## PRELIMINARY RESEARCH PROPOSAL (COE) (FY05)

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| TITLE: | Fish Passage and Survival at Little Goose, Lower Monumental and Ice Harbor Dams |
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| STUDY CODES: | SPE-W-04-2, SPE-W-04-4, SBE-W-05-1 |
| PROJECT DURATION: | FY2005 |
| SUBMISSION DATE: | August 2004 |

## PROJECT SUMMARY

### Research Goals

The goal of this study is to evaluate fish passage behavior including forebay residence time, passage distribution, spill efficiency, spill effectiveness, fish passage efficiency (FPE), fish guidance efficiency (FGE), and tailrace egress, and to provide estimates of project survival and route-specific survival for radio-tagged juvenile salmonids (*Oncorhynchus* spp.) passing Lower Monumental and Ice Harbor Dams. In addition, we will partition reach survival for radio-tagged juvenile steelhead between the tailraces of Lower Monumental and McNary Dams to determine where mortality is occurring and evaluate passage and survival in conjunction with a removable spillway weir (RSW) at Ice Harbor Dam. We will also evaluate passage behavior and project survival at Little Goose Dam under existing project operations. This information will

provide us with the direction and details for proposals of future evaluations at Little Goose Dam.

## Definitions of Passage Behavior Metrics and Survival Estimates

Fish passage behavior performance metrics, project survival, and route-specific survival as used in this proposal are defined as follows:

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| Spill Efficiency: | The number of fish passing the dam via the spillway divided by the total number of fish passing the dam. |
| Spill Effectiveness: | The proportion of fish passing the dam via the spillway divided by the proportion of water spilled. |
| Fish Passage Efficiency (FPE): | The number of fish passing the dam through non-turbine routes divided by total project passage. |
| Fish Guidance Efficiency (FGE): | The number of fish passing the dam through the juvenile bypass system divided by the total number of fish passing the dam through the powerhouse. |
| Tailrace Egress: | The elapsed time from project passage to exit from the tailrace. |
| Forebay Residence Time: | The elapsed time from arrival in the forebay of the dam until passage through the spillway, bypass, or turbines. |
| Project Survival (paired release): | Survival between the upstream limit of the boat restricted zone (BRZ) and the release location of reference groups downstream of the dam. |
| Route-specific Survival:<br>(paired release) | Survival between detection within a passage route<br>and the release location of reference groups downstream of the dam. |
| Project Survival (single release): | Survival between the upstream limit of the BRZ and the first downstream detection transect. |

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| Route-specific Survival: | Survival between detection within a passage route |
| (single release) | and the first downstream detection transect. |

## Study Objectives

Specific study objectives may change based on final analysis of 2004 research or changes in project operations.

### Objective 1

**Assess passage behavior and estimate project and route-specific survival for yearling chinook salmon under two spill conditions at Lower Monumental Dam.**

We propose to release radio-tagged yearling chinook salmon (*O. tshawytscha*) upstream and downstream from Lower Monumental Dam to evaluate passage behavior (forebay residence time, passage distribution, spill efficiency, spill effectiveness, fish passage efficiency (FPE), fish guidance efficiency (FGE), tailrace egress) and to estimate project survival under two different voluntary spill conditions at Lower Monumental Dam using a paired-release model. Additionally, we will estimate route-specific survival for all passage routes with sufficient numbers of tagged fish passing to estimate survival with reasonable precision. The goal of this objective is to determine Lower Monumental Dam project operations that will maximize passage survival for juvenile salmonids.

### Objective 2

**Assess passage behavior and estimate survival for yearling chinook salmon relative to operation of a removable spillway weir at Ice Harbor Dam.**

We propose to monitor radio-tagged hatchery yearling chinook salmon released as part of Objective 1 prior to and following passage through Ice Harbor Dam to evaluate passage behavior (forebay residence time, passage distribution, spill efficiency, spill effectiveness, FPE, FGE, and tailrace egress) as it relates to operation of the removable spillway weir (RSW). In addition, we will estimate project, RSW, and spillway passage survival under two operational conditions by pairing tailrace releases of radio-tagged yearling chinook salmon with the passage of fish released in Objective 1 using a paired-release model.

**Ojective 3**

**Assess passage behavior and estimate survival for juvenile steelhead relative to operation of a removable spillway weir at Ice Harbor Dam.**

We propose to monitor radio-tagged juvenile steelhead prior to and following passage through Ice Harbor Dam to evaluate passage behavior (forebay residence time, passage distribution, spill efficiency, spill effectiveness, FPE, FGE, and tailrace egress) as it relates to operation of the removable spillway weir (RSW). In addition, we will estimate project, RSW, and spillway passage survival under two operational conditions by pairing tailrace releases of radio-tagged juvenile steelhead with the passage of fish released above Ice Harbor Dam using a paired-release model.

**Ojective 4**

**Assess passage behavior and estimate survival for hatchery subyearling chinook salmon relative to operation of a removable spillway weir at Ice Harbor Dam.**

We propose to monitor radio-tagged hatchery subyearling chinook salmon prior to and following passage through Ice Harbor Dam to evaluate passage behavior (forebay residence time, passage distribution, spill efficiency, spill effectiveness, FPE, FGE, and tailrace egress) as it relates to operation of the removable spillway weir (RSW). In addition, we will estimate project, RSW, and spillway passage survival under two operational conditions by pairing tailrace releases of radio-tagged juvenile steelhead with the passage of fish released above Ice Harbor Dam using a paired-release model.

**Objective 5**

**Assess passage behavior and project survival for radio-tagged, yearling chinook salmon under current project operations at Little Goose Dam.**

We propose to release radio-tagged yearling chinook salmon (*O. tshawytscha*) upstream and downstream from Little Goose Dam to evaluate passage behavior (forebay residence time, passage distribution, spill efficiency, spill effectiveness, fish passage efficiency (FPE), fish guidance efficiency (FGE), tailrace egress) and to estimate project survival under one spill condition at Little Goose Dam using a paired-release model. The goal of this objective is to provide us with the direction and details for proposals of future evaluations at Little Goose Dam which will improve passage survival for juvenile salmonids.

## Relevance to the Biological Opinion

This study addresses Reasonable and Prudent Alternatives in sections 9.6.1.4.5 and 9.6.1.4.6 in the 2000 FCRPS Biological Opinion (NMFS 2000). This study also

addresses Question 3 and 7 of the Ten Key Questions for Salmon Recovery in the NMFS Salmon Research Plan (NMFS, 2002).

## PROJECT DESCRIPTION

**Objective 1: Assess passage behavior and estimate project and route-specific survival for yearling chinook salmon under two spill conditions at Lower Monumental Dam.**

### Relevance

The current voluntary spill program specified in the 2000 FCRPS Biological Opinion (NMFS 2000) calls for project operations at Lower Monumental Dam to rely on voluntary spill to increase FPE. Spill has been utilized increasingly to expedite the migration rates of juvenile salmonids past hydroelectric dams and to reduce the proportion of smolts passing through turbines where survival is lower (Muir et al. 2001b).

Survival estimates for juvenile salmonids that migrate through reservoirs, hydroelectric projects, and free-flowing sections of the Snake and Columbia Rivers are essential for developing effective strategies to recover depressed stocks. Recent survival studies at Lower Monumental Dam indicated that, among the different passage routes, survival was highest through the spillway, followed by the bypass, and then turbines (Hockersmith et al. 2000, Muir et al. 2001b).

As a result of construction completed in 2003 to repair the eroded stilling basin and installation of end-spillbay flow deflectors at Lower Monumental Dam new spill patterns have been developed for fish passage during the juvenile salmonid outmigration. During 2004, NMFS conducted a study using radiotelemetry to evaluate passage and survival at Lower Monumental Dam for yearling chinook salmon and analysis of the results is ongoing. Based on the results from 2004, Lower Monumental Dam project will likely be operated under two different voluntary spill patterns in order to evaluate fish passage and survival under each condition. The purpose of this objective is to provide the Action Agencies with fish passage behavior including passage distribution, spill efficiency, spill effectiveness, FPE, FGE, and tailrace egress as well as project and route-specific survival estimates at Lower Monumental Dam under two different voluntary spill conditions during the 2005 outmigration. This objective will provide the second year of passage behavior evaluation and survival evaluation at Lower Monumental Dam for yearling chinook salmon.

## Methods

Numerous research methods have been and are currently being used to evaluate fish passage and/or estimate survival, including PIT tags, balloon tags, hydro-acoustic, and radiotelemetry. Each research method has its advantages and disadvantages, but options are limited in some situations because of lack of sampling capabilities downstream or where fish behavior and survival estimates are needed. In these situations, radiotelemetry is an ideal method for evaluating passage behavior and estimating survival. During 1999 studies at Lower Granite Dam, NMFS and United States Geological Survey (USGS) compared the performance of sham radio-tagged yearling chinook salmon (both gastrically and surgically implanted tags) to PIT-tagged fish. Results, based on PIT-tag detections, indicated that radio tags did not significantly affect detection probability (approximately equal to FGE in the absence of spill) or survival of yearling chinook salmon between the tailraces of Lower Granite and Lower Monumental Dams (a 106 km reach which included two dams and two reservoirs) (Hockersmith et al. 2003).

In 2005, we propose to collect and radio tag river-run yearling chinook salmon at the Lower Monumental Dam smolt collection facility from April through June. All fish will also be PIT tagged. Fish handling methods such as water-to-water transfers and pre-anesthesia will minimize injury and stress to fish during the sorting and tagging process. Trained NMFS personnel will supervise all tagging operations and will use standard, previously documented tagging techniques. Tagging mortality is expected to be less than 4%. After tagging, fish will be held in 19-L containers partially submerged in a 126 x 217 x 41-cm tank for a minimum of 24 hours for recovery and determination of post-tagging mortality and/or tag loss. Holding densities will not exceed three fish per container. Holding tanks will be supplied with flow-through water.

The number of release groups and number of fish per release group were calculated to maximize the ability to provide a project survival estimate with 95% confidence intervals of +/- 3%. Sample sizes for releases were calculated based on data from radio-tagged yearling chinook salmon released at Lower Monumental and Ice Harbor Dams in 2002 and 2003 and annual PIT-tag survival estimates in the Lower Snake and Columbia Rivers (Table 1). Sample sizes may vary based on complete analysis of 2004 data. We used conservative assumptions in calculating sample sizes; our actual precision will likely be greater than shown.

We will use a paired-release study design with treatment fish released upstream and reference fish released into the tailrace of Lower Monumental Dam. Treatment groups will be created by regrouping radio-tagged yearling chinook salmon released as part of Objective 5 at Little Goose Dam that subsequently enter into the Lower Monumental Dam study area at the upstream end of the boat restriction zone (BRZ). Reference groups of tagged fish will be transferred to a small barge transported approximately 0.5 km downstream from Lower Monumental Dam and released water-to-water into the tailrace. To test the assumption that dead fish carrying an active radio tag do not float past a downstream detection line yielding a false-positive detection and

biasing survival estimates, euthanized radio-tagged fish will be released in conjunction with each group into the tailrace of Lower Monumental Dam.

Telemetry receivers and air antennas will be deployed to provide a minimum of three detection transects across the Snake River between Lower Monumental and Ice Harbor Dams. Minimum detection probabilities for each transect are expected to be 75%. At Lower Monumental Dam telemetry receivers will utilize underwater and air antennas to monitor the forebay, all routes of passage, and the tailrace to detect radio-tagged fish approaching, passing, and exiting the tailrace of the dam.

Lower Monumental Dam project operations during 2005 have not been finalized at the time of preparing this proposal. Based on results of the 2004 Lower Monumental Dam spillway survival evaluation, the voluntary spill program at Lower Monumental Dam in 2005 will probably follow a 4-day block design with 2 days of spill discharge volume described in the 2000 FCRPS Biological Opinion (NMFS 2000) through all 8 spillbays 24 hours per day, followed by 2 days of spill discharge volume described in the 2000 FCRPS Biological Opinion (NMFS 2000) discharged in a "bulk" spill pattern 24 hours per day (personal communication Mark Smith, USACE). "Bulk" spill patterns are patterns which utilize fewer spillbays and individual spillway gates are open a minimum of 5 stops.

Radiotelemetry detection data for all release groups will be compiled and processed as described in Eppard et al. (2000). The "complete capture history" protocol (Burnham et al. 1987) will be used to estimate project survival and detection probabilities by applying the single release-recapture model (Cormack 1964; Jolly 1965; Seber 1965; Skalski et al. 1998; Skalski et al. 2001) independently to the treatment and reference groups. The release-recapture data will be analyzed using the Survival with Proportional Hazards (SURPH) statistical software developed at the University of Washington (Smith et al. 1994). Route-specific survival will be estimated for all passage routes where adequate numbers of fish pass the project to provide estimates with a precision level of at least +/- 0.07. Survival estimates and passage behavior metrics for the two spill patterns will be compared by analysis of variance (ANOVA). Correlations between survival, passage behavior, project operations and environmental conditions will be examined by regression analysis to determine how these factors effect project survival, route-specific survival, and fish passage at Lower Monumental Dam.

## Critical Limitations

The degree of success of this objective will be contingent upon six primary factors: 1) adequate numbers of fish being collected and radio tagged at Lower Monumental Dam during the required time frame; 2) the pre-determined replicates and sample sizes providing the necessary precision for the survival estimates; 3) adequate numbers of radio-tagged fish passing through each passage route at Lower Monumental Dam to estimate route-specific survival with precision and evaluate passage behavior; 4) radiotelemetry receivers, PIT-tag detectors and bypass systems at downstream dams operating for the duration of the study; 5) the acquisition and availability of detailed

operations data in order to correlate passage behavior and survival with project operations; and 6) access to Lower Monumental Dam outside normal business hours.

**Objective 2: Assess passage behavior and estimate survival for yearling chinook salmon relative to operation of a removable spillway weir at Ice Harbor Dam.**

**Objective 3: Assess passage behavior and estimate survival for juvenile steelhead relative to operation of a removable spillway weir at Ice Harbor Dam.**

**Objective 4: Assess passage behavior and estimate survival for hatchery subyearling chinook salmon relative to operation of a removable spillway weir at Ice Harbor Dam.**

## Relevance

Survival estimates for juvenile salmonids that migrate through reservoirs, hydroelectric projects, and free-flowing sections of the Snake and Columbia Rivers are essential for developing effective strategies to recover depressed stocks. The current voluntary spill program specified in the 2000 FCRPS Biological Opinion (NMFS 2000) calls for Ice Harbor Dam project operations to rely on voluntary spill volumes at or near the total dissolved gas limits to increase fish passage efficiency (FPE). Eppard et al. (2000) reported that greater than 80% of yearling chinook salmon pass Ice Harbor Dam via the spillway. Studies of spillway passage survival at Ice Harbor Dam for yearling and subyearling chinook salmon have resulted in lower than expected survival estimates. For hatchery yearling chinook salmon survival was estimated at 97.8 (95% CI, ±4.0%), 89.2 (95% CI, ±5.2%), and 95.2% (95% CI, ±4.3%) under BiOp mandated operations in 2000, 2002, and 2003, respectively. For subyearling chinook salmon, spillway passage survival was estimated at 88.5 (95% CI, ±3.0%) and 89.4% (95% CI, ±4.0%) under BiOp mandated operations in 2000 and 2002, respectively (Eppard et al. 2002; Brad Eppard, NMFS personal communication). In 2003, spillway passage survival for subyearling chinook salmon was estimated at 96% (95% CI of 91 - 103%) under a bulk spill condition (Randy Absolon, NMFS personal communication).

In recent years surface collection and bypass systems have been identified as a viable alternative for increasing FPE for migrating juvenile salmonids at hydroelectric dams on the Snake and Columbia Rivers. Most notably is the Wells Dam project on the Columbia River where the spillway, located over the turbine units, passed 90% of fish while spilling just 7% of the total discharge (Johnson et al. 1992). Studies evaluating a removable spillway weir (RSW) installed at Lower Granite Dam in 2001 have indicated that the RSW is an effective and safe means of passing migrating juvenile salmonids (Angelea et al. 2003; Plumb et al. 2003 and 2004). The 2002 study showed that the RSW passed 56–62% of radio-tagged fish while discharging only 8.5% of the total discharge. In 2003, passage effectiveness ratios indicated that 8.3-9.9:1 fish were passed per percent

discharge through the RSW. Additionally, survival for radio-tagged fish passing through the RSW was estimated at 98% (95% CI, ±2.3%).

In an effort to increase passage survival for ESA listed salmon stocks the U.S. Army Corps of Engineers, in conjunction with regional resource managers, have selected Ice Harbor Dam for installation of an RSW. Installation is scheduled to be complete before the 2005 spring outmigration. The purpose of these objectives is to provide the Action Agencies with fish passage behavior as well as project, spillway, and RSW passage survival estimates at Ice Harbor Dam under 2 predefined operations during the 2005 outmigration.

## Methods

Numerous research methods have been and are currently being used to evaluate fish passage and/or estimate survival, including PIT tags, balloon tags, hydro-acoustic, and radiotelemetry. Each research method has its advantages and disadvantages, but options are limited in some situations because of lack of sampling capabilities downstream or where fish behavior and survival estimates are needed. In these situations, radiotelemetry is an ideal method for evaluating passage behavior and estimating survival. During 1999 studies at Lower Granite Dam, NMFS and United States Geological Survey (USGS) compared the performance of sham radio-tagged yearling chinook salmon (both gastrically and surgically implanted tags) to PIT-tagged fish. Results, based on PIT-tag detections, indicated that radio tags did not significantly affect detection probability (approximately equal to FGE in the absence of spill) or survival of yearling chinook salmon between the tailraces of Lower Granite and Lower Monumental Dams (a 106 km reach which included two dams and two reservoirs) (Hockersmith et al. 2003).

In 2005, we propose to collect and radio tag river-run yearling and subyearling chinook salmon and juvenile steelhead at the Lower Monumental Dam smolt collection facility from April through July. We will use a paired-release study design with treatment groups released upstream and reference groups released into the tailrace of Ice Harbor Dam. For Objective 2 treatment groups will be created by regrouping reference fish release as part of Objective 1 that subsequently enter into the Ice Harbor Dam study area at the upstream end of the BRZ. For Objective 3, we propose to collect and radio tag river-un juvenile steelhead at the Lower Monumental Dam smolt collection facility from April through June. For Objective 4, we propose to collect and radio tag river-run subyearling chinook salmon at the Lower Monumental Dam smolt collection facility from June through July. The study design for Objectives 3 and 4 will use a paired release design with treatment fish released about 5 km above Ice Harbor Dam and reference groups released into the tailrace. All fish will also be PIT-tagged. Fish handling methods such as water-to-water transfers and pre-anesthesia will minimize injury and stress to fish during the sorting and tagging process. Trained NMFS personnel will supervise all tagging operations and will use standard, previously documented tagging techniques. After tagging, fish will be held in 19-L containers partially submerged in a 126 x 217 x

41-cm tank for a minimum of 24 hours for recovery and determination of post-tagging mortality and/or tag loss. Holding densities will not exceed three fish per container. Holding tanks will be supplied with flow-through water.

The number of release groups and number of fish per release group were calculated to maximize the ability to provide a project survival estimate with 95% confidence intervals of +/- 3%. Sample sizes for releases were calculated based on data from radio-tagged yearling chinook salmon released at Lower Monumental and Ice Harbor Dams in 2002 and 2003 and annual PIT-tag survival estimates in the Lower Snake and Columbia Rivers (Table 1). Sample sizes may vary based on complete analysis of 2004 data. We used conservative assumptions in calculating sample sizes; our actual precision will likely be greater than shown. Treatment groups will be created by regrouping radio-tagged yearling and subyearling chinook salmon and juvenile steelhead released upstream and that subsequently enter into the Ice Harbor Dam study area at the upstream end of the boat restriction zone (BRZ). To test the assumption that a dead fish carrying an active radio tag could not float past a downstream detection line yielding a false-positive detection and biasing the survival estimate, euthanized radio-tagged fish will be released in conjunction with each group into the tailrace of Ice Harbor Dam.

Telemetry receivers and air antennas will be deployed to provide a minimum of three detection transects across the Snake and Columbia Rivers below Ice Harbor Dam. Minimum detection probabilities for each transect are expected to be 75%. At Ice Harbor Dam telemetry receivers will utilize underwater and air antennas to monitor the forebay, all routes of passage, and the tailrace to detect radio-tagged fish approaching, passing, and exiting the tailrace of the dam.

Radiotelemetry detection data for all release groups will be compiled and processed as described in Eppard et al. (2000). The "complete capture history" protocol (Burnham et al. 1987) will be used to estimate project survival and detection probabilities by applying the single release-recapture model (Cormack 1964; Jolly 1965; Seber 1965; Skalski et al. 1998; Skalski et al. 2001) independently to the treatment and reference groups. The release-recapture data will be analyzed using the Survival with Proportional Hazards (SURPH) statistical software developed at the University of Washington (Smith et al. 1994). Route-specific survival will be estimated for all passage routes where adequate numbers of fish pass the project to provide estimates with a precision level of at least +/- 0.07. Survival estimates and passage behavior metrics for the two spill patterns will be compared by analysis of variance (ANOVA). Correlations between survival, passage behavior, project operations and environmental conditions will be examined by regression analysis to determine how these factors effect project survival, route-specific survival, and fish passage at Ice Harbor Dam.

Ice Harbor Dam project operations during 2005 have not been finalized at the time of preparing this proposal. Expectations are that Ice Harbor Dam will operate under two basic conditions. One operation will be the RSW open with training spill in adjacent bays, the second operation is expected to be some form of voluntary spill (Tim Wik, USACE personal communication). The exact spill pattern may be based on results of the

2004 Ice Harbor Dam spillway survival evaluation. The study design will follow a 4-day block design with 2 days of RSW and training spill operation followed by 2 days of spill discharge volume described in the 2000 FCRPS Biological Opinion (NMFS 2000).

### Critical Limitations

The degree of success of this objective will be contingent upon seven primary factors:
1) adequate numbers of fish being collected and radio tagged at Lower Monumental Dam during the required time frame; 2) the pre-determined replicates and sample sizes providing the necessary precision for the survival estimates; 3) adequate numbers of radio-tagged fish passing through each passage route at Lower Monumental Dam to estimate route-specific survival with precision and evaluate passage behavior; 4) radiotelemetry receivers, PIT-tag detectors and bypass systems at downstream dams operating for the duration of the study; 5) installation of the 30 MHz MITAS system used at McNary Dam in 2003, 6) the acquisition and availability of detailed operations data in order to correlate passage behavior and survival with project operations and 7) access to Lower Monumental and Ice Harbor Dams beyond normal project business hours.

**Objective 5: Evaluate passage behavior and project survival for radio-tagged, yearling chinook salmon under current project operations at Little Goose Dam.**

### Relevance

The current voluntary spill program specified in the 2000 FCRPS Biological Opinion (NMFS 2000) calls for project operations at Little Goose Dam to rely on voluntary spill to increase FPE. Spill has been utilized increasingly to expedite the migration rates of juvenile salmonids past hydroelectric dams and to reduce the proportion of smolts passing through turbines where survival is lower (Muir et al. 2001b). Survival estimates for juvenile salmonids that migrate through reservoirs, hydroelectric projects, and free-flowing sections of the Snake and Columbia Rivers are essential for developing effective strategies to recover depressed stocks.

Since the advent of the voluntary spill program, passage behavior for migrating juvenile salmonids has not been evaluated at Little Goose Dam. The purpose of this objective is to provide the Action Agencies with a first look at fish passage behavior including passage distribution, spill efficiency, spill effectiveness, FPE, FGE, and tailrace egress as well as a project survival estimate at Little Goose Dam under one spill condition during the 2005 outmigration. This objective will provide the first year of passage behavior evaluation and survival evaluation at Little Goose Dam for yearling chinook salmon which will provide details and direction for subsequent evaluation next year.

## Methods

Numerous research methods have been and are currently being used to evaluate fish passage and/or estimate survival, including PIT tags, balloon tags, hydro-acoustic, and radiotelemetry. Each research method has its advantages and disadvantages, but options are limited in some situations because of lack of sampling capabilities downstream or where fish behavior and survival estimates are needed. In these situations, radiotelemetry is an ideal method for evaluating passage behavior and estimating survival. During 1999 studies at Lower Granite Dam, NMFS and United States Geological Survey (USGS) compared the performance of sham radio-tagged yearling chinook salmon (both gastrically and surgically implanted tags) to PIT-tagged fish. Results, based on PIT-tag detections, indicated that radio tags did not significantly affect detection probability (approximately equal to FGE in the absence of spill) or survival of yearling chinook salmon between the tailraces of Lower Granite and Lower Monumental Dams (a 106 km reach which included two dams and two reservoirs) (Hockersmith et al. 2003).

In 2005, we propose to collect and radio tag river-run yearling chinook salmon at either the Little Goose or Lower Monumental Dam smolt collection facility from April through June. All fish will also be PIT tagged. Fish handling methods such as water-to-water transfers and pre-anesthesia will minimize injury and stress to fish during the sorting and tagging process. Trained NMFS personnel will supervise all tagging operations and will use standard, previously documented tagging techniques. Tagging mortality is expected to be less than 4%. After tagging, fish will be held in 19-L containers partially submerged in a 126 x 217 x 41-cm tank for a minimum of 24 hours for recovery and determination of post-tagging mortality and/or tag loss. Holding densities will not exceed three fish per container. Holding tanks will be supplied with flow-through water.

We will use a paired-release study design with treatment fish released upstream and reference fish released into the tailrace of Little Goose Dam. Treatment fish will be transferred to a small barge transported approximately 5 km upstream from Little Goose Dam and released water-to-water. Treatment groups will be created by regrouping radio-tagged yearling chinook salmon released upstream that subsequently enter into the Little Goose Dam study area at the upstream end of the boat restriction zone (BRZ). Sample sizes for releases were calculated based on data from radio-tagged yearling chinook salmon released at Lower Monumental and Ice Harbor Dams in 2002 and 2003 and annual PIT-tag survival estimates in the Lower Snake and Columbia Rivers (Table 1). Sample sizes may vary based on complete analysis of 2004 data. Reference groups of tagged fish will be transferred to a small barge transported approximately 0.5 km downstream from Little Goose Dam and released water-to-water into the tailrace (Fig. 1). To test the assumption that dead fish carrying an active radio tag do not float past a downstream detection line yielding a false-positive detection and biasing survival estimates, euthanized radio-tagged fish will be released in conjunction with each group into the tailrace of Little Goose Dam.

Telemetry receivers and air antennas will be deployed to provide a minimum of three detection transects across the Snake River between Little Goose and Lower Monumental Dams. Minimum detection probabilities for each transect are expected to be 75%. Telemetry receivers will utilize underwater and air antennas to monitor the forebay, all routes of passage, and the tailrace to detect radio-tagged fish approaching, passing, and exiting the tailrace of the dam. Little Goose Dam project operations during 2005 have not been finalized at the time of this writing.

Radiotelemetry detection data for all release groups will be compiled and processed as described in Eppard et al. (2000). The "complete capture history" protocol (Burnham et al. 1987) will be used to estimate project survival and detection probabilities by applying the single release-recapture model (Cormack 1964; Jolly 1965; Seber 1965; Skalski et al. 1998; Skalski et al. 2001) independently to the treatment and reference groups. The release-recapture data will be analyzed using the Survival with Proportional Hazards (SURPH) statistical software developed at the University of Washington (Smith et al. 1994). Survival estimates and passage behavior metrics will be compared by analysis of variance (ANOVA). Correlations between survival, passage behavior, project operations and environmental conditions will be examined by regression analysis to determine how these factors effect project survival and fish passage at Little Goose Dam.

### Critical Limitations

The degree of success of this objective will be contingent upon five primary factors: 1) adequate numbers of fish being collected and radio tagged at Little Goose Dam during the required time frame; 2) the pre-determined replicates and sample sizes providing the necessary precision for the survival estimates; 3) radiotelemetry receivers, PIT-tag detectors and bypass systems at downstream dams operating for the duration of the study; 4) the acquisition and availability of detailed operations data in order to correlate passage behavior and survival with project operations; and 5) access to Little Goose Dam outside normal business hours.

## PROJECT IMPACTS

1. Collection, tagging, and fish-holding operations at Little Goose and Lower Monumental Dams will be coordinated with the Project Office and Smolt Monitoring Program personnel.
2. Activities related to marking and/or releasing fish at Little Goose, Lower Monumental, and Ice Harbor Dams may occur during all hours; therefore, unusual vehicle traffic and activity may occur outside normal COE duty hours during April through July.
3. Installation, deployment, maintenance, downloading, and removal of telemetry equipment by NMFS personnel including receivers, antennas, and cables will occur at Little Goose, Lower Monumental, and Ice Harbor Dams from February through July.

4. Moorage space for release barges may be needed in the forebay of Little Goose, Lower Monumental, and Ice Harbor Dams.

5. A reliable, uninterruptible power supply will be required at all projects for operation of radiotelemetry receivers.

## BIOLOGICAL EFFECTS

These studies will be carried out using an ESA Section 10 Permit issued to the National Marine Fisheries Service.

## TECHNOLOGY TRANSFER

Information acquired during the proposed work will be transferred to the fisheries community by presentations at meetings and workshops, by personal contact, by annual and final reports to the U.S. Army Corps of Engineers, and through scientific publications.

## KEY PERSONNEL AND DUTIES

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| M. Brad Eppard | Principal Investigator |
| Eric E. Hockersmith | Principal Investigator |
| Gordon A. Axel | Principal Investigator |
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| Byron L. Iverson | Electronics Technician |
| Bill Munger | Electronics Technician |
| Mark A. Kaminski | Electronics Technician |
| Steven G. Smith | Statistician |
| Benjamin P. Sandford | Statistician |
| Douglas B. Dey | Program Manager |
| John W. Ferguson | Acting Division Director |

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Table 1. Estimated sample sizes for tagging and release by objective for yearling and subyearling chinook and juvenile steelhead for fish passage behavior and survival at Little Goose, Lower Monumental, and Ice Harbor Dams in 2005.

| Release Group | Objective | Yearling chinook | Juvenile steelhead | Subyearling chinook |
|---|---|---|---|---|
| LGO Treatment | 5 | 1,000 | --- | --- |
| LGO Reference | 5 | 800 | --- | --- |
| LMN Treatment | 1 | 1,200 | --- | --- |
| LMN Reference | 1 | 1,650 | --- | --- |
| IHR Treatment | 2, 3, & 4 | 350 | 2,000 | 2,500 |
| IHR Reference | 2, 3, & 4 | 1,650 | 1,650 | 2,000 |
| Total | | 6,650 | 3,650 | 4,500 |