PRELIMINARY PROPOSAL FOR FY 2007 FUNDING

Title: Survival and Migration Behavior of Juvenile Salmonids During Operation of the Removable Spillway Weir at Lower Granite Dam, 2007.

Study Codes: SBE-W-96-01

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PROJECT SUMMARY

RESEARCH GOALS

The goal of our study is to measure the behavioral response and survival of juvenile salmonids relative to operation of the removable spillway weir (RSW). We are prepared to evaluate fish passage and survival relative to two spill treatments, though at the time of this proposal the regional fishery managers have not determined what these treatments will be.

STUDY OBJECTIVES

Objective 1: Determine the timing and route of passage for subyearling Chinook salmon at Lower Granite Dam relative to spill, powerhouse, and RSW operations.

Objective 2: Estimate route-specific and dam survival of subyearling Chinook salmon passing through Lower Granite Dam.

Note: These study objectives meet the summer research needs identified in SBE-W-96-01 objectives 1 and 3.

METHODOLOGY

For all objectives, we propose to use radio telemetry techniques to obtain both survival and behavioral information for juvenile salmonids migrating past Lower Granite Dam. Because radio-tagged fish are usually detected at high rates (>80% detection probability), radio telemetry techniques are well suited to estimate survival rates with small sample sizes and desired precision of survival estimates. We will use the route-specific survival model developed by Skalski et al. (2002) to estimate survival probabilities at Lower Granite Dam.

To provide passage and survival information at Lower Granite Dam, the COE has suggested a sample size of 2,000 radio-tagged subyearling Chinook salmon. However, we provide precision of survival estimates for a range of sample sizes. If survival estimates are not required, then smaller sample sizes of radio-tagged fish can be used to obtain passage information. For most passage routes, analysis suggests that a sample size of 2000 will yield survival probabilities with precision of ±0.03-0.06 for summer migrants.

RELEVANCE TO THE BIOLOGICAL OPINION

The relevance of this research to the operation of the Federal Columbia River Power System is discussed in Hydrosystem Substrategy 1.1, p 18, Substrategy 1.4, p 19, and ESU Specific Actions on pages 33, 39-40, and 43 of the "Updated Proposed Action for the FCRPS Biological Opinion Remand", dated November 24, 2004.

PROJECT DESCRIPTION

BACKGROUND

Reservoir drawdown, flow augmentation, and spill have been identified as potential means of improving the survival of migratory salmon smolts, thereby assisting the recovery of threatened and endangered salmon stocks. The U.S. Army Corps of Engineers (COE) has worked with regional, state, and federal resource agencies to design and implement experiments to determine which management alternatives would provide significant biological benefits to out-migrating smolts.

During 1995, the COE directed effort away from drawdown related issues towards the study of surface collection techniques to decrease turbine passage at dams and increase survival rates. Development of surface collection systems is based on observations that fish will readily pass obstructions to their downstream movement if they are provided a surface route of passage. Smith (1974) found that 58% of the juvenile Chinook salmon and 36% of the steelhead captures in vertical gillnets were traveling in the upper 12 ft of the reservoir. Beeman and Maule (2006) reported mean migration depths of radio-tagged yearling Chinook salmon were 3.2 m (95% CI 2.8 to 3.6 m) near the forebay of a Columbia River dam and those of juvenile steelhead were 2.3 m (95% CI 25 to 2.5 m), supporting the theory that these juvenile salmonids travel in the upper part of the water column. Based on the vertical distribution of fish and their natural tendency to travel near the surface, many researchers have concluded that surface-oriented passage routes may be more effective at passing juvenile salmonids. Perhaps the most successful example of surface bypass is at Wells Dam. The hydrocombine design of the dam is such that the spill bays are located above the turbine intakes. Hydroacoustic studies of juvenile salmon passage indicated an average of 7% of total discharge passed over 90% of the fish (Johnson et al. 1992). At Rock Island Dam, another Mid-Columbia River dam, shallow spill bays resulted in a 20% spill discharge passing 30% of the fish (Steig and Ransom 1991). In a review of surface spill and deep spill, Ransom and Steig (1995) estimated sluiceways typically produced a 13:1 ratio of percent total fish:percent total river flow passed. In contrast, the deep flow of conventional spillways passed fish at about a 1:1 ratio of fish to flow.

In pursuit of the potential benefits that surface collection and spill may have on smolt survival, the COE allocated considerable resources during 1996 towards the construction, implementation, and analysis of a surface bypass collector (SBC) prototype at Lower Granite Dam. In 1998, the behavioral guidance structure (BGS) was added to the forebay to divert fish away from the south half of the powerhouse and toward the SBC to improve passage into the structure. Also in 1998, the simulated Wells intake (SWI) was retrofitted to the back side of the surface bypass prototype to reduce the downward flow into the turbine intake in front of the SBC. Monitoring of the BGS and SWI was incorporated into the 1998 study design. In 2002 and 2003, the COE conducted further tests of the surface collection concept by constructing a removable spillway weir (RSW) at spill bay 1 at Lower Granite Dam. In 2006, the depth of the BGS was reduced and it was moved to a new location between turbine units 5 and 6. The BGS will be removed prior to the 2007 fish migration period, but additional evaluations of spill patterns and operations of the RSW are planned during the summer. Given the history and success of USGS research using acoustic- and radio-telemetry in Lower Granite Reservoir since 1994, we propose to continue research during the proposed 2007 experiments at Lower Granite Dam.

CURRENT STATUS

The USGS has conducted research at Lower Granite Dam since 1994. Detailed results from this research can be found in the annual reports to the U.S. Army Corps of Engineers. Between 1996 and 1998, hydroacoustics and biotelemetry were used concurrently at Lower Granite Dam to evaluate fish distribution and behavior relative to operation of the surface bypass collector. Three-dimensional acoustic telemetry and radio telemetry were used during spring 2000 surface bypass collector tests and again during the RSW evaluations in 2002 and 2003. A brief summary of pertinent information is provided below.

There is a limited amount of information on subyearling Chinook salmon relative to surface bypass tests at Lower Granite Dam. We tagged and release 199 subyearling Chinook salmon in 1997 and 295 in 1998. These data allowed us to examine the movement and passage of subyearling Chinook salmon relative to the Surface Bypass Collector (SBC) tests. Results of these tests indicated that the SBC passed juvenile salmonids, but was not effective enough to be a stand-alone bypass alternative at Lower Granite Dam.

During spring 2002, we tagged and released yearling Chinook salmon, hatchery steelhead, and wild steelhead to compare passage through the RSW during BiOP spill. Of the fish we determined passage routes for, 38% (SE = 1.7%) of yearling Chinook salmon, 44% (SE = 2.5%) of hatchery steelhead, and 42% (SE = 2.5%) of wild steelhead passed through the RSW. Passage through the spillway was 35% (SE = 1.7%) for yearling Chinook salmon, 27% (SE =2.3%) for hatchery steelhead, and 27% (SE = 2.3%) for wild steelhead. Guided turbine passage was 19% (SE = 1.4%) for yearling Chinook salmon, 26% (SE = 2.2%) for hatchery steelhead, and 23% (SE = 2.1%) for wild steelhead. Unguided turbine passage was 8% (SE = 1.0%) for yearling Chinook salmon, 3% (SE = 0.9%) for hatchery steelhead, and 8% (SE = 1.3%) for wild steelhead

Experiments to estimate RSW performance continued during the spring out-migration in 2003. We found that the RSW performed similarly as in 2002. Depending on species or rearing type, the RSW passed 58-69% of fish and BiOP spill passed 52-59% of fish, indicating that the RSW passed similar or higher percentages of fish as the currently-employed management strategy. In 2003, the survival of yearling Chinook salmon was estimated to be 0.980 ± 0.023 through the RSW and 0.931 ± 0.060 through BiOP spill. Although these observed estimates differed by six percentage points, this difference was not statistically significant.

During 2004, experiments were planned to evaluate the effect of the modified BGS on behavior, passage, and survival of juvenile salmonids. However, low discharge during the spring led to cancellation of the experiment because spill was to be curtailed. Instead, study objectives were altered to estimate passage and migration behavior of yearling Chinook salmon, wild steelhead, and hatchery steelhead during a low-flow year. In addition, objectives were altered to estimate route specific survival of yearling Chinook salmon using the paired release model. Experiments were also planned to estimate passage and survival rates of subyearling Chinook salmon during operation of the RSW and normal spill operations. However, courtmandated spill was imposed, which altered the fixed treatments and led to more variation in spill discharge. These changes, however, still allowed for estimating passage and survival of subyearling Chinook salmon passing through the RSW and spillway. Evaluations of passage during RSW and BGS operations were conducted in 2005 and 2006.

In 2005 we studied subyearling Chinook salmon passage and survival during two treatments within the court-ordered summer spill (Perry et al. 2006). The treatments were spill only (average 31% of project discharge) versus RSW + training spill (RSW 7% and spillway 12% of project discharge). We found that the proportion of fish passing the spillway during the RSW + training spill treatment was lower than passage through the spillway during the alternate treatment. This was likely due to the differences in the proportion of total discharge passed through the spillway during each treatment. During the RSW + training spill treatment the RSW passed 69% of the subyearling Chinook salmon and conventional spill bays passed 18%. During the RSW treatment the survival of subyearling Chinook salmon was greatest for those passing via the RSW (92%, 95%CI 87 to 97%) and least for those passing via the spillway (83%, 95%CI 71 to 93%). During the spill treatment the route of greatest survival was the spillway (85%, 95%CI 80 to 91%) and route of lowest survival was the turbines (71%, 95%CI 34 to 99%). We found no significant difference in any survival probability when comparing route-specific survival probabilities between spill and RSW treatments

In 2006 we evaluated behavior and survival of subyearling Chinook salmon during RSW operation with two spill treatments. We also evaluated spring Chinook salmon and juvenile steelhead behavior and survival during two BGS treatments. Data from 2006 are being analyzed at the time of this proposal.

PROJECT OVERVIEW

We will use radio telemetry to estimate passage and survival probabilities over a range of spatial scales and passage routes. At the finest spatial scale, we will use the route-specific survival model (RSSM) to estimate passage and survival probabilities. The RSSM model uses double antenna arrays to calculate detection and passage probabilities for a given route of passage. Given passage and detection probabilities of passage routes, the RSSM then uses the paired release-recapture models (PRRM) described by Burnham et al. (1987) and expanded on by Skalski et al. (2002) to calculate route-specific survival relative to survival rates of control groups released into the tailrace. The foundation of both of these models is based on the classical release-recapture models of Cormack (1964), Jolly (1965), and Seber (1965; CJS model). In addition to route-specific survival probabilities, these models will allow us to estimate overall survival rates through the dam, and survival from release to the dam.

To obtain an estimate of bypass survival, radio-tagged fish must be diverted into the river after being guided and passing through the juvenile bypass system. If radio-tagged fish are loaded onto barges, then we will be unable to obtain valid detections at downstream antenna arrays, and thus, unable to estimate bypass survival. Therefore, in addition to radio tags, we propose to implant PIT tags into all fish. Using PIT tags will allow radio-tagged fish to be diverted into the tailrace after passing through the bypass system.

For quantifying migration behavior, we will monitor travel times, approach paths to Lower Granite Dam, forebay movements, and routes of passage. Once fish pass the dam, we will examine their movements in the tailrace and monitor travel times downstream of the dam. To monitor fish behavior at Lower Granite Dam we will use multiple aerial and underwater radio telemetry arrays. At the dam, aerial antenna arrays will be installed on barges in the forebay, and at the navigation wall, spillway, powerhouse, earthen dam, adult fish ladder, fish collection channel, juvenile fish bypass system, tailrace, and three detection sites downstream within Little Goose Reservoir. To obtain movement information at finer spatial scales, we will install underwater antennas on the extended-length submersible bar screens, spillway, and juvenile fish bypass system.

OBJECTIVES AND METHODOLOGY

Objective 1: Determine the timing and route of passage for subyearling Chinook salmon at Lower Granite Dam relative to spill, powerhouse, RSW, and BGS operations.

Evaluations of subyearling Chinook salmon passage relative to the removable spillway weir were conducted in 2005 and 2006, though questions about the effects of various amounts of training spill are still present. Snake River subyearling Chinook salmon are currently federally listed as endangered and the RSW has been one of the leading options for a basin-wide management strategy. Therefore, it is prudent to evaluate the performance of the RSW in 2007 relative to migrating subyearling Chinook salmon to further evaluate its effects under various training spill regimes.

Under this objective, we propose to release radio-tagged subyearling Chinook salmon in Lower Granite Reservoir and monitor route of passage through Lower Granite Dam during removable spillway weir operations. This will be achieved using a series of aerial and underwater antennas in the forebay, on the dam, and on the RSW (Appendix Figures 1, 2, and 3). The spill treatments have not been decided at the time of this proposal, but there will likely be no more than two treatments. If so, we recommend evaluating the performance of the RSW using a study design consisting of one-day treatments randomized over a series of 2-day blocks. The one-day treatments within each of the 2-day blocks will serve as replicates over the length of the study period. We propose one-day treatments due to the brevity of the subyearling Chinook salmon run at Lower Granite Dam and anticipate the study period to be only 20-25 days long. We propose to release a minimum of 1,000 radio-tagged subyearling Chinook salmon upstream of the dam to evaluate the performance of the RSW under this objective during the summer of 2007.

Schedule of tasks

Task 1.1: Conduct releases of subyearling Chinook salmon in Lower Granite Reservoir during the summer of 2007.

Activity 1.1.1

Complete the necessary Endangered Species Act documentation and obtain the necessary permits and approval to work in the Snake River.

Schedule:

January 2007.

Activity 1.1.2

Coordinate with appropriate agencies to sequester, implant tags, and release subyearling Chinook salmon smolts during the months of June and July 2007.

Schedule:

February through March 2007.

Activity 1.1.3

Monitor the movements of radio-tagged fish in the forebay and tailrace of Lower Granite Dam relative to the tests of the RSW.

Schedule:

June through July 2007.

Objective 2: Estimate route-specific and dam survival of subyearling Chinook salmon passing through Lower Granite Dam.

Survival estimates are paramount in determining whether a passage enhancement structure will have an adverse affect on fish survival. Under this objective, we propose to use the 1,000 subyearling Chinook salmon released upstream of Lower Granite Dam under Objective 1 to estimate route-specific survival at Lower Granite Dam. In addition, depending on desired precision of survival estimates, we propose to release additional radio-tagged fish (Table 1, Figure 1) to estimate survival probabilities. Addition of these fish will yield a dam survival probability with a precision ranging between ± 0.036 and 0.041 (± 95% confidence interval). This objective also requires 100 additional transmitters to test the battery life of the tags and to test the assumption of mistaking dead radio-tagged fish for live radio-tagged fish. Two treatments will be used to test the performance of the RSW with the BGS in either the out or in position. We will use the route-specific model (Appendix Figure 4) to estimate survival.

Sample sizes for subyearling Chinook salmon are larger than for yearling Chinook salmon to obtain similar precision of survival estimates. For example, the expected standard error for dam survival is 0.036 for a sample size of 2,000 fish. This sample size yields a minimum detectable difference between treatments of 0.071 (for a 2-tailed test, Power = 0.80, and alpha = 0.10). Past research summaries have requested appropriate sample size to detect a survival difference of 4%. To achieve a 4% detectable difference for subyearling Chinook salmon at Lower Granite Dam would require a total sample size of greater than 10,000 fish.

Table 1. Sample size, expected standard error, and 95% confidence interval for route-specific survival probabilities of subyearling Chinook salmon. Total sample size assumes two treatments of dam operations. Note: about 100 additional tags will be needed for releasing euthanized tagged fish and for conducting a tag life study.

Sample size per treatment	Route	Expected sample size for each route	Expected standard error	± 95% Confidence Interval
1000	Dam	540	0.026	0.052
	RSW	324	0.030	0.060
	Spill	108	0.048	0.097
	Bypass	92	0.049	0.099
	Turbine	16	0.120	0.240
2000	Dam	1080	0.018	0.036
	RSW	648	0.021	0.042
	Spill	216	0.034	0.069
	Bypass	184	0.034	0.070
	Turbine	32	0.085	0.171

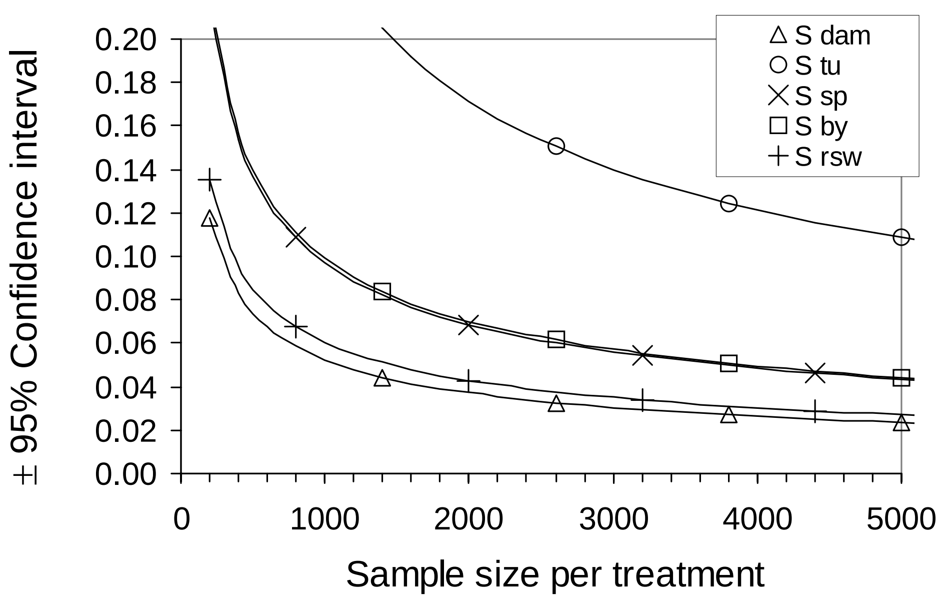

Figure 1. The effect of sample size on precision of dam survival (S_{dam}), turbine survival (S_{Tu}), spill survival (S_{Sp}), bypass survival (S_{By}), and rsw survival (S_{rsw}) probabilities for subyearling Chinook salmon at Lower Granite Dam. Note: about 100 additional tags will be needed for releasing euthanized tagged fish and for conducting a tag life study.

Schedule of tasks

Task 2.1: Conduct releases of subyearling Chinook salmon in the tailrace of Lower Granite Reservoir during the summer of 2007.

Activity 2.1.1

Develop analytical procedures for determining route specific survival estimates for subyearling Chinook salmon through the RSW and Spillway. Since our laboratory has extensive experience conducting survival studies using radio telemetry data, much of the groundwork has been completed to accomplish this task. We will consult with statisticians prior to finalizing survival estimates tasks and objectives.

Schedule:

Ongoing through Sept. 2007.

Activity 2.1.2

Install and test additional monitoring sites downstream of Lower Granite Dam. Additional sites will be needed below the dam to collect the necessary capture history data inherent to generating survival estimates.

Schedule:

March through May 2007.

Activity 2.1.3

Monitor the movements of radio-tagged fish released above and below Lower Granite Dam to estimate relative survival of subyearling Chinook salmon through the RSW and Spillway during the 2007 tests of the RSW.

Schedule:

June through July 2007.

Activity 2.2.4

Conduct "dead fish release". To validate assumptions of the survival model relative to false-detection rates, we propose to conduct releases of dead fish in the tailrace of the dam.

Schedule:

June through July 2007.

FACILITIES AND EQUIPMENT

Although some of the special or expensive equipment or services for the proposed study have been purchased during previous years of this study, there is a need for additional equipment. The purchase of the radio transmitters will perhaps be the most significant purchase for the proposed study. The coded radio transmitters manufactured by Lotek Engineering cost about $200 each.

Divers will be needed to assist in testing and repair of existing underwater antennas on and around the RSW. At this time, we are unsure of the expense involved in these activities.

The USGS operates the Columbia River Research Laboratory that includes research boats, vehicles, office space, and laboratory facilities to conduct this study. Boats will be operated at cost with no additional lease cost to the project. Only department of Interior certified boat operators trained in CPR and First Aid will operate boats. In order to meet U.S. Coast Guard standards boats will be inspected by a third party. Furthermore, USGS will provide a quality control system consistent with the Good Laboratory Practices Act.

Other resources include:

-A selection of 30 boats up to 30 feet in length for work on the river.
-Two 2700 square foot storage facilities with a shop.
-4000 square foot wet lab facility.
-A local computer network integrating state-of-the-art GIS capabilities.
-A technical staff of 60-100 fishery biologists, ecologists, and GIS specialists.
-An office and analytical laboratory in a 15,000 square foot facility.

IMPACTS

<u>Impacts to other researchers</u>

Because we will be using radio-telemetry technology to study the movements of the test fish, there is a great potential for interference with other studies that use the same technology. Other studies using radio tags with the same frequencies may cause interference and could cause the loss of data that would otherwise be collected. During 1994, 1995, and 1996 our ability to collect data was compromised due to radio interference caused by other researchers. An extensive coordination effort throughout the basin allowed us to minimize this problem during 1997-1998. In conjunction with coded tag manufacturers we were able to incorporate radio tags that operated on a unique frequency used only by USGS scientists. During the 2000-2001 study periods we used these modified radio tag frequencies to reduce multiple signal collisions and eliminate unwanted detections (of fish released by other researchers), and therefore increased overall data integrity. This unique tag frequency will be used during the 2007 evaluation.

Coordination with researchers conducting the evaluation of JSATS vs. PIT tags (NOAA Fisheries and Battelle PNNL) will be required due to competing needs for study fish. In 2006 the tag evaluation study obtained study fish at Little Goose Dam. If they require fish from Lower Granite Dam in 2007 we will need to coordinate with them. The contact person for the tag evaluation study is Brad Ryan and NOAA Fisheries.

Impacts to the Lower Granite Project

Pre-season installation of equipment will start in February 2007 and continue through May 2007. The equipment will be in use through the end July 2007. We are capable of installing most of the necessary equipment for the aerial arrays, and the impact to the Lower Granite project should be minimal. However, we are not equipped to repair and install all of the underwater antennas at the RSW, turbine intakes, and Extended Length Bar Screens. At this stage in the development of the 2007 study design, the impacts to the Lower Granite Project, and the assistance we might require from Army Corp of Engineer personnel is as follows:

Underwater antennas on the RSW --We will require divers to repair and install underwater antennas on the RSW. Turbine outages and spill gate closures must be in effect during diving activities. As a result, this work must be coordinated with the Lower Granite project and should be completed prior to increased flows in the Snake River. Perhaps the most effective way to meet all the diving needs is to have all the work covered in one contract that is awarded by the COE.

Underwater antennas on Extended Length Bar Screens-- We will need the assistance of Lower Granite Project personnel to raise and lower each screen during the repair and reinstallation of underwater antennas on the ELBS. Re-installation of the ELBS telemetry arrays is dependent on the work of numerous other contractors, and therefore a more specific schedule is difficult to estimate.

COLLABORATIVE ARRANGEMENTS and/or SUB-CONTRACTS

Some of the labor needed to complete the activities outlined in this proposal my be furnished through a sub-contract with a labor service provider.

LIST OF KEY PERSONNEL AND PROJECT DUTIES

Personnel	Organization	Project Duties
Dennis Rondorf	BRD	Section Leader
John Beeman	BRD	Project Leader
Noah Adams	BRD	Co-project Leader
Scott Fielding	BRD	Technical Lead, implementation/coordination

TECHNOLOGY TRANSFER

We plan to transfer information obtained from our analysis in the manners listed below. Once this information is transferred, it will be used to make decisions relative to operation of the Federal Columbia River Power System and Juvenile Transportation Program as discussed in the draft Biological Opinion, July 27, 2000, 9.6.1.4.2, page 9-69. In addition, the information will be used by other federal and state agencies, Indian Tribes, and the public to make management decisions to aid in the recovery of threatened and endangered populations of salmon in the Columbia Basin.

1. Preliminary report letter to the Army Corps of Engineers. A preliminary letter reporting our findings from the analysis will be submitted by November 1, 2007.

2. Presentation to the Anadromous Fish Evaluation Program (AFEP) in November 2007, and presentation to fisheries agencies, tribes, and the public at the Annual Research Review, 2007.

3. Expected draft report for 2007 by February 1, 2008 and final report by May 31, 2008.

4. Presentations to the Army Corps of Engineers staff and study review groups.

5. Presentations at professional meetings (e.g., American Fisheries Society) and publication of information in peer reviewed journals.

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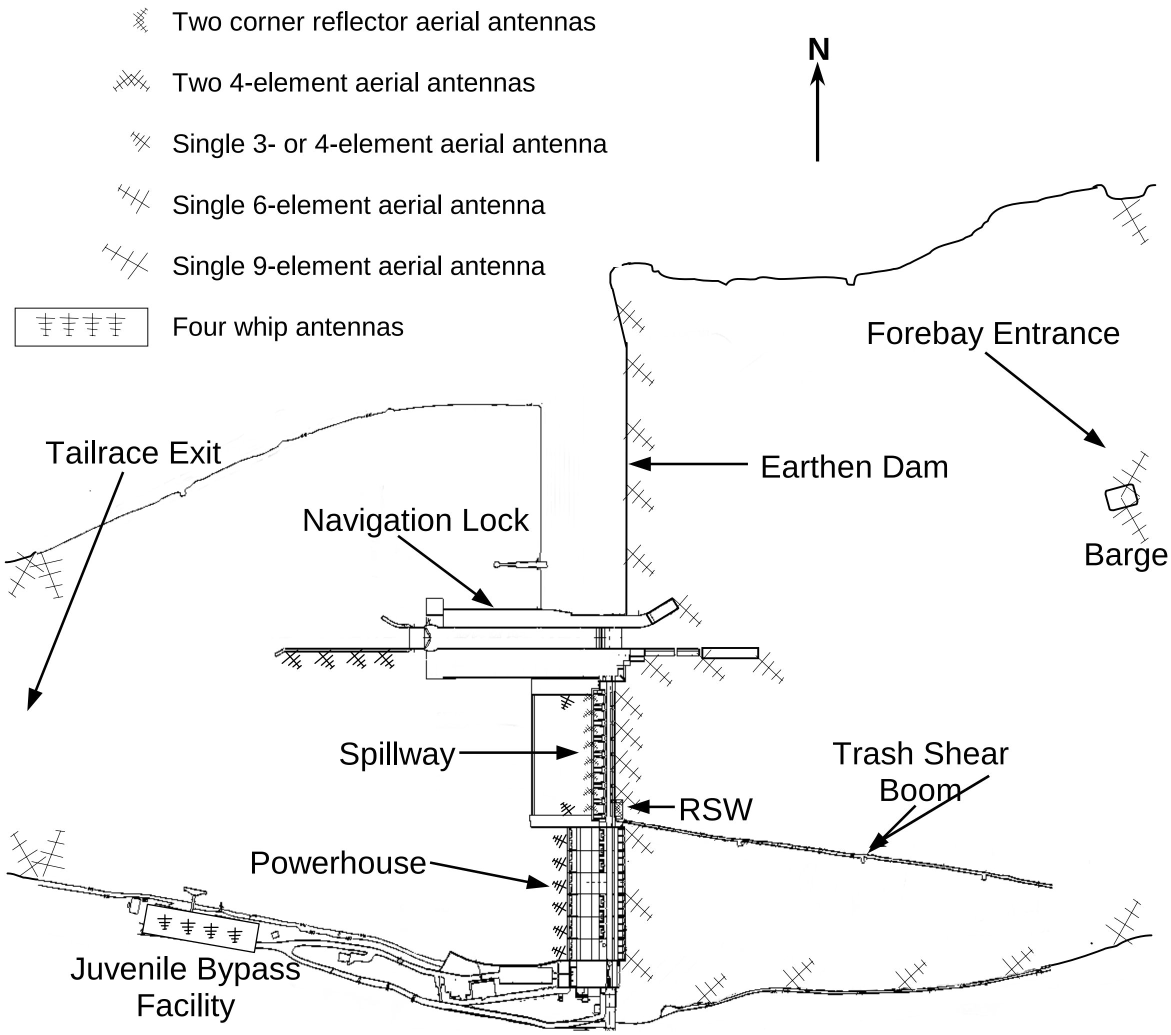
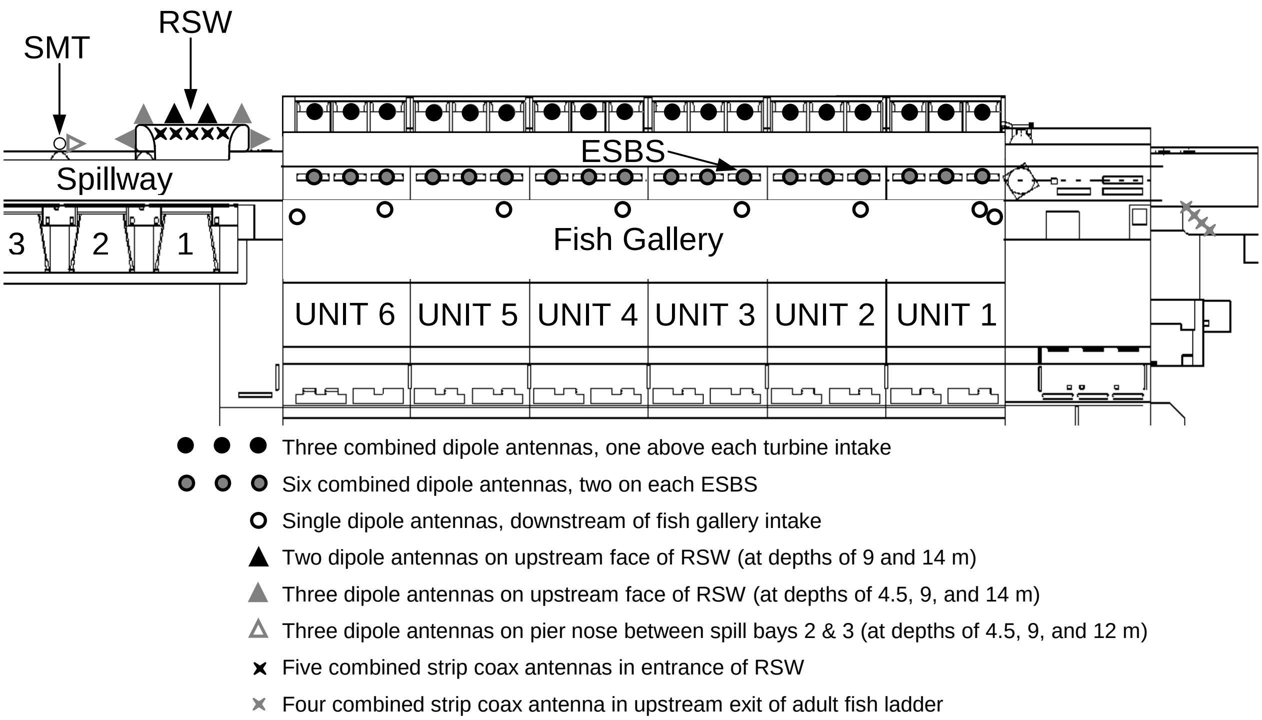
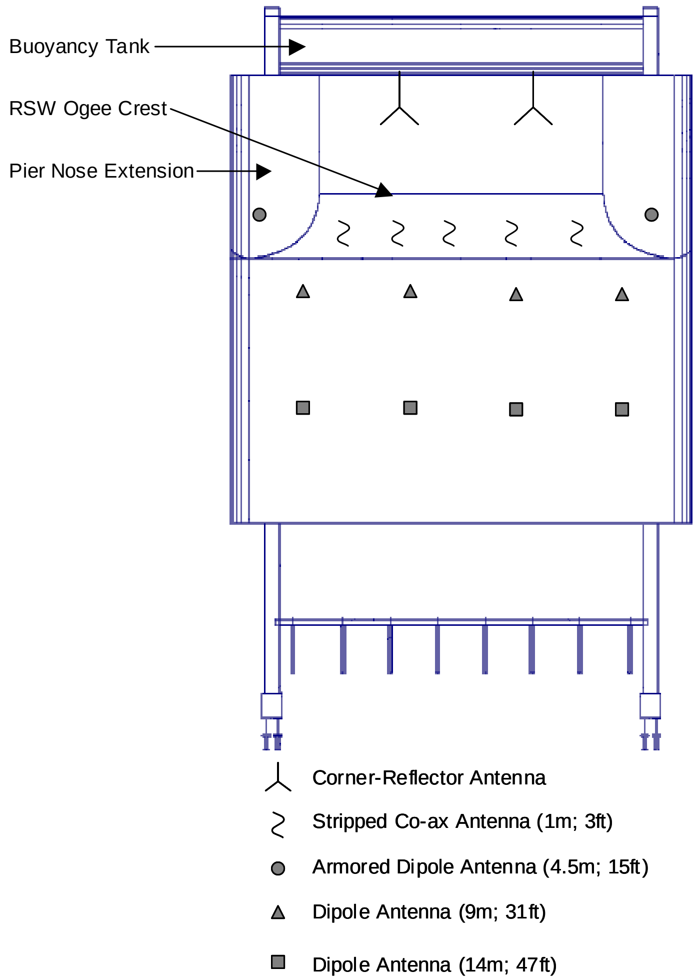


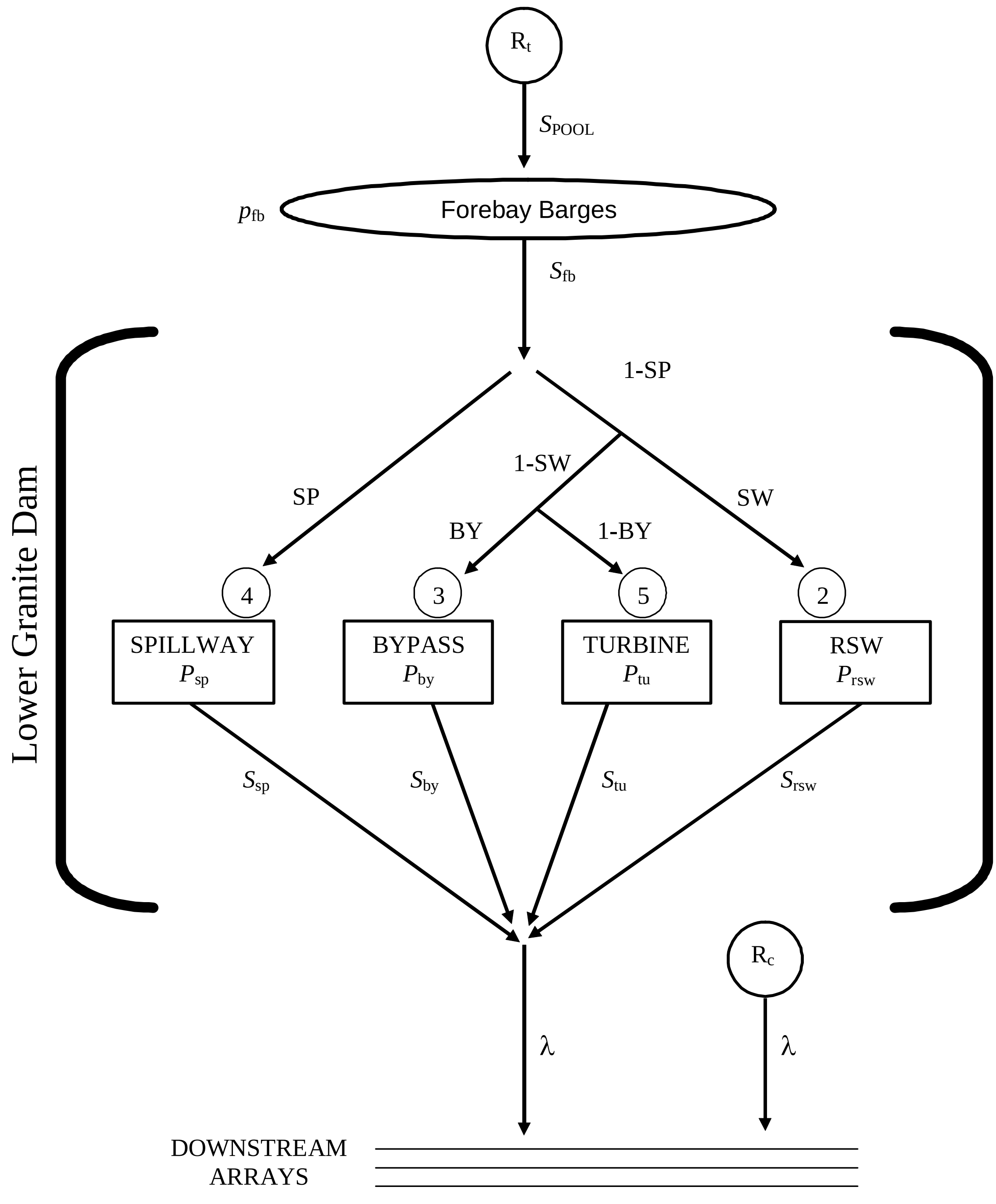
Appendix Figure 1. Plan view of proposed aerial antenna arrays at Lower Granite Dam during 2007.



Appendix Figure 2. Schematic of proposed underwater antennas near the powerhouse of Lower Granite Dam during 2007.



Appendix Figure 3. Frontal view of Lower Granite Dam's RSW showing locations of proposed radio telemetry antennas during 2007. Numbers in parenthesis represent depth of antenna locations. Antennas without depth are aerial antennas.



Appendix Figure 4. Schematic of route-specific survival model showing release sites, passage routes, and estimable parameters of detection, passage, and survival probabilities at Lower Granite Dam. Shown are the treatment releases (R_t) upstream of Little Goose Dam and control releases in the tailrace (R_c). Estimable parameters include passage (Sp, By, and SW), detection (p_{fb}, p_{Sp}, p_{By}, p_{Tu}, and p_{rsw}), and survival (S_{pool}, S_{fb}, S_{Sp}, S_{By}, S_{Tu}, and S_{rsw}) probabilities. Lambda (λ_t, λ_c) is the joint probability of surviving and being detected by the downstream antenna arrays.