook salmon JBS survival ranged from 0.62 to 1.28. The average JBS survival was estimated to be 0.90 (SE = 0.053). The average JBS survival for the day releases was estimated to be 0.870 (SE = 0.089) and for night releases was 0.946 (SE = 0.0374). The average survival estimates were not found to be significantly different between day and night releases (variance weighted one-tailed t-test, $P = 0.23$). Significant relations (linear regression, $P < 0.1$) between total river discharge, total turbine discharge, and total powerhouse 2 discharge were detected.

Spill operations at Bonneville Dam were present during the last seven paired releases of yearling Chinook allowing post-hoc comparisons to be made between fish arriving during spill and no spill operations. No significant differences between the survival of fish passing via all routes at Bonneville Dam during spill and no spill operations were detected. However, when the paired releases were separated into turbine and non-turbine passed fish, there were significant differences in survival between fish passed during spill and no spill operations. The survival of yearling Chinook passing via the turbines was greater during periods of no spill versus spill operations while the opposite was true for non-turbine passed fish (e.g., survival was greater during periods of spill vs. no spill operations). The opposite trends in survival between these two groups likely contributed to the insignificant difference in the survival of fish passing via all routes at Bonneville Dam during spill and no spill.

Evaluations of radio-tagged yearling Chinook salmon survival through a minimum gap runner (MGR) turbine unit and the downstream migration channel at Bonneville Dam's powerhouse 1 were conducted during 2002. Using releases of radio-tagged yearling Chinook salmon released as part of the survival evaluation at The Dalles Dam, and releases made below the outfall of the second powerhouse juvenile bypass system, we were also able to evaluate survival through the spillway and the first and second powerhouses. We estimated that the survival of yearling Chinook salmon released through the John Day Dam juvenile bypass during 2002 ranged from 0.90 to 1.33. The average survival of yearling Chinook salmon released through the MGR turbine unit at powerhouse 1 (control group released directly below front roll of turbine unit) during the 2002 migration season was 1.06 (± 0.057, 95% confidence interval). We estimated that the survival of yearling Chinook salmon released into the MGR turbine unit at Bonneville Dam's powerhouse 1 (control release below the powerhouse 2 JBS outfall) during 2002 ranged from 0.90 to 1.13. The average survival was estimated to be 1.01 (± 0.031, 95% confidence interval). We estimated that the survival of yearling Chinook salmon released into the DSM at Bonneville Dam's powerhouse 1 (control release below the powerhouse 2 JBS outfall) during 2002 ranged from 0.60 to 1.05. The average survival was estimated to be 0.91 (± 0.081, 95% confidence interval). Using capture histories generated from the detections of radio-tagged yearling Chinook salmon released at The Dalles Dam and below the powerhouse 2 juvenile bypass outfall, we generated maximum likelihood estimates of the route-specific passage and survival probabilities for yearling chinook salmon at Bonneville Dam. The survival of yearling Chinook salmon through the Bonneville Dam spillway was estimated to be 0.977 (SE = 0.0135; profile likelihood 95% confidence interval = [0.951, 1.000). For yearling Chinook passing via powerhouse 1 the estimated survival was 0.902 (SE = 0.036, profile likelihood 95% confidence interval [0.824, 0.965]) and for yearling Chinook passing via powerhouse 2 the estimated survival was 0.993 (SE = 0.036, profile likelihood 95% confidence interval [0.964, 1.021]). Yearling Chinook salmon dam survival through Bonneville Dam was estimated to be 0.977 (SE = 0.019).

The survival of yearling and sub-yearling Chinook salmon and steelhead trout were evaluated during 2004. Both RSSM and paired release model designs were employed to evaluate the survival through various routes at Bonneville Dam. As of the submission of this preliminary proposal, releases have been completed and data processing is underway.

OBJECTIVES AND METHODOLOGY

There are certain common analyses that will be conducted for all of the potential survival estimation scenarios presented in the objectives below. In this section we will present the proposed objectives and associated tasks and then follow with a discussion of the methodologies proposed for the survival analyses.

Objective 1. Determine the appropriate experimental design and conduct power analyses to determine sample size requirements for assessing survival of juvenile salmonids at Bonneville Dam using radio-telemetry.

Rationale

The USGS will work with the Army Corps of Engineers and University of Washington staff to formulate the experimental design and sample size requirements for the radio-telemetry survival evaluations at Bonneville Dam during 2005. The process of prioritizing and selecting specific evaluations has been an iterative process in past years and thus, requires design flexibility within the context of existing logistical constraints. Appropriate release strategies, models, and statistical tests will be identified given the final set of objectives and hypotheses selected.

Objective 2. Estimate the survival of juvenile yearling and sub-yearling Chinook salmon and steelhead trout passing through the ice and trash sluiceway at Bonneville Dam's powerhouse 1. (SPE-P-02-1)

Rationale

In the National Marine Fisheries Service (NMFS) Federal Columbia River Power System (FCRPS) Biological Opinion (NMFS 2001), certain hydropower system actions have been proposed to improve the passage survival of in-river migrants through FCRPS dams and reservoirs. Included in these actions are enhanced spill, spillway improvements to facilitate higher spill levels without exceeding harmful TDG levels, improved flow management, physical improvements to both juvenile and adult fish passage facilities, and continuation of spill at collector projects to maximize survival rates of in-river migrants. The dam passage survival rate at Bonneville Dam is currently at an unacceptable level and thus, has been designated as a high priority for improvements (NMFS 2001). Specific dam operation measures for Bonneville Dam have been described in the biological opinion, including 24-hour spill with nighttime spill limited to the TDG cap and daytime spill limited to 75 kcfs for adult passage. Evaluations of survival will assist managers in determining the efficacy of the actions at improving the survival of in-river migrants.

Using releases of radio-tagged fish made directly into the ice and trash sluiceway, releases into the tailrace below Bonneville Dam, and the paired release-recapture models of Burnham et al. (1987) the series of survival parameters depicted in Figure 1 will be generated. In the last reach, survival (S) and capture processes (p) cannot be differentiated (i.e., $\lambda = S \cdot p$).

Task 2.1 Prepare data for input into SURPH software.

Activity 2.1.1 Proof database of contacted radio-tagged fish for accuracy by applying established protocols for determining the validity of records.

Schedule: June through September 2005

Activity 2.1.2 Generate capture-history matrices from the proofed database using the Statistical Analysis System (SAS).

Task 2.2 Generate survival estimates using SURPH software.

Activity 2.2.1 Test the validity of model assumptions.

Schedule: September through October 2005

Activity 2.2.2 Model the downstream survival and capture processes of each paired release using forward- and reverse-sequential procedures.

Schedule: September through November 2005

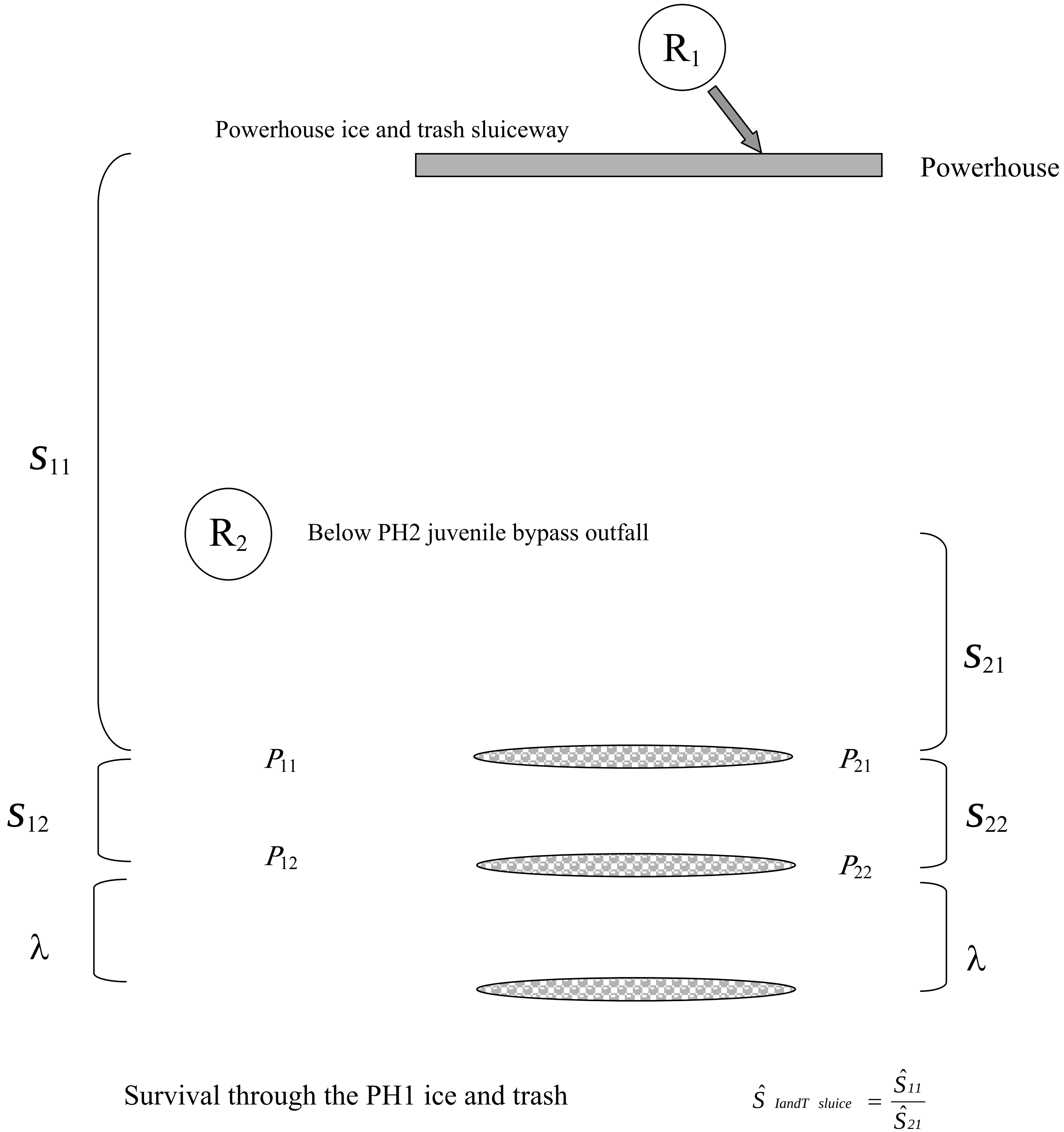


Figure 1. Schematic of releases, possible detection sites, and estimated survival parameters (S = survival estimate, p = capture probability, and $\lambda = S \cdot p$) generated in a paired release-recapture design to estimate migrant juvenile salmonid survival through the ice and trash sluiceway at powerhouse 1, Bonneville Dam. Release R_1 represents fish released into the sluiceway. Dams are represented by rectangles and ovals represent potential detection arras.

Activity 2.2.3 Combine survival estimates across replicate releases and generate survival parameters.

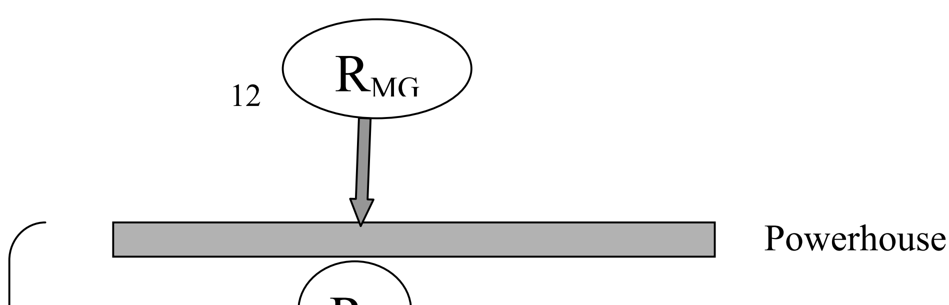
Schedule: September through November 2005

Objective 3. Estimate the survival of juvenile yearling and sub-yearling Chinook salmon and steelhead trout passing through a minimum gap runner turbine unit at Bonneville Dam. (SPE-P-02-1)

Rationale

To increase juvenile salmonid survival through Bonneville Dam, the juvenile fish passage facilities have been modified. Included in these modifications are a new juvenile bypass system and outfall. Evaluations of the survival of yearling Chinook salmon through the new juvenile bypass system and outfall at Bonneville Dam's powerhouse 2 were initiated in 2000 and continued in 2001. Additional structural and operational modifications have also been stipulated in the NMFS FCRPS biological opinion. Included among these are extended submerged screen intakes, surface collectors, and installation and evaluation of minimum gap runner units at Bonneville Dam's powerhouse 1, spillway deflector optimization development at the spillway, and surface bypass corner collector at Bonneville Dam's powerhouse 2 (NMFS 2001). Estimates of survival generated prior to these modifications or evaluations of survival through existing modifications will allow managers to assess the usefulness of these actions at improving the in-river survival of migrant salmonids

During 2000, an evaluation of the survival of fish passing through a minimum gap runner (MGR) turbine unit installed at Bonneville Dam was conducted (Schwartz, 2000). Schwartz (2000) found significant differences in the survival of balloon tagged fish released into MGR units versus existing units and thus provided estimates of direct mortality through the MGR unit. We also conducted evaluations of survival through the minimum gap runner turbine unit during 2002; preliminary results suggest that survival through this unit was high for yearling Chinook. During 2004, we continued these evaluations. Releases of radio-tagged fish were made directly into the MGR turbine unit and directly below the unit downstream of the front-roll. We will use the paired release-recapture models of Burnham et al. (1987) to generate estimates of relative survival through this route. Using these releases of radio-tagged fish, the series of survival parameters depicted in Figure 2 will be generated. In the last reach, survival (*S*) and capture processes (*p*) cannot be differentiated (i.e., $\lambda = S \cdot p$).



Task 3.1 Prepare data for input into SURPH software.

Activity 3.1.1 Proof database of contacted radio-tagged fish for accuracy by applying established protocols for determining the validity of records.

Schedule: June through September 2005

Activity 3.1.2 Generate capture-history matrices from the proofed database using the Statistical Analysis System (SAS).

Schedule: September 2005

Task 3.2 Generate survival estimates using SURPH software.

Activity 3.2.1 Test the validity of model assumptions.

Schedule: September through October 2005

Activity 3.2.2 Model downstream survival and capture processes of each paired-release using forward- and reverse-sequential procedures.

Schedule: September through November 2005

Activity 3.2.3 Combine survival estimates across replicate releases and generate survival parameters.

Schedule: September through November 2005

Objective 4. Estimate the route specific, dam, and project survival of juvenile salmonids passing through Bonneville Dam (SPE-P-02-1)

Rationale

To increase juvenile salmonid survival through Bonneville Dam, the juvenile fish passage facilities have been modified. Included in these modifications are a new juvenile bypass system and outfall. Additional structural and operational modifications have also been stipulated in the NMFS FCRPS biological opinion. Included among these are extended submerged screen intakes, surface collectors, and installation and evaluation of minimum gap runner units at Bonneville Dam's powerhouse 1, spillway deflector optimization development at the spillway, and surface bypass corner collector at Bonneville Dam's powerhouse 2 (NMFS 2001). The corner collector at powerhouse 2 has been completed and estimates of survival will allow managers to assess the usefulness of this route at safely passing juvenile salmonids past Bonneville Dam.

We propose to use radio telemetry and the Route Specific Survival Model (RSSM) developed at the University of Washington to estimate survival through

Bonneville Dam. Using releases of radio-tagged fish at The Dalles Dam and below the outfall of the powerhouse 2 juvenile bypass and the radio-telemetry detection arrays below Bonneville Dam, the series of survival estimates shown in Figure 3 can be generated.

Task 4.1 Prepare data for input into the USER 1.0 software.

Activity 4.1.1 Proof database of contacted radio-tagged fish for accuracy by applying established protocols for determining the validity of records.

Schedule: June through September 2005

Activity 4.1.2 Generate capture-history matrices from the proofed database using the Statistical Analysis System (SAS).

Schedule: September 2005

Task 4.2 Generate project survival estimates using the RSSM and the USER 1.0 software

Schedule: September through November 2005

Objective 5. Estimate the false-positive detection rates for radio-tagged fish released in the tailrace of Bonneville Dam (SPE-P-02-1).

Rationale

A basic assumption when using release-recapture models to estimate survival is that all fish detected at a particular detection array are alive. However, radio tags on dead fish may result in false-positive detections (Skalski et al. 1998a) which would result in positively biased estimates of survival. Since false-positive detections may occur from dead radio-tagged fish that are transported downstream by the river current or predators, flow conditions may affect the numbers of fish detected at downstream locations. During 2000 and 2001 no dead fish were detected from releases at John Day and The Dalles dams. However, one dead yearling Chinook salmon was detected at all arrays below Bonneville Dam and one sub-yearling Chinook salmon was detected at the first array below Bonneville Dam during 2001, but not during subsequent evaluations. Thus, we will radio tag and release dead fish in the tailrace of Bonneville Dam to empirically evaluate false detection rates and coordinate with University of Washington staff to incorporate detections of dead fish into the survival estimates if necessary.

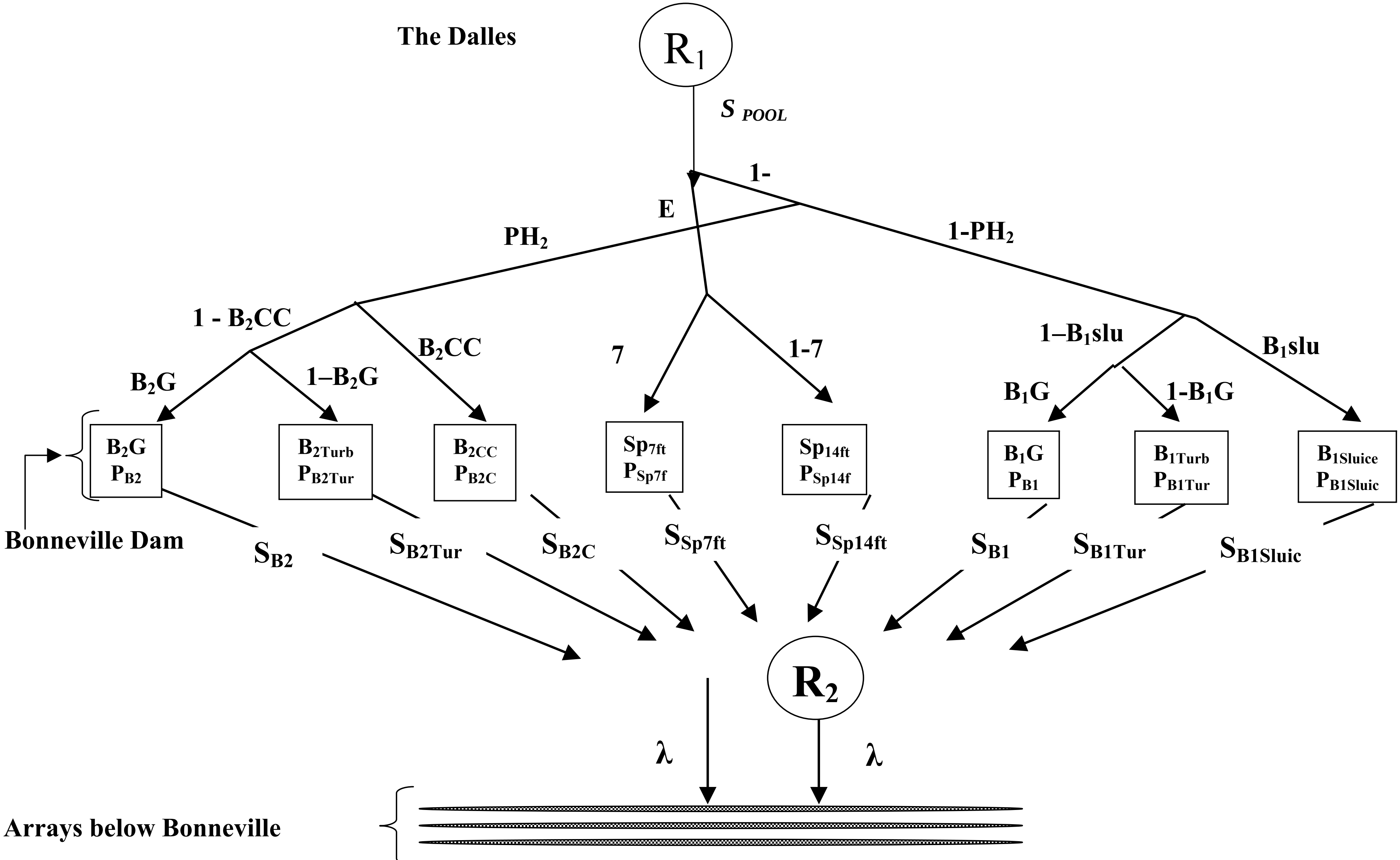


Figure 3. A description of the parameters that can be estimated using the route specific survival model (RSSM) using the proposed release and detection schemes for 2005. Included in the detection scheme is a double radio-telemetry array at Bonneville Dam that is necessary to use the RSSM.

Task 5.1 Implant radio transmitters, euthanize, and release dead fish in areas below Bonneville Dam.

Activity 5.1.1 Juvenile salmonids will be implanted with radio transmitters, subjected to a lethal dose of MS-222, pithed, and released at normal release locations below Bonneville Dam.

Schedule: May through July 2005

Task 5.2 Calculate the percent false-positive detections for radio-tagged fish.

Activity 5.2.1 Verify the validity of contacts of dead radio-tagged fish detected at arrays downstream of release sites.

Schedule: June through September 2005

Activity 5.2.2 Estimate the rate of false-positive detections for all areas of interest.

Schedule: September 2005

Task 5.3 Coordinate with University of Washington personnel to develop methods of incorporating false-positive detections into the survival estimates if necessary.

METHODS FOR GENERATING SURVIVAL ESTIMATES

From 1999 to 2004 survival estimates for yearling and sub-yearling Chinook salmon and steelhead trout were generated from radio telemetry studies in the lower Columbia River by the U. S. Geological Survey-Biological Resources Division-Columbia River Research Laboratory. The analyses of these data are ongoing and will be used to provide information on detection and survival probabilities, logistics, and model assumptions that will facilitate the design of the studies proposed for 2005. A report entitled "Statistical Methods to Extract Survival Information from the John Day and The Dalles Dam Radiotag Studies" submitted to Marvin Shutters, ACOE from Dr. John R. Skalski, University of Washington outlines some of the methods that will be used to perform the analyses of 2005 data. Descriptions of various aspects of the RSSM can be found in Skalski et al. (1998a).

There are assumptions associated with using the paired release-recapture model to estimate survival, some are biological and some pertain to the statistical models (Burnham et al. 1987, Skalski et al. 1998a, Skalski 1999a). The validity of some of the assumptions listed below can be evaluated using statistical tests and others can be met through careful consideration of fish collection, holding, tagging, and detection techniques. Strict protocols are already in place for the radio tagging techniques that will be used in these studies, and we will perform further statistical tests where possible to ensure that the assumptions associated with the release-recapture models are met. The assumptions are the following:

A1. Individuals marked for the study are a representative sample from the population of interest.

A2. Survival and capture probabilities are not affected by tagging or sampling (i.e., tagged animals have the same probabilities as untagged animals).

A3. All sampling events are "instantaneous" (i.e., sampling occurs over a short time relative to the length of the intervals between sampling events).

A4. The fate of each tagged individual is independent of the fate of all others.

A5. All individuals alive at a sampling location have the same probability of surviving until the end of that event.

A6. All tagged individuals alive at a sampling location have the same probability of being detected on that event.

A7. All tags are correctly identified and the status of fish (i.e., alive or dead) is correctly identified.

The first assumption (A1) involves making inferences from the sample to the target population. For instance, if a sample is drawn from a population of fish and the size of the radio transmitter biases your sample to include only larger members of the population, then non-statistical inferences justifying the similarity between the target population and the sample are necessary. In past radio telemetry studies conducted by the Columbia River Research Laboratory, the size of the smallest radio transmitters available has resulted in this type of bias. However, recent advancements have led to the development of a coded radio transmitter that is much smaller than the transmitters previously available, which would allow us to include smaller fish in our sample and better represent the target population. Field tests of these tags were conducted during 2001.

Assumption A2 regards making inferences to the target population. If tagging has a detrimental effect on survival, then survival estimates from the radio-tagged fish will be negatively biased (i.e., underestimated). To limit the effects of our tagging methods on our tagged fish we have used the criteria established in Adams et al. (1998). The development of the smaller tags mentioned in the discussion of assumption A1 would further limit the impacts of our tagging methods on our sample fish.

Assumption A3 stipulates that mortality be negligible in the area near sampling stations so that mortality incorporated into the survival estimates occurs in the river reach in question and not during the sampling event. Our radio-tagged fish spend only a brief amount of time near the antenna array to that spent traveling between detection locations.

The assumption of independence (A4) implies that the fate of any particular fish does not affect the fate of others. This assumption is common to all tagging studies and in a large system such as the Columbia River; there is no evidence to suggest that it is not true. Violations of A4 have little effect on the point estimate but may bias the variance estimate to be lower than it actually is.

Assumption A5 specifies that prior detection has no effect on the subsequent survival of fish. The lack of handling following initial release minimizes the risk that detection influences survival. Assumption A6 could be violated if downstream detections were affected by fish passage routes. Providing adequate coverage of the entire river or placing arrays below mixing zones will reduce the likliehood of violating this assumption.

Assumption A7 implies that fish do not lose their tags and are later misidentified as dead or not captured, and that dead fish are not incorrectly recorded as alive. Tag loss or radio failure would negatively bias survival estimates. Typically, the retention rate of radio tagging is high suggesting that the effects of tag loss on survival estimates would be minimal. For example, with the exception of one fish that became entangled in a tank structure, Adams et al. (1998) did not report any tag loss for Chinook salmon with gastric and surgically implanted transmitters during a 21 d laboratory experiment. Dead fish drifting downstream could result in false-positive detections and upwardly bias survival estimates. However, a prudent selection of detection arrays that are sufficiently spaced would minimize this occurrence. Further, as we propose in Objective 5, false-detection rates can be empirically evaluated by calculating rates from releases of dead fish.

Survival in all objectives using the paired release recapture models will be estimated by the expression:

$$\hat{S} = \frac{\hat{S}_{11}}{\hat{S}_{21}} \tag{1}$$

with a variance estimate based on the Delta method (Seber 1982) of:

$$V\hat{a}r\left(\hat{S}_W\right) \cong \left(\frac{\hat{S}_{11}}{\hat{S}_{21}}\right)^2 \left[\frac{Var\left(\hat{S}_{11}\right)}{\hat{S}_{11}^2} + \frac{Var\left(\hat{S}_{21}\right)}{\hat{S}_{21}^2}\right]$$
$$= \hat{S}_W^2\left[\hat{C}V\left(\hat{S}_{11}\right)^2 + \hat{C}V\left(\hat{S}_{21}\right)^2\right]$$

(2)

where $\hat{S}_{11}$ = survival estimates for fish released through a particular route and $\hat{S}_{22}$ = fish released below the project or route being evaluated.

and where

$$\hat{C}V\left(\hat{\theta}\right) = \frac{\sqrt{Var\left(\hat{\theta}\right)}}{\theta}$$

In order to estimate S, the survival S_{11} is assumed to be of the form:

$$S_{11} = S \cdot S_{21}$$

leading to the relationship

$$\frac{S_{11}}{S_{21}} = \frac{S \cdot S_{21}}{S_{21}} = S \qquad (3)$$

The equality (3) suggests two additional assumptions for valid survival estimation using the paired release-recapture protocol.

A9. Survival in the upriver segment (S) is conditionally independent of survival in the lower river segment.

A10. Releases (R_1) and (R_2) have the same survival probability in the lower river segment (S_{21}).

Assumption A9 stipulates that there is no synergistic relationship between survival processes in the two river segments (i.e., fish released above the dam that survive the first river segment are no more or less susceptible to mortality in the second river segment than fish released below the dam).

Assumption A10 is satisfied if the paired releases mix as they migrate through the second river segment but can also be satisfied if the survival process is stable during passage by the two releases. Under similar flow and spill conditions, a stable survival process should be expected.

To test whether releases within a paired release have similar survival and capture histories, likelihood ratio tests can be performed to compare models H_{1N} and $H_{k\text{-}1N}$ and other intermediate scenarios (Burnham et al. 1987). Burnham et al. (1987) also suggest that a 2 x 2 contingency table test to determine where the capture and survival rates for the paired releases are equal at or below the first downstream antenna array (i.e., $p_{11} = p_{21}$, $S_{11} = S_{21}$, $p_{12} = p_{22}$, etc.) be used as another indication of complete mixing. The 2 x 2 table would be of the form:

	Release	
	R_1	R_2
m_1	m_{11}	m_{21}
Z_1	z_{11}	z_{21}

where m_1 is the number of fish detected at the first downstream array for a given release and z_1 is the number of fish that were not detected at the first array but were subsequently detected at a downstream array. While the contingency table provides tests of equality of overall recapture for paired releases, it does not provide the resolution of the equal site-specific capture and survival rate for both releases. Thus, inferences regarding mixing will be largely based on the sequential use of likliehood ratio tests.

The assumption of downstream mixing can be tested at each downstream array. An R x C contingency table test of homogenous recoveries over time can be performed using a table of the form:

		Release	
		R_1	R_2
Day of detections	1		
	2		
	3		
	⋮		
	D		

For each paired-release, a chi-square test of homogeneity will be performed at each downstream array. Tests would be performed at $\alpha = 0.10$. Because there will be multiple release and tests across paired releases, Type I error rates should also be adjusted for an overall experimental-wise error rate of $\alpha_{EW} = 0.10$.

In the survival estimation scenarios, a number of potential models will be generated and subsequently evaluated (Burnham et al. 1987, Lebreton et al. 1992). Forward-sequential and reverse-sequential procedures will be used to find the most parsimonious statistical model that adequately describes the downstream survival and capture processes of the paired-release. The most efficient estimate of survival will be based on the statistical model for the paired releases that properly share all common parameters between release groups.

Survival estimates for certain objectives will be generated from paired replicate lots of radio tagged fish. A weighted average of the survival estimates from the replicated releases can be calculated according to the formula:

$$\hat{\bar{S}} = \frac{\sum_{i=1}^{k} W_i \hat{S}_i}{\sum_{i=1}^{k} W_i} \tag{4}$$

where k = number of replicate releases:

and where $\hat{S}_i$ = survival estimates from the ith release (i = 1, ..., k);

The weight W_I is calculated using the formula:

$$W_i = \frac{1}{\left(\frac{V\hat{a}r\left(\hat{S}_i\right)}{\hat{S}_i^2}\right)} = \frac{1}{CV\left(\hat{S}_i\right)^2} \tag{5}$$

with variance

$$Var\left(\hat{\bar{S}}\right) = \frac{\sum_{i=1}^{k} W_i \left(\hat{S}_i - \hat{\bar{S}}\right)^2}{(k-1)\sum_{i=1}^{k} W_i} \tag{6}$$

If the average is estimating a mean over some static process then weighting would be inversely proportional to the variance. However, in the release-recapture models,

$$Var\left(\hat{S}\right) \propto S^2$$

Therefore, the variance is correlated with the point estimates of survival. The weight (5) eliminates this correlation, yet weights in proportion to the sampling precision (i.e., *CV*). Unfortunately, while the weighted average has been applied by others examining the survival of PIT-tagged salmonids in the Columbia River Basin, the use of this methodology for estimating mean survival using radio-tagged fish has resulted in certain estimates (e.g., those that have survival and capture probabilities near 1) having highly disproportionate weights that invariably results in estimates of average survival that are very near 1, despite the fact that the majority of the individual survival estimates are much lower than this value. Weighted averages are designed to weight the average by certain observations with given qualities or other derived variables or quantities. Thus, they cannot be expected to represent the value that would exist given an un-weighted estimator. However, the use of a weighted estimator that skews the evaluation to indicate that the survival of fish passing a given project is 1, when as researchers we know this to not be the case, is unacceptable.

The high capture probabilities possible with current radio-telemetry systems and the nature of the way the SURPH software calculates the variance of the survival estimates of the individual releases (e.g., analogous to the binomial variance formula) has resulted in this difficulty. Coordination between the USGS and the University of Washington, and subsequent efforts by University of Washington personnel have failed to resolve this problem. Consequently, we will evaluate the use of the weighted average, but will use the arithmetic mean to represent the survival of yearling Chinook salmon and steelhead trout at the various projects if it appears that the use of the weighted estimator results in estimates that are disproportionately influenced by the aforementioned computational difficulty. Current efforts to standardize survival methodologies within the region will provide further guidance on this matter.

The objectives of the site-specific releases are varied, but in general, are designed to provide point estimates of survival through each route evaluated and to provide a means of comparing survival between routes. Concerns regarding the effects of using hose releases in these types of evaluations have been raised by researchers conducting survival evaluations in the Columbia River Basin because the estimates may be sensitive to the release location within the passage route (Al Giorgi, Bioanalysts, personal communication). However, the consensus is that while the absolute values may be sensitive to the releases location, the estimates should be suitable as indices of survival.

Expected Precision

As results from the 2004 studies become available we will update the information presented in Tables 1 and 2, which present the expected precision based on information available to us prior to 2004. Using the information collected during 2004 will help to refine the expected precision estimates.

Table 1. The expected precision of yearling Chinook salmon and steelhead trout survival estimates for proposed evaluations of survival through the minimum gap runner turbine unit at powerhouse 2 (B2), the B2 juvenile bypass system and powerhouse 1 ice and trash sluiceway. Expected standard errors are for estimates generated using the paired release recapture methods of Burnham et al. (1987) and were formulated using survival and capture probabilities from past years studies where available. Since the environmental conditions and dam operations and thus, the survival and capture probabilities, may differ during 2005, the actual precision of the survival estimates for 2005 may also differ from the estimated precision presented in this table. No prior estimates are available for steelhead trout. Thus, for this exercise, we assumed that the expected precision would be similar for the two species.

		B1 MGR		B2 Juvenile Bypass System		B1 ice and trash sluiceway [B]	
N/release [A]	# releases	SE	Half 95% CI	SE	Half 95% CI	SE	Half 95% CI
60	15	0.033	0.064	0.019	0.036	0.026	0.051
60	20	0.028	0.056	0.016	0.031	0.023	0.044
60	25	0.025	0.050	0.014	0.028	0.020	0.040
60	30	0.023	0.046	0.013	0.026	0.019	0.036
60	35	0.022	0.042	0.012	0.024	0.017	0.034
60	40	0.020	0.039	0.011	0.022	0.016	0.032
60	45	0.019	0.037	0.011	0.021	0.015	0.030
60	50	0.018	0.035	0.010	0.020	0.014	0.028

[A]- includes both treatment and control release groups.
[B]- assumed same as for B1 DSM, no other values available.

Table 2. The expected precision of sub-yearling Chinook salmon survival estimates for proposed evaluations of survival through the powerhouse 1 (B1) downstream migration channel and minimum gap runner turbine unit, powerhouse 2 (B2) juvenile bypass system and ice and trash sluiceway, and the spillway. Expected standard errors are for estimates generated using the paired release recapture methods of Burnham et al. (1987) and were formulated using survival and capture probabilities from past years studies, where available. Since few evaluations of sub-yearling Chinook salmon survival have been conducted at Bonneville Dam using radio-telemetry, we will assume similar survival and capture probabilities between various routes at Bonneville Dam. If the evaluations go forward during 2005, more data will be available to use in this exercise in subsequent years.

		B1 MGR [A]		B2 Juvenile Bypass System[B]	
N/release [C]	# releases	SE	Half 95% CI	SE	Half 95% CI
60	15	0.033	0.064	0.041	0.080
60	20	0.028	0.056	0.035	0.070
60	25	0.025	0.050	0.032	0.062
60	30	0.023	0.046	0.029	0.057
60	35	0.022	0.042	0.027	0.052
60	40	0.020	0.039	0.025	0.049
60	45	0.019	0.037	0.024	0.046
60	50	0.018	0.035	0.022	0.044

[A]- assumed same as for B1 MGR for yearling Chinook, no other values available.
[B]- assumed same as for B2 JBS, no other values available
[C]- includes both treatment and control release groups.

Route Specific Survival Model

Model Assumptions

The assumptions associated with the Route Specific Survival Model (RSSM) are described in detail in Skalski et. al. (2002) and are similar to those for the paired–release recapture model of Burnham et. al. (1987).

Assumptions of the RSSM are:

A1. Individuals marked for the study are a representative sample from the population of interest.

A2. Survival and capture probabilities are not affected by tagging or sampling (i.e., tagged animals have the same probabilities as untagged animals).

A3. All sampling events are "instantaneous" (i.e., sampling occurs over a short time relative to the length of the intervals between sampling events).

A4. The fate of each tagged individual is independent of the fate of all others.

A5. All tagged individuals alive at a sampling location have the same probability of surviving until the end of that event.

A6. All tagged individuals alive at a sampling location have the same probability of being detected.

A7. All tags are correctly identified and the status of fish (i.e., alive or dead) is correctly identified.

A8. Survival in the upriver segment (S) is conditionally independent of survival in the lower river segment.

A9. Both the upstream and downstream release groups within a paired release experience the same survival probability in the segment of the river that they travel together.

Skalski et. al. (2002) identified two additional assumptions are associated with the RSSM:

A10. Routes taken by the radio-tagged fish are known without error.

A11. Detections in the primary and secondary antenna arrays within a passage route are independent.

Skalski et al. (2002) suggest that assumption A10 can be qualitatively assessed by examining radio telemetry detection histories to determine whether inconsistencies in individual fish detection histories exist. Skalski et al. (2002) use an example of a situation where a radio-tagged fish is detected in the upstream array of a route and then in the downstream array of another route, resulting in uncertainty in the route taken. That is, they used aerial antennas that monitored the tailrace area to help determine passage. Similar to the radio-telemetry system used in Skalski et al (2002), the double array we will deploy at Bonneville Dam will consist of aerial and underwater telemetry systems that interrogate fish in the immediate forebay area of each particular route, with the exception of the juvenile bypass system where underwater antennas will be placed at two locations within the bypass structure. However, while we will have a radio-telemetry system monitoring the tailrace area of each route, we do not consider detections in the tailrace when determining passage routes.

Skalski et al. (2002) determined that while assumption A11 is necessary for valid estimation of in-route detection probabilities, the assumption cannot be empirically assessed with the data collected with this type of study. Rather, they suggest that the detection fields of the primary and secondary arrays should be located in a way that fish detected in one array does not have a higher or lower probability of being detected in the secondary array than the primary array. Further, they suggest that this is best accomplished by having independent receivers for each antenna array and by having the detection field of at least one array encompass the entire passage route. The arrays we will deploy at powerhouse 1, powerhouse 2, and the spillway will conform to these requirements.

Parameter Estimation

The double radio-telemetry array systems that we will deploy at Bonneville Dam will allow us to estimate route specific detection probabilities. In turn, these route specific detection probabilities can be incorporated into a statistical analysis that will extract route specific passage and survival (Skalski et. al. 2002). The releases made at The Dalles Dam (R_1) and the releases made below the powerhouse 2 JBS outfall (R_2) will be interrogated at three arrays below Bonneville Dam, the furthest downriver being an array deployed on the I-205 Bridge. A branching process will be used to model the migration and survival of releases R_1 and R_2 (Figure 3). Additional details regarding the methodology used in the formulation of the RSSM and the estimation of the associated parameters can be found in Skalski et al. (2002). For the RSSM survival probabilities, both standard errors and profile likelihood 95% confidence intervals will be reported (Skalski et al. 2002).

The variance for the dam survival estimate will be estimated using the delta method (Seber 1982, pp 7-9). All of the route specific survival and passage probabilities will be estimated using the USER (User Specified Estimation Routine) developed at the University of Washington (Lady et al. 2003; see: (http://www.cqs.washington.edu/paramEst/USER/).

Sample Size for the RSSM analyses

As discussed previously on p. 23, as results from the 2004 studies become available we will update the information presented in Table 3, which presents the expected precision based on the information that is available to us prior to 2004. Using the information collected during 2004 will help to refine the expected precision estimates.

Table 3. Standard errors are presented for *S ph1* (survival of age-1 Chinook salmon through all routes at the B1 powerhouse), *S sp* (survival through the Bonneville Dam spillway), *Sph2* (survival through all routes at the B2 powerhouse), *S dam* (total dam passage survival through Bonneville Dam for three release scenarios. The actual model used during 2004 will estimate survival through additional routes (see Figure 3) and thus the estimates below apply to the specific model represented below. R1 refers to releases made above Bonneville Dam and R2 refers to releases in the tailrace area of Bonneville Dam. The parameters used to perform these analyses were from the route specific survival model analyses conducted during 2002 at Bonneville Dam for yearling Chinook salmon. The actual parameter values for yearling Chinook salmon during tests of different dam operations will likely be different for future dam operations. Further, other combinations of R1 and R2 release numbers may also be suitable to obtain these detectable differences.

			Standard errors			
Release	Sample size per release group	Total release per treatment	*S ph1*	*S sp*	S ph2	*S dam*
R1	2000	3000	0.029	0.010	0.011	0.014
R2	1000					
R1	4000	5000	0.021	0.009	0.009	0.011
R2	1000					
R1	7000	9000	0.016	0.006	0.007	0.008
R2	2000					

IMPACTS

The impacts of the objectives discussed in this proposal are listed in the corresponding Columbia River Research Laboratory proposals pertaining to study codes SPE-P-00-7 and SPE-P-02-1.

COLLABORATIVE ARRANGEMENTS and/or SUB-CONTRACTS

As stated previously the activities contained within this research proposal are presented in the context of other work proposed by the Columbia River Research Laboratory for 2005. As such, the proposed research will be intensively coordinated with all of the respective studies. To assist with the analyses of the data and the design of these studies the U.S. Geological Survey will collaborate with John Skalski who has many years of experience with survival estimation methodologies and is one of the principal authorities on this subject.

LIST OF KEY PERSONNEL AND PROJECT DUTIES

Jim Petersen	Project Leader: project administration, research product review
Tim Counihan	Principal Investigator: project management, data analysis, interpretation, and reporting
Jill Hardiman	Principal Investigator: data analysis, interpretation, and reporting
John R. Skalski	Consulting Statistician: consulting on statistical models and design

TECHNOLOGY TRANSFER

Results from this study will aid in the evaluation of the relation between dam operations and juvenile salmonid survival. We believe that the detailed survival information from this study will be used in the decision-making process to the operation of the Federal Columbia River Power System and Juvenile Transportation Program as discussed in the 1995 and 2000 Biological Opinion (NMFS 1995, NMFS 2001). Results will be disseminated in the form of preliminary reports, annual reports of research, oral presentations and briefings, and peer-reviewed journal publications. Preliminary survival estimates for the spring and summer outmigration periods will be available by AFEP. The draft annual report of research will be completed by January 31, 2006, with the final version on June 1, 2006. As per an agreement with the ACOE, comments on the draft report will be received in our office on or before 45 days from the mailing of this draft. After the 45-day period, if we receive comments pertaining to the draft, we will produce a final report within 60 days. If we do not receive comments within the 45 days of mailing this draft report, we will consider the draft report suitable for printing as the final report.

REFERENCES CITED

Adams, N. S., D. W. Rondorf, S. D. Evans, J. E. Kelly, and R. W. Perry. 1998. Effects of surgically and gastrically implanted radio transmitters on swimming performance and predator avoidance of juvenile Chinook salmon (Oncorhynchus tshawytscha). Canadian Journal of Fisheries and Aquatic Sciences 55:781-787.

Burnham, K.P., D.R Anderson, G.C. White, C. Brownie, and K.H. Pollock. 1987. Design and analysis methods for fish survival estimates based on release-recapture. American Fisheries Society Monograph No. 5.

Counihan, T.D., K. J. Huskey, and James H. Petersen. 2002. Survival Estimates of migrant Juvenile Salmonids in the Columbia River from John Day Dam through Bonneville Dam using Radio-Telemetry. Annual report for 2000 prepared for the U.S. Army Corps of Engineers, Portland, Oregon.

Counihan, T.D., G. S. Holmberg, K. J. Felton, and James H. Petersen. In review. Survival Estimates of migrant Juvenile Salmonids in the Columbia River from John Day Dam through Bonneville Dam using Radio-Telemetry. Annual report for 2001 prepared for the U.S. Army Corps of Engineers, Portland, Oregon.

Dawley, E.M., L.G. Gilbreath, E.P. Nunnallee, and B. P. Sandford. 1998. Survival of juvenile salmon passing through the spillway of The Dalles Dam, 1997. Annual report prepared for the U.S. Army Corps of Engineers, Portland, Oregon. Contract MIPR E96970020.

Giorgi, A.E., M. Miller, J. Stevenson. 2002. Mainstem passage strategies in the Columbia River System: transportation, spill and flow augmentation. Technical Report Northwest Power Planning Council, Portland, Oregon.

Hockersmith, E. E., and seven coauthors. 2000. Comparative performance of Sham radio-tagged and PIT-tagged juvenile salmonids. Report to the Army Corps of Engineers, Walla Walla District, Contract W66QKZ91521282.

Iwamato, R.N., Muir, W.D., Sandford, McIntyre, Frost, D.A., Williams, J.G., Smith, S.G., and J.R. Skalski. 1994. Survival estimates for the passage of juvenile Chinook salmon through Snake River Dams and reservoirs, 1993. Report prepared for the U.S. Department of Energy, Bonneville Power Administration. Division of Fish and Wildlife, Contract DE-A179-93BP10891, Project 93-29. 139 pp.

Lebreton, J.D., K.P. Burnham, J. Clobert, and D. R. Anderson. 1992. Modeling survival and testing biological hypotheses: using marked animals: A unified approach. Ecological Monographs 62:67-118.

Muir, W.D., and eleven coauthors. 1995. Survival estimates of the passage of juvenile salmonids through Snake River Dams and reservoirs, 1994. Annual report prepared for the Bonneville Power Administration, Portland, OR and U.S. Army Corps of Engineers, Walla Walla, Washington. Contract DE93-29A179-93B101891, Project 93-29. 187 p.

National Marine Fisheries Service. 2001. Biological Opinion. Reinitiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin. Northwest Region.

Normandeau Associates, Inc., J.R. Skalski, and Parametrix, Inc. 1998. Feasibility of estimating smolt survival with radio telemetry through the Priest Rapids hydroelectric project, Columbia River, Washington. Report prepared for Grant County Public Utility District No. 2.

Prentice, E. F., T. A. Flagg, and C. S. McCutcheon. 1990. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. American Fisheries Society Symposium 7:317-322.

Raymond H. L. 1979. Effects of dams and impoundments on migrations of juvenile Chinook salmon and steelhead from the Snake River, 1966-1975. Transactions of the American Fisheries Society 90:58-72.

Scwartz, D. 2000. CRFMP-System Study Turbine Survival Program. Turbine Passage Survival Workshop, June 14-15, 2000, Portland, Oregon. U.S. Army Corps of Engineers.

Seber, G.A.F. 1982. The estimation of animal abundance and related parameters. Macmillan, New York.

Skalski, J.R. 1992. Sample size calculations for normal variates under binomial censoring. Biometrics. 48:877-882.

Skalski, J.R. 1999a. Statistical methods to extract survival information from the John Day and The Dalles dams radiotag studies. Report to the Army Corps of Engineers.

Skalski, J.R. 1999b. Sample Size Calculations for conducting John Day Project smolt survival studies. Report to the Army Corps of Engineers.

Skalski, J.R., R.L. Townsend, and A.E. Giorgi. 1998a. The design and analysis of salmonid tagging studies in the Columbia River Basin, Volume XI, Recommendations on the design and analysis of radiotelemetry studies of salmonid smolts to estimate survival and passage efficiencies. Report prepared for the U.S. Department of Energy, Bonneville Power Administration. Division of Fish and Wildlife, Contract DE-B179-90BP02341.

Skalski, J. R., Smith, S. G., Iwamato, R.N., Williams, J.G., and A, Hoffman. 1998b. Use of passive integrated transponder tags to estimate survival of migrant juvenile salmonids in the Snake and Columbia rivers. Canadian Journal of Fisheries and Aquatic Sciences. 55:1484-1493.

Skalski, J. R., R. Townsend, J. Lady, A.E. Giorgi, J.R. Stevenson, and R.D. McDonald. 2002. Estimating route-specific passage and survival probabilities at a hydroelectric project from smolt radio-telemetry studies. Canadian Journal of Fisheries and Aquatic Sciences. 59:1385-1393.

Smith, S. G., J.R. Skalski, J.W. Schlechte, A. Hoffman, and V. Cassen. 1996. Introduction to SURPH.1 analysis of release-recapture data for survival studies. Report prepared for Bonneville Power Administration, Environment, Fish, and Wildlife, Portland, Oregon. DOE/BP-02341-3, October 1996.

Smith, S.G., W.D. Muir, E.E. Hockersmith, S. Achord, M.B. Eppard, T.E. Ruehle, and J.G. Williams. 1998. Survival estimates or the passage of juvenile salmonids through Snake River Dams and reservoirs, 1996. Annual report prepared for the Bonneville Power Administration, Portland, Oregon. Contract DE93-29A179-93B101891, Project 93-29. 197 p.

Stier, D.J. and B. Kynard. 1986. Use of radio telemetry to determine the mortality of Atlantic salmon smolts passed through a 17-MW Kaplan turbine at a low-head hydroelectric dam. Transactions of the American Fisheries Society. 115:771-775.