JUVENILE SALMONID DIRECT SURVIVAL/INJURY IN PASSAGE THROUGH THE ICE HARBOR DAM SPILLWAY, SNAKE RIVER

Contract No. DACW68-02-D-0002
Task Order 0006

April 2004

NORMANDEAU ASSOCIATES
ENVIRONMENTAL CONSULTANTS

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EXECUTIVE SUMMARY

Releases of HI-Z tagged (HI-Z tag or balloon tag) chinook salmon smolts, *Oncorhynchus tshawytscha*, (and rainbow trout, *O. mykiss*, in summer) were made into Spillbay 5 and downstream of Spillbay 1 (spring controls) and through the juvenile fish facility bypass pipe (spring and summer controls) at Ice Harbor Dam from 23 April to 2 May 2003 (spring) to (1) estimate survival (direct effects) within ≤±3%, 90% of the time, in passage at shallow (7 ft above ogee) and deep (3 ft above ogee) sites at 50% spill, 100% spill, and a special spill pattern, and (2) better understand the injury mechanisms to assist in possible spillway/deflector modifications for enhanced fish survival. In summer (July 2003) direct effects of dispersed and bulk spill volumes were estimated; fish were released at a deep release site (dispersed spill) and at shallow and deep sites at a bulk spill pattern. The resulting survival estimates from these releases were to be within ≤±5%, 90% of the time. Differences in survival or clean fish estimates between treatment conditions were statistically tested *a posteriori*; the initial study was not designed to detect statistical differences.

Average total fish length in spring was about 141 mm and 123 mm in summer. Water temperatures ranged from 10.0 to 11.5°C (50.0 to 52.7°F) in spring and from 19.5 to 20.5°C (67.1 to 68.9°F) in summer. Estimated impact velocities encountered by released fish in spring ranged from 70.2 to 71.6 ft/s; in the summer, impact velocities ranged from 70.1 to 73.2 ft/s. Laboratory studies suggest impact velocity exceeding about 58 ft/s may inflict injury/mortality to fish.

Recapture rates (physical retrieval of alive and dead fish) were higher in April and May than for the July releases. Recapture rates for treatment groups in April and May were 99.7 to 100%; for the controls recapture rates were 99.3%. Recapture rates of chinook salmon treatment groups in July ranged from 90.8% (bulk spill, shallow release) to 97.0% (dispersed spill, deep release); recapture rates for the two rainbow trout treatment groups (n=20 for each) ranged from 95.0% (bulk spill, shallow release) to 100% (bulk spill, deep release). July recapture rate for the control group released through the bypass pipe was 99.2%.

Estimated immediate survival rates (1 h) were higher in April and May (all ≥98.7%) than in July. For the summer releases they ranged from 88.9 (bulk spill, shallow release) to 97.8% (dispersed spill, deep release). The 48 h survival estimates for spring releases also exceeded 98% (range 98.7 to 99.0%) with little difference either between spill patterns or between release sites. Unacceptable holding mortality in both the treatment (32 to 42%) and control (about 31%) groups precluded reliable estimation of 48 h survival.

The pre-specified precision (ε) level of ≤±3%, 90% of the time was met on all survival estimates in spring; the pre-specified precision (within ≤±5%) was attained for two of the three treatment groups (shallow release at bulk spill and deep release at dispersed spill) in the summer investigation. Bacterial infections at the tag insertion site or fungal infections on gills were observed on fish in holding in July and were likely exacerbated by the higher summer water temperatures (19.5 to 20.5°C or 67.1 to 68.9°F). Smaller fish size in July may have also affected the physical recapture rates to a certain extent due to the higher propensity for tag dislodgment (fish assumed dead) on smaller sized fish.

Survival estimates derived from detection of PIT-tagged fish released through Spillbays 1 and 3 at the same time in summer were reported at 96%; interestingly, these estimates are higher than the summer direct estimates at the bulk spill (88.9 to 92.3%; pooled 90.1%) and counterintuitive because estimates derived from the PIT tag-recapture technique contain the direct (immediate) and indirect (occurring over a longer time and distance). The difference between the two estimates at summer dispersed spill condition is small in favor of the direct estimate (97.8% for direct and 96% for PIT

tagged fish). Estimates from our investigation represent only the direct effects of passage. However, the proportion of the PIT tagged fish injured during passage is unknown.

“Clean fish” estimates (CFE) differed between spill patterns and passage locations within the spillbay. With respect to spill patterns, CFE for deep released fish (79.3%) at 50% spill pattern was significantly lower ($P<0.05$) than at 100% spill (87.8%) in spring. However, CFEs for deep released fish at special spill (78.3%) and 100% spill (87.8%) were not significantly different ($P>0.05$); the sample size was too small for this test to detect a difference. With respect to release locations within each spill pattern in spring, significant differences ($P<0.05$) were noted with deep releases having lower CFEs at both 100% spill and bulk spill patterns than shallow released fish; the magnitude of difference between release locations was similar (about 12%) at both spill patterns.

The effect of passage location was also evident in the July test. CFE for deep released fish (81.3%) was significantly lower ($P<0.05$) than for shallow released fish (95.1%) at the bulk spill pattern; the only spill pattern at which fish were released at two locations. CFE for deep released fish at the dispersed spill pattern was estimated at 79.6%, comparable to that at the bulk spill pattern. Except for one clean fish estimate, 97.4%, in spring (shallow release site at 100% spill) the other seven estimates were lower than those reported for the summer released PIT tagged fish (96%); it appears that all maladies observed in our investigation were not lethal or the two groups of fish traveled different paths in exiting the spillbays.

Spill volume and passage location appeared to affect injury types and rates. In spring, higher injury rates (20.7%) occurred at the 50% spill volume (3.4 to 5.1 kcfs through Spillbay 5) than at the 100% spill, 8.5% (4.25 to 8.5 kcfs through Spillbay 5). At 100% spill volume, only 1.3% of the shallow pipe released fish were injured compared to 12.2% for the deep release pipe. For the special spill (8.5 kcfs spill through Spillbay 5), injury rates were 8.3 and 21.7% for the shallow and deep release pipes, respectively. In the summer, injury rate was high (18.4 to 20.0%) for fish released via the deep pipe at both bulk and dispersed spill; however it was only 4.9% for fish passed by the shallow pipe at dispersed spill. The differential injury rates relative to release location and spill volume through the test spillbay may be related to the unique hydraulic characteristics of the jet as it enters the tailrace.

The predominant injury type was hemorrhaged or damaged eye. The causative mechanisms for the observed injury types may have resulted from shear forces in the vicinity of the flow deflector. Fish passed via the deep pipe were much more likely to sustain eye damage (13% deep pipe, 2% shallow).

It is unknown whether the passage-related maladies are lethal on a long-term basis. Because eye damage was the dominant injury type, information is needed on the persistence and severity of this injury type on post spillway passage survival of emigrating fish, effects on vision, predator avoidance and feeding success. The finding that fish passed close to the ogee (deep release pipe) suffered more injuries regardless of spill rate also needs to be integrated with the proportion of the naturally emigrating population that would be subjected to the hydraulic conditions experienced by these fish. Preliminary hydroacoustic data from Ice Harbor in 2003 suggest that most fish pass higher above the ogee; however, at low tainter gate openings (2 to 3 ft) fish do not have much of an opportunity to orient higher in the discharge jet. Thus, at lower gate openings the fish may have a greater chance of being exposed to injurious hydraulic conditions particularly in the vicinity of the flow deflector. The concurrent sensor fish data collected at Ice Harbor indicate that injurious hydraulic conditions do exist in the immediate vicinity of the flow deflector especially for sensors passed via the deep pipe. Further research is needed to ascertain the relationship between potentially injurious hydraulic conditions and depth of sensor fish upon passing the flow deflector and submergence depth of the flow deflector.

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1.0 INTRODUCTION

Juvenile salmonids on their seaward journey encounter any or all of the following exit routes at hydro dams: turbines, spillways, and bypasses. There are two inter-related concerns associated with passage through any of these routes for overall survival. One is the proportion of fish utilizing any of these routes during emigration and the other is their subsequent post-passage condition and survival. Spill of varying magnitude and duration is used at most hydro dams on the Columbia River Basin to enhance passage effectiveness and overall survival of juvenile salmonids (Wilson *et al.* 1991). However, spill is expensive in terms of lost power generation and with some spillway configurations and flow patterns, potentially lethal levels of total dissolved gas (TDG) in the river can result. To alleviate the TDG supersaturation levels at Ice Harbor Dam (Ice Harbor) on the lower Snake River (Figure 1-1), flow deflectors were installed downstream of the spillway at Spillbays 1 through 10. Flow deflectors are concrete sills installed on the downstream face of a spillway to maximize the surface skimming effect of spilled water and prevent plunging to the bottom of the stilling basin thus reducing the pressure gradient that forces atmospheric gases into the solution; the installation depths of the flow deflectors varies with sites. Due to a variety of factors (*e.g.*, spill volume, spill pattern, passage location within a spillbay, and flow deflector elevation), fish passage survival and injury rates in passage through spillbays equipped with flow deflectors have not been ≥98% at all of the hydroelectric dams on the Columbia River Basin (Normandeau Associates *et al.* 2003a). Consequently, there is a need for a better understanding of mechanisms influencing passage survival of juvenile salmonids so that appropriate mitigative measures, if needed, can be implemented.

Some recent spillway passage studies on juvenile salmonids at Ice Harbor utilizing PIT tags and radio tags have indicated variation between seasons and years; passage survival estimates were approximately 98% in the spring of 1999 but lower in the summer of 1999 and spring of 2002 (Absolon *et al.* 2003; Eppard *et al.* 2003). Powerhouse survival (turbine and bypass combined) was estimated to be 98% in 2001. Due to low river flows in 2001, spillway operations were constrained. However, mechanisms for lower survival at Ice Harbor could not be delineated by these studies. It is thought that the survival of fish passing through the spillway at Ice Harbor may be linked to the relationship between the spillway deflector elevation and the tailwater elevation. Tailwater elevation is dependent primarily upon project discharge at Ice Harbor.

Surface oriented salmonid emigrants generally occupy the top 20 ft of the water column and must sound to deeper depths to exit the Ice Harbor spillway equipped with bottom opening tainter gates. The height of the bottom opening and associated spill volume create hydraulic passage conditions which may affect fish survival and injury rates.

The primary objective of the present study was to obtain estimates of direct spillway passage survival of juvenile salmon within $\leq\pm3\%$, 90% of the time, at two spill volumes (50 and 100% of the river flow) under typical spring high tailwater condition. Fish were introduced at two depths in Spillbay 5, shallow (7 ft above the ogee) and deep (3 ft above the ogee). Additionally, a smaller scale experiment was conducted at a special spill pattern. Results from the spring study elicited a secondary experiment in summer (low tailwater) to obtain survival estimates within $\pm5\%$, 90% of the time at two additional spill conditions, bulk spill and dispersed spill. An additional objective was to determine the extent and types of injuries incurred by spillway passed juvenile salmon under spring and summer tailwater conditions.

Some recent studies have indicated that the use of the HI-Z tag-recapture (HI-Z tag or balloon tag) technique (Heisey *et al.* 1992, 2002a) can provide useful information on potential mechanisms influencing the direct effects of passage through various exit routes at hydroelectric dams.

1.1 Project Description

Ice Harbor is the first dam on the Snake River upstream of the confluence with the Columbia River (Figures 1-1 and 1-2). It has six Kaplan type turbine units and 10 spillway bays, along with a navigation lock and an earthfill section. The stilling basin for the spillway is 59 ft long and 168 ft wide with a floor elevation of 304 ft msl. Each spillbay is equipped with a 53 ft high and 50 ft wide tainter gate that seals at an elevation of 389 ft msl. The crest elevation for the spillway is 391 ft msl. Standard-length submersible traveling screens (STSs) are present in all turbine intake bays. The present investigation was conducted at Spillbay 5.

In order to reduce the level of TDG supersaturation produced by water passing over a spillbay, the Corps had installed flow deflectors on the downstream face of all spillbays that direct the flow along the surface of the tailrace rather than allowing it to plunge to the bottom of the spilling basin; these flow deflectors are located at an elevation of 338 ft msl on Spillbays 2 through 9 and at an elevation of 334 ft msl at the outer spillbays. The shallow and deeper flow deflectors are submerged 7 and 11 ft, respectively, below a typical springtime tailwater elevation of 345 ft msl (Figures 1-1 and 1-2).

A 12 ft high concrete end sill and 8 ft high by 10 ft wide dentates extends across the spillway to aid in energy dissipation (Figure 1-2). These structures are submerged approximately 29 and 33 ft during the typical springtime tailwater elevation (345 ft msl). The end sill and dentates are approximately 170 and 128 ft downstream of the face of the spillway, respectively.

The Ice Harbor tailwater elevation is directly dependent upon river flow (project discharge). At low discharge (less than 50k cfs), the tailwater is generally below 341 ft. The tailwater is generally above 345 ft at discharges greater than 100k cfs. The normal operating range of the tailrace elevation is 339.5 to 345 ft.

2.0 STUDY DESIGN

There are two primary components which affect fish using any exit route: direct and indirect effects. Direct effects are manifested immediately after passage (*e.g.*, instantaneous fish mortality, injury, loss of equilibrium); indirect effects (*e.g.*, predation, disease, physiological stress) may occur over an extended period or distance after passage. The present study was designed to estimate the direct effects. Spillway fish passage survival and condition was measured by a straightforward approach of introducing a known number of HI-Z tagged alive fish into Spillbay 5 (treatment) and downstream of the spillway (control), recapturing them immediately after passage, enumerating the alive and dead fish, and then carefully examining the condition of each fish. The sample sizes needed to estimate survival within a prespecified precision (ε) level were based on estimating the direct effects of passage.

Treatment fish were released either 3 ft or 7 ft above the ogee and approximately 16 ft upstream of the tainter gate (Figures 2-1 and 2-2). Control fish were released to assess the effects of handling, transport, tagging, release, and recapture. Controls were released either downstream of Spillbay 1 (spring) or via the juvenile facility fish bypass pipe in spring (April and May) and summer (July) (Figure 1-1). Table 2-1 provides the daily fish release schedule.

Ambient river temperature during the study ranged from 10.0 to 11.5°C (50.0 to 52.7°F) in April/May and 19.5 to 20.5°C (67.1 to 68.9°F) in July (Table 2-1). Table 2-2 provides total project discharge and spill volumes at Spillbay 5 and over the entire spillway during the study. During fish releases, spill volume through Spillbay 5 ranged from 3.4 to 8.5k cfs in spring and from 3.4 to 13.6k cfs in summer.

Total project spill between the two periods ranged from 31.0 to 79.0k cfs during the spring experiment and 13.6 to 45.0k cfs in summer (Table 2-2). The respective total project discharge ranged from 60.6 to 101.4k cfs and 14.4 to 56.1k cfs. The 100% spill condition, in reality, was less because the Project required the operation of at least one turbine. Tailwater elevation ranged from 342.2 to 345.9 ft msl in spring and 338.2 to 341.1 ft msl in summer. Thus, the respective submergence depth of the flow deflector ranged from 4 to 8 ft and 0 to 3 ft. The characteristics of the discharge jet upon interception of the flow deflector are shown in Figure 2-3. Forebay elevations ranged from 438.0 to 438.9 ft in spring and 438.2 to 439.4 ft in summer (Table 2-2). The respective net heads were 93.5 to 96.5 and 97.7 to 100.3 ft. Hourly values for the above project operations data are presented in Appendix Table A-1.

Three spill conditions were tested in spring and two in summer (Appendix B). The spring conditions were designated 50%, 100%, and special spill. The summer conditions were designated bulk spill and dispersed spill. During the 50%, 100%, special, and dispersed spill conditions, the spill volume was spread nearly uniformly across all spillbays (Table 2-3). During the bulk spill, Spillbay 5 was set at 8 stops (13.6k cfs) and the most of the spill was passed via this spillbay.

2.1 Sample Size Requirement

Prior to initiating the fish survival investigation at Ice Harbor Dam, the sample size requirement was determined to fulfill the primary objective of the study: achieving a prespecified precision (ε) level (within $\leq\pm0.03$ (April and May) or $\leq\pm0.05$ (July), 90% of the time) on the individual estimates of passage survival ($\hat{\tau}$). The sample size is a function of the recapture rate (P_A), expected passage survival ($\hat{\tau}$) or mortality ($1-\hat{\tau}$), survival of control fish (S), and the desired precision (ε) at a given probability of significance (α). In general, sample size requirements decrease with an increase in control survival and recapture rates. Only precision (ε) and α levels can be strictly controlled by an investigator. The expression to calculate sample sizes for achieving a prespecified precision (ε) level is given in Mathur *et al.* (1996).

In performing the sample size calculations, we assumed capture data from replicate releases could be pooled (*i.e.*, natural variability $\sigma_{\tau}^{2}=0$). We calculated that with the following assumptions: a recapture rate of 0.98, control survival rate (S) of 0.99, and spillbay survival ($\hat{\tau}$) of 0.97, a precision (ε) level of $\leq\pm0.03$, 90% of the time might be achievable with releasing 264 fish per treatment; however, only 95 fish per treatment are needed at a precision (ε) level of $\leq\pm0.05$ (Table 2-4).

Based on the results of several recent spillbay survival experiments from other sites on the Columbia River Basin (Table 2-5), a sample size of approximately 250 and 150 fish per treatment release was deemed sufficient to attain the two prespecified precision levels (ε) of $\leq\pm0.03$ and $\leq\pm0.05$, 90% of the time. Given the above assumptions, the projected number of fish allocated for the April/May and July study period were 945 (655 treatment and 290 controls) and 450 (300 treatment, 150 controls), respectively.

Past experience suggests that the sample sizes can be adjusted as a study progresses because the statistical results are available daily. If recapture and control survival rates are higher than initially assumed, sample size can be reduced. Conversely, if the values of these parameters are lower than initially assumed, then sample size can be increased to achieve the pre-specified statistical precision. However, under certain extenuating circumstances (*e.g.*, time, fish availability, or desired test condition constraints) sample size adjustments may not always be possible during the course of an experiment. Indeed, the full initial allocation of fish for the spring study was not utilized because the precision (ε) objective had been achieved by a release of fewer fish. Consequently, this allowed releasing the remainder of the fish to assess another spill condition (special spill pattern), *albeit* on a smaller scale.

2.2 Source and Maintenance of Specimens

Juvenile chinook salmon smolts used in the spring study were obtained from the Leavenworth National Fish Hatchery, Washington. Fish for the summer experiment were collected at John Day Dam. Some 1,208 fish were transported from the hatchery and approximately 475 fish from John Day Dam via truck to a 600 gal circular holding pool on the tailrace deck at Ice Harbor Dam (Table 2-6). Due to the limited supply of in-river fish (475) during the July experiment, the summer tests were supplemented with 500 rainbow trout from the Trout Lodge Hatchery, Soap Lake, Washington. The transport tank for the Leavenworth fish was equipped with a recirculation system and supplemental oxygen supply. The approximate transport times from Leavenworth Hatchery and John Day Dam to the study site were 3.5 and 2 h, respectively. Approximately 24 h prior to tagging, 150 fish were transferred to a 200 gal holding tank on the upper spillway deck. Fish holding tanks, equipped with degassing units, were continuously supplied with ambient river water. Fish were held a minimum of 24 h prior to tagging to alleviate handling stress and to allow fish to acclimate to ambient river conditions. Water temperature in the holding pools ranged from 10.5 to 11.0°C in the spring and 20.0 to 20.5°C in the summer. The higher ambient river temperatures in July (19.5 to 20.5°C) appeared to have imposed some stress on the sub-yearling chinook. Seven of the 475 sub-yearling chinook died in the holding tanks prior to testing and another 25 fish had excessive scale loss (>20% per side) or developed fungal infections (Table 2-6). None of the fish in the spring succumbed during the pre-test holding period or developed infections. Consequently, because of the poor fish condition and subsequent unacceptable level of holding mortality, the 48 h survival estimates for the July experiment were not generated.

2.3 Tagging and Release

Fish handling and tagging recapture techniques were identical to those previously used at other hydroelectric projects on the Columbia River Basin (Heisey *et al.* 1992; Mathur *et al.* 1996, 1999; Normandeau Associates *et al.* 1996a,b,c). Briefly, lots of 5 to 10 fish were removed with a water sanctuary equipped net from holding tanks (on the spillway deck) to the adjacent tagging site using a small tub full of water. Fish displaying abnormal behavior, severe injury, fungal infection, or descaling (>20% per side) were not used. The same fish selection criterion was applied to all treatment and control groups. Fish were anesthetized in a 0.5% MS 222 solution (<5 min) and equipped with two uninflated HI-Z tags and a miniature radio tag. Table 2-1 shows the number of treatment and control fish released each day.

Figure 2-4 summarizes the length data of the treatment and control fish groups. Chinook salmon lengths averaged about 141 mm (range 122 to 181 mm) in April and May and 123 mm (range 113 to 157 mm) in July. Most fish were longer than 140 mm in spring, while in summer most fish measured less than 135 mm. The rainbow trout used in July averaged 144 mm (range 118 to 166 mm).

Tags were attached via a stainless steel pin inserted through the musculature beneath the dorsal and adipose fins. A radio tag was attached in combination with the dorsal HI-Z tag (Heisey *et al.* 1992). A uniquely numbered VI tag (Visual Implant, Northwest Marine Technology, Inc., Shaw Island, Washington) was also inserted in the postocular tissue for use in tracking 48 h survival of individual recaptured fish. Fish also received a fin clip to designate release location (test or control) in the event the VI tag became dislodged. HI-Z tagged fish were placed in a covered, 20 gal container continually supplied with ambient river water until fully recovered from anesthesia (generally 30 to 45 min, minimum 20 min). After full recovery from anesthesia, fish were individually placed into the induction system, tags were activated, and the fish was released. Inflation time of the tags was partially regulated by the temperature and amount of water injected into the tags just prior to release and/or the ingredients within the tag.

All treatment and control fish were released through an induction apparatus that consisted of a small holding basin attached to a 4 in diameter flexible hose (Normandeau Associates and Skalski 1999, 2000a; Normandeau Associates and Mid Columbia Consulting 2001; Normandeau Associates *et al.* 1996a,b,c). The release hose was continuously supplied with river water to ensure fish were transported quickly to the desired release point.

At each treatment release site the 4 in diameter flexible hose was threaded through a 6 in diameter welded steel pipe (Figures 2-1 and 2-2). The steel pipe and hose was held in position by braces mounted on the spillway headworks and steel guide wires secured to the spillbay nose piers. The terminus of each treatment release hose was oriented downstream either 3 (deep) or 7 (shallow) ft above the ogee. The deep and shallow release pipes were offset 4 and 2 ft, respectively, from the middle of Spillbay 5 and approximately 16 ft upstream of the tainter gate (Figures 2-1 and 2-2).

One control release pipe with induction hose was positioned downstream of Spillbay 1 (Figure 1-1). The terminus of this pipe was approximately 170 ft downstream of the base of Spillbay 1 and approximately 24 ft and 29 ft above the tailrace, in spring and summer, respectively. The second control release site utilized the juvenile fish facility bypass pipe. Fish were released into the bypass pipe via an approximately 5 ft long section of the 4 in diameter induction hose. Fish were introduced 1,150 ft upstream of the end of the bypass pipe (Figure 1-1). The bypass pipe alternate control release site was chosen because dye releases through the Ice Harbor model at the Corps' Vicksburg, Mississippi facility indicated the potential for some fish released downstream of Spillbay 1 to be drawn upstream.

Procedures for handling, tagging, release, and recapture of fish were identical for treatment and control groups. Fish were randomly selected from each day's transport. All spill tests, except the 100% spill tests, were conducted during daylight hours (0700 to 1800 h). The 100% spill tests were conducted only in the evening. The Project did not commence 100% spill until 1800 h and terminated it at 0600 h.

Fish allocation for the spring 50%, 100%, and special spill was 310, 225, and 120 fish, respectively. The number of control fish released was 140 downstream of Spillbay 1 and 150 fish via the bypass pipe (Table 2-1). The summer releases consisted of 179 and 100 treatment chinook salmon for the bulk spill and dispersed spill, respectively, and 125 controls released only at the bypass pipe (Table 2-1). An additional 40 rainbow trout were released at the bulk spill; no control rainbow trout were released.

2.4 Fish Recapture

Upon passage, fish were tracked and retrieved when buoyed to the surface downstream of the spillbays by one of three or four recapture boat crews. Boat crews were notified of the radio tag frequency of each fish upon its release. Only crew members trained in fish handling were used to retrieve tagged fish. To minimize crew bias, no crew was specifically assigned to retrieve either control or treatment fish.

Radio signals were received on a 5-element Yagi antenna coupled to an Advanced Telemetry System receiver. The radio signal transmission enabled the boat crew(s) to follow the movement of each fish after passage and position the boats downstream for retrieval when the HI-Z tag buoyed the fish to the surface. Boats were required to remain a safe distance downstream of the turbulent discharge.

Occasionally during the summer testing period spill was temporarily curtailed after a group of 10 to 15 fish were released to permit the boats to recapture fish that had moved into eddy areas. Spill curtailment was not possible in the spring and a few fish that became inaccessible to the boat crews were replaced with additional fish. Additionally, control fish could not be successfully released and recaptured during bulk spill conditions in July because the fish were drawn upstream from the exit of the bypass pipe into the turbulent Spillbay 5 discharge. Consequently, control fish were released during a period of no spill or dispersed spill.

Active radio tags which failed to surface were tracked for a minimum of 30 min and then periodically thereafter to ascertain if fish displayed movement patterns typical of emigrating smolts or that of a predator. Recaptured fish were placed into an on-board holding facility and tags were removed (Heisey *et al.*1992). Each fish was immediately examined for maladies consisting of injuries, descaling, and loss of equilibrium and assigned appropriate condition codes, if necessary, per the descriptions presented in Table 2-7. Tagging and data recording personnel were notified via a two-way radio system of each fish's recovery time and condition.

Each recaptured fish with a visible injury or scale loss was assigned a likely causal mechanism. Limited controlled experiments (Neitzel *et al.* 2000; PNNL *et al.* 2001) to replicate and correlate injury type and characteristic to a specific causative mechanism provides some indication of the cause of observed injuries in the field. Some injury symptoms can be manifested by two different sources which may lessen the probability of accurate delineation of a cause and effect relationship (Eicher Associates 1987).

All fish recaptured alive were transferred in 5 gal pails to 600 gal pools on the tailrace deck for assessment of delayed effects (48 h). Each pool equipped with a degassing unit was continuously supplied with ambient river water and shielded to prevent potential fish escape and/or avian predation. Each day’s treatment and control fish were held together in the same pools for 48 h.

As a precautionary measure, the Corps secured the services of personnel from the U. S. Department of Agriculture to scare gulls from the tailrace. Past experience has shown that the hazing of gulls minimizes the potential loss of buoyed experimental fish to gulls, and thus maintains the use of prespecified sample sizes. However, predation by piscivores (*e.g.*, northern pikeminnow, smallmouth bass, or walleye) on tagged fish could not be controlled.

2.5 Classification of Recaptured Fish

As in the previous investigation at spillways and other experiments on the Columbia River Basin (Normandeau Associates *et al.* 1996a,b,c, 1997; Normandeau Associates and Skalski 1998, 1999, 2000a,b,c) the immediate post-passage status of an individual recaptured fish and recovery of inflated tags dislodged from fish was designated as alive, dead, tag and pin recovered, unknown, or predation. The following criteria have been established to make these designations: (1) alive--recaptured alive and remaining so for 1 h; (2) alive--fish does not surface but radio signals indicate movement patterns typical of emigrating juveniles; (3) dead--recaptured dead or dead within 1 h of release; (4) dead--only inflated dislodged tag(s) are recovered, and telemetric tracking or the manner in which inflated tags surfaced is not indicative of predation; (5) unknown--no fish or dislodged tags are recaptured, or radio signals are received only briefly, and the subsequent status cannot be ascertained; and (6) predation--fish are either observed being preyed upon, the predator is buoyed to the surface, or subsequent radio telemetric tracking indicates predation (*i.e.*, rapid movements of tagged fish in and out of turbulent waters or sudden appearance of fully inflated tags). Unrecovered preyed upon fish are assumed dead in the survival calculations; alive recaptured fish suspected of predator attack were included with the alive category.

Mortalities of recaptured fish occurring after 1 h were assigned 48 h post-passage effects although fish were observed at approximately 12 h intervals. Specimens were examined for descaling and injury, and those that died were necropsied to determine the probable cause of death. Additionally all specimens alive at 48 h were re-anesthetized and closely examined for injury and descaling. The re-examination of immobilized fish minimizes the need for extensive handling and associated stress upon immediate recapture. The initial examination allows detection of some injuries, such as bleeding and minor bruising that may not be evident after 48 h due to natural healing processes (Normandeau Associates *et al.* 1996a,b,c). Injury and descaling were categorized by type, extent, and area of body.

Fish without visible injuries that were not actively swimming or swimming erratically at recapture were classified as "loss of equilibrium". This condition has been noted in most past studies and often disappears within 10 to 15 min after recapture if the fish is not injured (Normandeau Associates *et al.* 1996a,b,c). A malady category was established to include fish with visible injuries, scale loss (greater than 20% on either side), or loss of equilibrium. Dead fish without any of these symptoms were not included in this category. Fish without maladies were designated "clean fish". Detailed descriptions of maladies observed on each recaptured fish are presented in Appendix Tables B-1 and B-2.

This clean fish metric was established to provide a standard way to present a rate depicting how a specific passage route affected the condition of passed fish. Clean fish, the absence of maladies, was chosen so that this metric may be more comparable to survival; however, the clean fish metric is based solely on fish physically recaptured and examined. Additionally, the clean fish metric in concert with site-specific hydraulic and physical data can provide insight into what passage conditions may provide safer fish passage.

Visible injuries were also categorized as minor or major, based on laboratory studies by PNNL *et al.* (2001) and Normandeau's field observations. These are as follows:

- Minor – Injuries that were visible but not life threatening and tended to heal and disappear over the post-exposure observation period. Hemorrhages that covered less than half an eye or small bruises (approximately 0.5 cm in diameter) with minor discoloration (most commonly observed at the dorsal insertion of the operculum) were given a minor injury rating because fish quickly recovered from such injuries and/or displayed no apparent ill effects.
- Major – Any injury that was life threatening, or persisted throughout the post–exposure observation were rated major, except eye hemorrhages of less than 50%. For example, a large bruise (>0.5 cm in diameter), damage to the spinal column, cuts with visible bleeding, injured eyeballs (bulging, hemorrhaged, or missing), gill damage (inverted gill arches severe enough to result in bleeding).

2.6 Spill Volume and Impact Velocity

The spill volume through Spillbay 5 varied between 3.4 (2 stops) and 8.5k cfs (5 stops) during the spring investigation to maintain a 50 or 100% spillway discharge (Table 2-2). During the summer bulk spill study, only two spill volumes (3.4 and 13.6k cfs, 2 and 8 stops) were tested at Spillbay 5.

Impact velocities were estimated for deflector impact only because the flow of the discharge swept the deflector. The velocity of the discharge jet upon impact with the flow deflector was calculated by adding vertical and horizontal vectors of velocity. The vertical component was calculated based on the vertical distance from the center of the jet to the deflector. Estimated impact velocities averaged from 70.2 to 71.6 ft/s in spring and from 70.0 to 73.3 ft/s in the summer (Appendix A); the laboratory studies suggest these velocities exceed those capable of inflicting injury/mortality (approximately 58 ft/s) on fish (Neitzel *et al.* 2000).

2.7 Survival and Clean Fish Estimation and Data Analysis

Passage survival probabilities ($\hat{\tau}$) for each spill condition were estimated relative to the control fish survival (Heisey *et al.* 2002a; Mathur *et al.* 1996, 1999). Survival probabilities were also computed for approximate location of fish passage; shallow (released 7 ft above ogee) and deep (released 3 ft above ogee). Data from individual daily trials (Appendix Tables B-3 and B-4) were used in the analysis. However, excessive mortality of both treatment and control fish occurred during the 48 h delayed assessment period in the summer experiment and thus, immediate (1 h) survival was estimated. The treatment conditions and common controls were simultaneously analyzed and modeled by joint likelihood (Normandeau Associates *et al.* 1996a,b,c).

A likelihood ratio test was used to determine whether recapture probabilities were similar for alive (P_A) and dead (P_D) fish. The statistic tested the null hypothesis of the simplified model (H_O:P_A=P_D) versus the alternative of the generalized model (H_A:$P_A \neq P_D$). Depending upon the outcome of this analysis for the 1 h survival the parameters and their associated standard errors were calculated using that model.

As in previous studies (Normandeau Associates and Skalski 2000a), separate chi-square analyses (Appendix C) were performed to test for homogeneity (P=0.05) between daily treatment and control releases with respect to recapture frequencies of alive, dead, and non-recovered fish. Homogeneity (P>0.05) between daily control trials within each season (spring and summer) allowed pooling of data. Thus, data from all of the daily control releases within each season were pooled and survival for each spill condition and passage location was estimated relative to survival of the pooled control group. All statistical analyses were conducted using the Statistical Analysis System (SAS). The statistical outputs with exact probabilities are provided in Appendix C (output discussed in the report are highlighted). The disposition of individual fish is given in Appendix D and only summarized information is discussed in the main body of the report.

The clean fish estimate (CFE) was calculated separately for both spring and summer releases. It was based on recaptured fish without maladies (*i.e.*, no visible injuries, scale loss, or loss of equilibrium) or displayed maladies that were not attributable to passage, *i.e.*, injuries solely attributed to predator attack or tag induced (tear at tag site). Clean fish estimates for each spillbay were made relative to the probabilities of control fish that were free of any maladies. Data from individual daily trials (Appendix Tables B-5 and B-6) were used in the analysis.

The 90% confidence intervals on the survival for clean fish estimates were calculated using the profile likelihood method (Normandeau Associates *et al.* 1996a,b,c and Appendix C); these are deemed superior to those based on the assumption of normality. Although the study was not designed for hypothesis testing, differences in survival and clean fish estimates between spill rates or passage location were tested, *a posteriori*, by Z-statistics (see Appendix C).

2.8 Autonomous Sensor Fish

Sensor fish, an instrumented package designed to determine exposure histories to turbulence and pressure during passage (PNNL *et al.* 2001) were equipped with two or three HI-Z tags and a miniature radio tag and released using the identical induction release hose into the same spill conditions as for the live fish during the spring investigation. No sensor fish were released in summer. Sensor fish were also released at the control release sites. Generally, at least one sensor fish was released with each group of 10 fish. The results of sensor fish passage are to be provided by PNNL in a separate report. However, relevant portions of that report can be included when available to explain some of the observed results on alive fish releases. Preliminary results were presented in November 2003 at the annual AFEP meeting in Walla Walla, Washington (Carlson and Duncan 2003).

2.8.1 Sensor Fish on Adult Fish

The feasibility of attaching a sensor fish externally to an adult fish and recapturing them after spillway passage was evaluated. This procedure will provide a means to obtain the post-passage physical condition of a fish along with the hydraulic forces it encountered during passage. The basic procedures utilized to attach HI-Z tags to adult salmonids passed through a turbine at McNary Dam were followed (Normandeau Associates and Mid Columbia Consulting 2003). Three rainbow trout 406 to 508 mm long and 1 to 2 kg were obtained from Pacific Northwest National Laboratory (PNNL), Richland, Washington. These fish were held at Ice Harbor in a 200 gal tank on the spillway deck.

Prior to HI-Z tag and sensor fish attachment the adult fish were removed from the holding tank and placed into a 12 gal tub full of water. The fish were then guided into a fish stress reduction tube (Figure 2-5). This device covers the head and eyes while still providing room for opercular movement and also allows large sized fish to be tagged and the tags activated with minimal stress and without anesthesia (Heisey *et al.* 2002b). This stress reduction device is a foam-lined, split, hinged, 6 inch diameter PVC tube that can be securely closed around the test specimens. Several notches cut into this device allow access to the fish for attachment of tags. One large (20 by 55 mm pre-inflated) HI-Z tag and a radio tag was sutured near the dorsal fin insertion and another HI-Z tag was sutured near the adipose fin. The fish was then turned over and the sensor fish package sutured at the base of one pelvic fin and the anal fin. A sensor package included a radio tag and a small HI-Z tag attached to the sensor fish in the event that the sensor package were to become detached from the adult fish. Two large HI-Z tags were attached at the base of the other pelvic fin. The adult fish was then transferred to the release site, the HI-Z tags injected with catalyst, and the fish was removed from the restraining tube and hand released into the Spillbay 1 discharge. The recapture crew followed basic fish recapture methods used on juvenile fish (Section 2.4) to track and retrieve adult tagged fish with a sensor package. The boat crews retrieved the buoyed fish with a net equipped with a water sanctuary and placed it into a tub of water and then removed the tags and sensor fish. Each recaptured fish was examined for injuries.

3.0 RESULTS

3.1 Recapture Rates

Recapture rates (physical retrieval of both alive and dead fish) of treatment and control groups were generally higher in spring than for summer releases (Tables 3-1 and 3-2). Recapture rates of treatment groups in spring were 100% for all conditions except fish released through the deep pipe at 50% spill where all but 1 of the 305 fish released was recaptured. Recapture rates of the control group were also high, 99.3%; only 2 of the 290 fish released were not recaptured. Most of the recaptured treatment (98.8%) and control (100%) fish were alive.

Recapture rates of sub-yearling chinook salmon treatment groups in summer ranged from 90.8% (bulk spill, shallow release) to 97.0% (dispersed spill, deep release) (Table 3-2). Recapture rates for the rainbow trout treatment groups ranged from 95.0% (bulk spill, shallow release) to 100% (bulk spill, deep release). The recapture rate for the control group released through the bypass pipe was 99.2%.

The percentage of fish from all groups in July assigned to the dead category ranged from 0% (rainbow trout, bulk spill, deep) to 8.4% (chinook salmon, bulk spill, shallow; Table 3-2). Three (2.5%) sub-yearling salmon assigned dead from the bulk spill shallow experiment were preyed upon. This was the highest predation rate observed.

Some 4.5% of the chinook salmon released for the bulk spill pattern test in the summer had dislodged tags, while none were observed in the dispersed spill test, and only 0.3% was observed for the treatment fish released in the spring (Table 3-2). The higher incidence of tag dislodgment may have been partially due to the smaller sized fish used in the summer (average 123 mm) than in the spring (average 141 mm).

Chi-square analyses indicated homogeneity ($P>0.05$) between daily control trials, allowing for the pooling of data. Homogeneity ($P>0.05$) was also revealed between each daily treatment trial. Thus, survival for each treatment condition was estimated relative to survival of the pooled control data in each season. Appendix C provides the outputs of these analyses with the associated exact probabilities.

With one exception (the estimate for deep release at 100% spill in spring), likelihood ratio tests indicated no significant differences ($P>0.05$) between the simplified ($H_O:P_A=P_D$) and generalized ($H_A:P_A \neq P_D$) models. For 48 h estimates, however, there were no exceptions. It was noted that the recovery probability for dead fish (P_D) could not be estimated by the embedded constraints in the data set and it was assumed 1.0. The standard error of the estimate could not be calculated as well for the 1 h survival. For this data set, of the 148 treatment fish released, 147 were classified alive and 1 dead at 1 h; at 48 h there were 146 fish alive and 2 dead. At 48 h, an additional fish was dead and all of the model calculations were possible. The likelihood ratio test indicated no difference ($P>0.05$) between the recapture probabilities of dead (P_D) and alive (P_A) fish. Consequently, the 1 h statistic was ignored for the purposes of delineating trends in survival. Thus, survival probabilities and their associated standard errors were calculated using the simplified model for all test conditions. These values are highlighted in Appendix C (statistical outputs).

3.2 Retrieval Times

Retrieval times (the interval between fish release through the induction system and physical retrieval) for various releases were short and similar (Figure 3-1). Average times were 6.3 to 7.6 min for treatment groups and 9.4 min for control groups in the spring. During the summer, average recapture times for treatment fish ranged from 6.2 to 9.8 min and 5.4 min for control fish.

3.3 Survival Estimates

The 1 h survival estimates during the spring were high (≥98.7%) (Table 3-3) and little variation between release locations within a spill pattern occurred. However, differences in immediate (1 h) survival between spill patterns at release locations were observed. Survival for deep released fish ($\hat{\tau}$ =0.987) at 50% spill was significantly lower ($P<0.05$, one tailed Z-test) than at 100% spill ($\hat{\tau}$ =1.00). No other differences were detected.

For the summer test, the estimated immediate survival estimates were lower than those in spring (Table 3-3). Survival ranged from 88.9 to 97.9%. The effects of spill pattern (bulk spill versus dispersed spill) for comparable deep release location were evident; the survival was substantially higher (97.8%, 90% CI=93.9 to 100.0%) at dispersed spill than at bulk spill (92.3%, 90% CI=85.7 to 93.9%). The pooled (deep and shallow) immediate survival for the bulk spill was 90.1%; this estimate is also substantially lower than at the dispersed spill.

Precision (ε) on all immediate survival estimates for spring was $\leq\pm$1.5%, 90% of the time. Precision (ε) on all estimates in the summer was lower ($3.0 \leq \pm\ \varepsilon \leq \pm\ 6.0\%$). The lower precision in summer was primarily due to lower recapture rates, survival, and a relatively smaller sample size.

The 48 h survival estimates in the spring were nearly the same as the 1 h estimates (Table 3-3); 98.7% (50% and special spill conditions) and 99.4% (100% spill). Little difference occurred between treatments. The statistical difference noted at 1 h between the 50% spill and 100% spill patterns at the deep release location was not detected at 48 h due to a loss of some treatment fish during holding. Reliable 48 h survival estimates for the summer releases could not be generated due to unacceptable high control fish mortality (>20%) during the delayed assessment period. Again, the prespecified precision (ε) level of ≤±3%, 90% of the time, was met on all 48 h estimates in spring (Table 3-3).

As stated above, mortality of experimental and control fish during the 48 h assessment period was higher than desirable during the summer tests. Some 31% of the control fish died during the delayed holding period and 32 to 41% of the treatment groups also died (Table 3-2). In contrast, none of the 288 control fish and only 2 of 647 treatment fish died during the 48 h delayed assessment period in the spring (Table 3-1).

3.4 Injury Classification, Rates, and Probable Causal Mechanisms

All recaptured fish were examined for types of external injuries and those that were recaptured dead were also examined for internal injuries. Detailed descriptions of all recaptured injured fish are presented in Appendix Tables B-1 and B-2. Injury rates given below are based on the total number of recaptured fish examined and not the total number of fish released and refer to only passage-related injuries, adjusted for controls. Injury rates for both control releases (Spillbay 1 and bypass pipe) were zero (0%) in the spring and 1.6% in the summer.

Passage-related injury rates during the spring experiment appeared to be a function of spill volume and passage location (Table 3-4). Injury rates were generally lower, particularly for shallow released fish, with a greater spill volume through Spillbay 5. Higher injury rates (20.0 to 20.7%) occurred at the 50% spill (3.4 to 5.1 kcfs through Spillbay 5) volume than at the 100% spill, 1.3 to 12.2% (4.25 to 8.5 kcfs spill through Spillbay 5); at special spill pattern (8.5 kcfs through Spillbay 5) the injury rate was 8.3 to 21.7%.

Passage location (shallow or deep) also affected injury rates (Table 3-4). Fish released at the shallow depth suffered lower injury rates (1.3 to 8.3%) than those released through the deep pipe (12.2 to 21.7%); only five fish were released at the shallow depth at 50% spill pattern to provide conclusive information. For the special spill, the injury rates for these respective release pipes were 8.3 and 21.7%. When the effect of passage location is examined across all spill conditions, the injury rate is 4.9 and 18.4% for fish that passed through the shallow and deep pipes, respectively.

The common injury types in spring were hemorrhaged or damaged eye (11.5%), bruises and/or scrapes (3.4%), and gill or operculum damage (3.2%) (Table 3-4 and Figures 3-2 to 3-4). Few treatment fish sustained lacerations (1.1%) or internal injuries (0.6%). Fish passing via the deep pipe were more likely to sustain eye damage than those passed through the shallow pipe, 13.7 versus 3.5%. The incidence of gill/opercular damage and hemorrhaged body was higher for the deep pipe passed fish (3.7 to 3.9%) than for the shallow pipe released fish (1.4%).

The effect of passage location (shallow or deep) on injury rates was similar in the summer experiment (Table 3-5). The passage related injury rates for the bulk spill were 4.9 and 18.4% for the shallow and deep fish releases, respectively (Table 3-5). The dispersed spill flow pattern (deep release only) had an injury rate of 20.0%. The injury rate, 19.5%, for fish released via the deep pipe for the combined spill patterns was similar to that observed in the spring tests (18.4%). The injury rates were identical (4.9%) for fish released by the shallow pipe, combined spills, during both spring and summer.

One of 20 (5.0% unadjusted; no controls were released) rainbow trout released deep during bulk spill in the summer tests exhibited an injury. None of the 20 rainbow trout passed via the shallow pipe at bulk spill were injured. Rainbow trout also appeared to be immune to the infection that affected some of the subyearling chinook salmon during the delayed assessment period.

The common injury types in summer were again bruises and/or scrapes, hemorrhaged or damaged eyes, and gill or operculum damage (Table 3-5 and Figures 3-2 to 3-4). During bulk spill, the deep pipe released fish, when adjusted for controls, incurred 8.3% eye damage, 8.3% hemorrhaged body, 7.3% opercular damage, and 5.5% cuts to the body. Fish released through the deep pipe during the dispersed spill had a higher rate of eye (13.6%) and opercular (9.3%) damage, but lower body hemorrhaging (1.3%) and no lacerations.

Shear forces were the probable cause for most of the eye injuries (especially hemorrhage) observed among treatment fish. Other injury types were more likely the result of contact with spillway or tailrace structures, possibly the flow deflector.

When the incidence of equilibrium loss and/or scale loss are included with the visibly injured fish to obtain a malady rate the results follow the trend observed for visible injuries (Tables 3-6 and 3-7). The malady rates (adjusted for control fish) for the special spill, 50% spill, and 100% spill tests in the spring (deep and shallow combined) were 15.8, 21.4, and 10.3%, respectively (Table 3-6). Fish released through the shallow pipe had a lower rate (6.3%) than those passed through the deep pipe (19.4%) for all spill levels combined in the spring.

The shallow release site for the summer bulk spill also had the lowest malady rate (4.3%; Table 3-7). The malady rates for fish passed through the deep pipe at the bulk and dispersed spill during July were 19.6 and 21.8%, respectively.

3.5 Clean Fish Estimates (CFE)

CFEs were considerably lower (up to 20%) than the direct survival estimates (Tables 3-3 and 3-8). The CFEs for the 50%, 100%, and special spill releases in spring were 78.6 (90% CI=74.8 to 82.5%), 89.7 (90% CI=86.4 to 93.1%), and 84.2% (90% CI=78.7-89.6%), respectively. The 90% CI for the above estimates were between ≤±3 to 5%.

Although the study was not originally designed to detect differences between two treatments, Z-statistic (two-tailed test) was used *a posteriori* to assess statistical differences. With respect to spill patterns, significant differences ($P<0.05$) were noted between 50% and 100% spill patterns in spring. CFE was significantly lower ($P<0.05$, $Z=2.38$) for deep released fish (0.877) at 100% spill pattern than at 50% spill pattern (0.793). CFE for deep released fish at special spill (0.783) was not significantly lower ($P>0.10$) than for deep released fish at 100% spill (0.878); the sample size was too small to detect this difference. CFEs for deep released fish at 50% spill and special spill were virtually identical (0.786 and 0.783).

With respect to release locations within each spill pattern in spring, significant differences ($P<0.05$)were noted with deep released fish having lower CFEs at both 100% spill and bulk spill patterns (Table 3-8). The magnitude of difference was similar at both spill patterns (about 12%).

The same effect of passage location was also observed in the July test (Table 3-8). Clean fish estimates were significantly lower ($P<0.05$) for the fish passed through the deep pipe (81.3%, 90% CI=72.2 to 90.5%) than the shallow pipe (95.1%, 90% CI=90.7 to 99.4%) at the bulk spill condition. The clean fish estimate for fish passed through the deep pipe at dispersed spill (77.4%) was also significantly ($P<0.05$) lower than the estimate for fish released via the shallow pipe (95.1%, 90% CI=89.7 to 100.0%) at bulk spill.

3.6 Adult Fish

No injuries were observed on the two adult fish equipped with a sensor package. The sensor package attachment method proved feasible. All balloon tags and radio tags, along with the sensor package, were securely attached to the adult fish upon recapture. Recapture times for the two fish were 4 and 5 minutes.

4.0 DISCUSSION

The primary objectives and assumptions established for the experiment were met for the spring (April and May) high tailwater condition. However, the objectives for the summer (July) low tailwater condition could not be fully realized, particularly the 48 h direct survival estimate with a prespecified precision (ε) level. The summer investigation was affected by a relatively high mortality of experimental and control fish during holding (>20%). Consequently, reliable 48 h survival estimates could not be generated from these data.

The fish appeared to tolerate handling stress associated with tagging, release, and recapture considerably better at lower water temperatures (≤15°C or ≤59°F) than at higher water temperatures (≥19°C or ≥67°F) in the summer. Less than 1% of the fish died during the 48 h holding period in spring compared to 35% in the summer. In the summer test, immediate (1 h) losses of treatment and control fish in the daily trials ranged from 0 to 15%. However, losses over the 48 h holding period ranged from 0 to 42% for treatment and 20 to 43% for control fish.

Control losses of greater than 10% are rare, particularly at water temperatures ≤15.0°C (≤59.0°F); in only 1 of 37 (3%) similar investigations of estimating direct effects of passage elsewhere on the Columbia River Basin did losses exceed 10% (Normandeau Associates *et al.* 2003a,b). Muscle necrosis (bacterial), particularly at the tagging location, was observed, along with fungal infection. These observations were also corroborated by fish infections in the holding tanks prior to tagging, handling, and release. Some 5% of the fish developed fungal infections. The handling, tagging, and recapture methods were identical both in the spring and summer. These observations are similar to those made during the recent survival experiments conducted at The Dalles and Bonneville spillways at water temperatures ≥19°C or ≥67°F (Normandeau Associates *et al.* 2003a,b).

Although only 40 juvenile rainbow trout were tested during the summer, there is evidence that these hatchery fish were less susceptible to disease and mortality during the delayed assessment period than the subyearling chinook salmon collected from the river. Only 1 of the 37 trout died during the 48 h delayed assessment period. Additionally, none of the trout appeared to develop fungal infection.

Tag dislodgment from smaller fish size in the summer (average length 123 mm versus 141 mm in spring) may have also contributed to the lower estimate of survival to a certain extent (Normandeau Associates *et al.* 2003a,b). Tag dislodgment, perhaps exacerbated by passage through turbulent waters, was more common on fish <120 mm long than on fish >120 mm; tag dislodgment does not necessarily indicate fish mortality though the fish is assumed dead in survival estimation (Mathur *et al.* 1996). Of the 9 treatment tag dislodgment(s) observed in summer, 8 occurred on fish <120 mm long and the remainder one on the larger rainbow trout. In the spring, only one tag dislodgment occurred. The fish were longer (most >130 mm) in the spring.

Regardless of spill pattern tested in both spring and summer, the deeper releases, particularly at a lower spill volume (≤5 kcfs) through the test Spillbay 5, had a notably higher incidence of malady rates than the shallow releases. The overall malady rate for deep releases ranged from 14.3 to 22.6% versus 2.6 to 10.0% for shallow releases. It is likely that fish passing closer to the ogee would be prone to pass near the flow deflector increasing the potential for collision. The actual path traversed by each balloon tagged fish released in the present study and the unique hydraulic jet conditions (*e.g.*, plunging, skimming, or undulating) experienced in the tailrace are unknown. However, data from concurrent release of balloon tagged "sensor fish" by PNNL to simulate the hydraulic conditions experienced by alive released fish indicate potentially injurious hydraulic conditions in the immediate vicinity of the flow deflector (Carlson and Duncan 2003). Although the present study suggests that fish passing close to the ogee have a greater chance of injury, the proportion of naturally entrained fish subjected to these conditions must be ascertained to estimate the potential injury rate to these fish. Hydroacoustic data from Ice Harbor in 2003 (Moursund *et al.* 2003) suggest that most fish would pass higher above the ogee than the deep release point. However, the proportion of entrained fish subjected to potentially injurious conditions could increase at lower tainter gate openings (2 to 3 ft) because they would have less opportunities to orient higher in the discharge jet.

One notable finding of the summer experiment was a discrepancy between survival estimates in the present experiment and that derived from the PIT tag detection technique. Intuitively, estimates derived by the HI-Z tag-recapture method, which reflects direct effects of passage, are expected to be higher than those derived from the PIT tag detection technique; the estimates from the latter methodology portray both the direct and indirect post-passage effects (which may occur over time and distance). The present study estimated 1h survival of 88.9% (bulk spill shallow release) and 92.3% (bulk spill deep release). The preliminary survival estimate from PIT tagged fish released through Spillbays 1 and 3 was 96% (Absolon *et al.* 2003). Possible explanations for the discrepant estimates may include: (1) The HI-Z tag estimates may be conservative because only the tags were recaptured on 4.2% of the bulk spill shallow releases and 5.0% of the bulk spill deep releases; these fish were assigned dead status, but in fact may have survived. If this were the case, then the PIT and HI-Z tag estimates would be comparable; (2) the fish were released at different locations with consequent different travel paths in exiting the spillbay. PIT tagged fish were released at a relatively shallow depth (approximately 10 ft) upstream of the project (Absolon *et al.* 2003) and were likely entrained higher in the discharge jet and could have passed over the ogee at a shallower depth; (3) HI-Z tagged fish were released through Spillbay 5 while PIT tagged fish were released through Spillbays 1 and 2; differences in passage survival between spillbays have been noted elsewhere (Normandeau Associates *et al.* 2003b); and (4) PIT tagged fish, if injured, did not succumb; injuries, if similar to those observed herein, were not lethal. Any potential adverse effect of the induction hose for the HI-Z tagged fish was ruled out because the same induction system has been used at many sites on the Columbia River Basin without injurious effects on the released fish; injury rates on control fish were negligible. Additionally, upon completion of the study, the induction hose was physically examined via camera for defects; none were observed.

The PIT tag derived summer survival estimates were also higher than those estimated by radio telemetry (Eppard *et al.* 2003). They reported relative spillway passage survival estimates of 94.8 and 92.8% for BiOp (100%) and 50% spill releases in the spring, respectively. As expected, these are lower than those estimated in the present study (>98%).

The assignment of causal mechanisms to individual injury types in the field though difficult, followed symptoms noted by Neitzel *et al.* (2000) in laboratory studies. They reported that localized shear forces caused a variety of injuries to the eyes, opercles, and body of juvenile salmonids. In the current study, most of the passage-related eye injuries and tears at the opercle attachment site were attributed to shear forces. However, some of the eye damage may have been due to physical contact with spillway structures, likely the flow deflector. Additionally, tears and abrasions on the opercle appeared to be contact related. Scrapes and swaths of scale loss on the head or body were attributed to contact or impact with the spillbay flow deflector or tailwater structures (baffles and end sill). Some bruises, however, can be caused by shear forces (Neitzel *et al.* 2000).

Unlike in some recent summer studies at other hydroelectric dams on the Columbia River Basin (Normandeau Associates *et al.* 2003a,b) predation on tagged fish had a minimal effect on the results; approximately 2% (bulk spill, shallow release) of the treatment and 0% of the control fish were lost to predation in summer. For the spring releases there was no loss to predation of treatment or control fish. At other sites, predation on HI-Z tagged fish had exceeded 10% in summer experiments.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Some evidence exists to suggest that a higher spill volume through one to three spillbays may be more beneficial for passage survival and minimizing fish injury than dividing the same spill volume among all of the spillbays. Differences may be partially due to a greater "water cushion" for entrained fish at a higher spill volume. Additionally, when a divided spill volume is released through all of the spillbays rather than a few (one to three spillbays), the opening for each tainter gate is substantially less. For example, each gate would be opened approximately 3 ft for a total spill of 50k cfs apportioned to 10 spillbays versus a 10 ft tainter gate opening if only three spillbays were operated. Fish entrained higher in the water column are less likely to encounter solid downstream structures (*e.g.*, flow deflectors, rock outcrops, etc.).

Injury rates may be a better indicator of potentially adverse passage conditions relative to the spill pattern and passage location than absolute survival estimates *per se*. Fish entrained deeper within the discharge jet had higher visible injury rates (16.5 to 20.0%) than fish that likely passed higher in the jet. It is likely that the fish which passed via the shallower (7 ft above the ogee) release pipe were provided a better "water cushion" than those passed via the deeper pipe. Causal mechanisms of injuries were primarily shear and collisions with hard objects in the stilling basin.

Released fish experienced potentially injurious impact velocities during the study. Although estimated impact velocities encountered by released fish ranged from 70.1 to 73.2 ft/s and laboratory studies suggest that impact velocities exceeding approximately 58 ft/s may inflict injury and mortality on fish, the unique characteristics of the jet upon intercepting the tailwater with its associated elevation and submergence of flow deflectors may expose only a proportion of fish released.

Because eye damage was the dominant injury type, information is needed on the persistence and severity of eye injuries on post-spillbay survival of emigrating fish, effects on vision, predator avoidance, and ability to feed.

Although the effects of flow deflector *per se* on direct fish survival were minimal in the spring, it appears that injury/malady rates provided some evidence of the potential adverse effects of passage location at Ice Harbor. Regardless of the spill pattern, fish that passed through the deeper (3 ft above ogee) release pipe suffered more injuries than those released through the shallow release pipe (7 ft above ogee). These findings need to be integrated with the proportion of the emigrating juvenile salmonid population that is subjected to the prevailing hydraulic conditions. Further research is needed to ascertain the relationship between potentially injurious hydraulic conditions and the travel pattern of sensor fish and submergence depth of the flow deflector.

The susceptibility of juvenile salmonids to the stress associated with handling, tagging, and release at high water temperatures (>19.0°C or 66.2°F), resulted in high treatment and control losses (>10%) during the summer study. In contrast, losses attributed to handling stress in spring (water temperatures of 10.0 to 11.5°C or 50.0 to 52.7°F) were near 0%. To minimize losses from handling stress and improve the precision of the survival estimates, future studies at Ice Harbor should be conducted at water temperatures ≤15.0°C (≤59.0°F).

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TABLES

Table 2-1

Daily spring (23 April to 2 May) and summer (13 to 15 July) releases of juvenile chinook salmon smolts and juvenile rainbow trout into Spillbay 5 and downstream of Spillbay 1 (spring controls) and through the juvenile fish facility bypass pipe (spring and summer controls) at Ice Harbor Dam, 2003.

	Ambient Water Temperature		50% Spill		100% Spill		Special Spill		Control	
Date	(°C)	(°F)	Shallow	Deep	Shallow	Deep	Shallow	Deep	Spillbay 1	Bypass Pipe
Spring (chinook salmon)										
23 Apr	10.3	50.5	5*	5	28	20	--	--	--	--
24 Apr	10.0	50.0	--	--	19	29	--	--	10	20
25 Apr	11.0	51.8	--	--	30	20	--	--	20	20
26 Apr	10.0	50.0	--	100	--	--	--	--	20	30
28 Apr	10.5	50.9	--	--	--	20	--	--	20	10
29 Apr	10.5	50.9	--	--	--	59	--	--	20	20
30 Apr	10.5	50.9	--	100	--	--	--	--	20	30
01 May	11.0	51.8	--	100	--	--	--	--	30	20
02 May	11.5	52.7	--	--	--	--	60	60	--	--
Totals			***5****	***305***	***77***	***148***	***60***	***60***	***140***	***150***
			Bulk Spill		**Dispersed Spill**				**Control**	
			Shallow	**Deep**	**Shallow**	**Deep**			**Spillbay 1**	**Bypass Pipe**
Summer (Subyearling chinook salmon)										
13 Jul	19.5	67.1	60	60	--	--			--	5
14 Jul	20.0	68.0	--	--	--	100			--	60
15 Jul	20.5	68.9	59	--	--	--			--	60
Totals			***119***	***60***	***--***	***100***			***--***	***125***
Summer (Rainbow Trout)										
15 Jul		68.9	20	20	--	--			--	--

* Pretest and not enough fish to include in survival or clean fish calculations.

Table 2-2

Summary of physical conditions during release of juvenile salmon through Spillbay 5 at Ice Harbor Dam, April and May (spring) and July (summer), 2003. Hourly data are presented in Appendix A.

Condition Tested	Spill Volume (kcfs) Spillbay 5	Total Spill Volume (kcfs)	River Flow (kcfs)	Elevation (ft) Forebay	Elevation (ft) Tailwater	Net Head (ft)	Ambient Water Temperature (°C)	Ambient Water Temperature (°F)
				April/May (Spring)				
50% spill	3.4-5.1	31.0-50.7	62.5-101.4	438.4-438.9	342.7-345.9	92.7-95.7	10.0-11.0	50.0-51.8
100% spill	4.25-8.5	42.3-79.0	60.6-92.8	438.0-438.8	342.2-344.7	93.5-96.3	10.0-10.5	50.0-50.9
Special spill	8.5	44.4-45.4	63.3-71.5	438.6-438.7	342.2-343.0	95.7-96.5	11.5	52.7
				July (Summer)				
Bulk spill	13.6	13.6-45.0	14.4-56.1	438.2-439.4	338.3-341.1	97.7-100.3	19.5-20.5	67.1-68.9
Dispersed spill	3.4	30.5-37.1	40.0-48.1	438.5-438.7	339.9-340.3	98.2-98.6	20.0	68.0

Table 2-3

Spillbay release pattern (stop openings) followed during Spillbay 5 passage survival experiments at Ice Harbor Dam, April and May (spring) and July (summer) 2003. Boxed, bold numbers indicate experimental conditions (special spill on 2 May, dispersed spill on 14 July) which deviated from the preestablished values. One stop at a spillbay equals approximately 1,700 cfs.

Spillbay											
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total No. Stops**	**Total Spill (kcfs)**
1.5	1.5	1.5	1.5	2	1.5	1.5	1.5	1.5	2	16	27.6
2	1.5	1.5	1.5	2	2	1.5	1.5	1.5	2	17	29.3
2	1.5	1.5	2	2	2	1.5	2	1.5	2	18	31.1
2	1.5	1.5	2	2	2	2	2	2	2	19	32.8
2	2	2	2	2	2	2	2	2	2	20	34.5
2	2	2.5	2	2	2	2	2	2	2.5	21	36.2
2	2	2.5	2	2.5	2	2.5	2	2	2.5	22	37.9
2	2.5	2.5	2.5	2.5	2	2.5	2	2	2.5	23	39.6
2	2.5	2.5	2.5	2.5	2.5	2.5	2	2.5	2.5	24	41.3
2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25	43
2.5	**3**	**2.5**	**2.5**	**2**	**2.5**	**2.5**	**2.5**	**3**	**2.5**	**25.5**	**43.3***
2.5	3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3	26	44.7
2.5	**2.5**	**2**	**2.5**	**5**	**2.5**	**2**	**2**	**2.5**	**2.5**	**26**	**44.7****
2.5	3	2.5	2.5	2.5	2.5	3	3	3	2.5	27	46.4
2.5	3	3	2.5	2.5	3	3	3	3	2.5	28	48.1
2.5	3	3	3	3	3	3	3	3	2.5	29	49.8
3	3	3	3	3	3	3	3	3	3	30	51.5
3	3.5	3.5	3	3	3	3	3	3	3	31	53.2
3	3.5	3.5	3.5	3.5	3	3	3	3	3	32	54.9
3	3.5	3.5	3.5	3.5	3.5	3.5	3	3	3	33	56.6
3	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3	34	58.3
3	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4	35	60
3	4	4	3.5	3.5	3.5	3.5	3.5	3.5	4	36	61.7
3	4	4	4	4	3.5	3.5	3.5	3.5	4	37	63.4
3	4	4	4	4	4	4	3.5	3.5	4	38	65.1
3	4	4	4	4	4	4	4	4	4	39	66.8
4	4	4	4	4	4	4	4	4	4	40	68.5
4	5	4	4	4	4	4	4	4	4	41	70.2
4	5	5	4	4	4	4	4	4	4	42	71.9
4	5	5	5	4	4	4	4	4	4	43	73.5
4	5	5	5	5	4	4	4	4	4	44	75.2
4	5	5	5	5	5	4	4	4	4	45	76.9
4	5	5	5	5	5	5	4	4	4	46	78.6
4	5	5	5	5	5	5	5	4	4	47	80.3

* Dispersed spill, July 14.

** Special spill, May 2.

Table 2-4

Required sample sizes (R) if control survival (S) is 0.99, 0.98, or 0.95, recapture rate (P_A) is 0.99, 0.98, or 0.95, and expected survival probability ($\hat{\tau}$) of treatment fish passed is 0.95, 0.97, and 0.99 to achieve a precision level (ε) of ≤±0.03 or ≤±0.05, 90% of the time. Highlighted values are discussed within the text.

	Expected Survival ($\hat{\tau}$)		
Control Survival (S)	**0.95**	**0.97**	**0.99**
		Precision (ε) ≤±0.03	
		Recapture Rate=0.99	
0.99	256	**205**	150
0.98	314	264	212
0.95	496	451	405
		Recapture Rate=0.98	
0.99	314	264	218
0.98	373	325	274
0.95	556	514	469
		Recapture Rate=0.95	
0.99	496	451	405
0.98	556	514	469
0.95	745	709	670
		Precision (ε) ≤±0.05	
		Recapture Rate=0.99	
0.99	113	**95**	76
0.98	134	117	99
0.95	200	185	169
		Recapture Rate=0.98	
0.99	134	117	99
0.98	156	139	122
0.95	222	208	192
		Recapture Rate=0.95	
0.99	178	162	146
0.98	200	185	169
0.95	268	255	241

Table 2-5

Sample size, recapture and control survival rates, and estimated 48 h survival (direct effects) of juvenile salmonids in passage through non-turbine exit routes at hydroelectric dams on the Columbia River Basin. Estimates based on balloon tag-recapture methodology (Heisey *et al.* 1992). Present study data are shown in italics.

Station	Exit Route	Species	Water Temperature (°C)	Sample Size	Head (ft)	Test Spill Volume (kcfs)	Recapture Rates (%) Control	Recapture Rates (%) Treatment	Control Survival (%)	Passage Survival (%)
The Dalles, WA	Spillway	Chinook salmon	15-17	270	81	10.5	97.0	94.1	97.0	95.5
	Spillway[b]	Chinook salmon	15-17	271	81	10.5	97.0	97.4	97.0	99.3
	Spillway[b]	Chinook salmon	15-17	210	81	4.5	96.2	94.3	96.2	99.0
	Spillway	Chinook salmon	10-14	391	75-80	7.5-10.5	98.7	96.7	98.0	97.4
	Spillway	Chinook salmon	10-14	396	75-80	4.5-7.5	98.7	95.4	98.0	97.4
	Spillway	Chinook salmon	10-14	405	75-80	3.0-6.0	98.7	93.8	98.0	93.8
Wanapum, WA	Sluice	Chinook salmon	5-8	195	79	2.0	100.0	97.9	100.0	97.4
	Spillway	Chinook salmon	5-8	235	79	4.3	100.0	99.6	99.6	99.6
	Spillway[a]	Chinook salmon	5-8	235	79	4.3	100.0	97.9	99.6	95.7
	Spillway[b]	Chinook salmon	5-8	155	79	2.0	100.0	97.4	100.0	92.0
	Spillway[b]	Chinook salmon	5-8	160	79	4.0	96.7	98.8	96.7	96.9
	Spillway	Chinook salmon	17-18	180	82	2.8	100.0	100.0	94.5	100.0
	Spillway	Chinook salmon	17-18	244	82	6.0	100.0	99.6	95.8	99.3
	Spillway	Chinook salmon	17-18	130	82	11.5	98.4	99.2	94.3	94.6
	Spillway[a]	Chinook salmon	17-18	200	82	2.8	100.0	100.0	96.5	99.0
	Spillway[a]	Chinook salmon	17-18	199	82	6.0	100.0	98.5	95.3	97.6
	Spillway[a]	Chinook salmon	17-18	191	82	11.5	98.4	96.7	94.3	92.8
	Spillway	Chinook salmon	16	180	82	2.8	100.0	100.0	97.5	99.4
	Spillway	Chinook salmon	16	169	82	6.0	100.0	100.0	95.8	97.6
	Spillway	Chinook salmon	16	198	82	7.5	100.0	100.0	94.3	99.5
	Spillway[a]	Chinook salmon	16	180	82	2.8	100.0	100.0	96.5	98.3
	Spillway[a]	Chinook salmon	16	170	82	6.0	100.0	98.8	95.3	98.2
	Spillway[a]	Chinook salmon	16	210	82	7.5	100.0	99.0	82.3	97.6
	Bypass Pipe	Chinook salmon	16	500	76-80	0.4	99.6	99.8	99.6	100.0
	Spillway[a,b]	Chinook salmon	5-6	300	81-82	10.4-12.5	100.0	99.0	97.3	99.0
Bonneville, WA	Spillway	Chinook salmon	15-17	280	60	12.0	96.1	96.8	96.1	100.0
	Spillway[a]	Chinook salmon	15-17	280	60	12.0	96.1	99.3	96.1	100.0
	Spillway[a]	Chinook salmon	12-14	130	54-58	3.2-4.8	100.0	97.7	97.7	97.9
	Spillway[a*]	Chinook salmon	12-14	166	54-58	3.2-6.4	100.0	95.8	97.7	95.9
	Spillway[a]	Chinook salmon	12-14	238	50-55	5.1-7.9	95.4	98.3	97.7	98.6
	Spillway[a*]	Chinook salmon	12-14	241	50-55	7.1-9.8	95.4	97.1	97.7	99.0
	Spillway[a]	Chinook salmon	20-21	166	60-65	4.0-4.1	86.9	83.7	82.6	90.5
	Spillway[a*]	Chinook salmon	20-21	175	60-65	5.0-6.0	86.9	88.1	82.6	88.6
	Spillway[a]	Chinook salmon	20-21	250	60-64	5.0-6.0	87.6	87.6	82.6	100.0
	Spillway[a*]	Chinook salmon	20-21	250	60-64	6.9-7.9	87.6	89.6	82.6	100.0

Table 2-5

Continued.

Station	Exit Route	Species	Water Temperature (°C)	Sample Size	Head (ft)	Test Spill Volume (kcfs)	Recapture Rates (%) Control	Recapture Rates (%) Treatment	Control Survival (%)	Passage Survival (%)
Lower Granite, WA	Spillway[a]	Chinook salmon	9-10	120	90	3.4	100.0	100.0	100.0	97.5
	Surface Bypass Collector[a]	Chinook salmon	9-10	120	90	3.4	100.0	99.2	100.0	95.8
	Spillway[a]	Chinook salmon	8-10	130	90	3.4	92.1	94.6	92.1	97.6
	Surface Bypass Collector[a]	Chinook salmon	8-10	133	90	3.4	92.1	97.8	92.1	97.0
Little Goose, WA	Spillway	Steelhead	8-9	150	90	5.6	100.0	100.0	100.0	100.0
	Spillway	Steelhead	8-9	150	90	9.5	100.0	100.0	100.0	100.0
	Spillway	Steelhead	8-9	100	90	1.8	99.0	100.0	99.0	100.0
	Spillway[c]	Steelhead	8-9	40	90	5.6	100.0	98.0	100.0	100.0
	Spillway[c]	Steelhead	8-9	120	90	9.5	100.0	99.0	100.0	98.3
	Spillway[a]	Steelhead	8-9	150	90	5.6	100.0	99.0	100.0	98.0
	Spillway[a]	Steelhead	8-9	150	90	9.5	100.0	100.0	100.0	100.0
	Spillway[a]	Steelhead	8-9	100	90	1.8	99.0	100.0	99.0	99.0
	Spillway[a,c]	Steelhead	8-9	39	90	5.6	100.0	100.0	100.0	100.0
	Spillway[a,c]	Steelhead	8-9	120	90	9.5	100.0	99.0	100.0	99.2
Ice Harbor, WA[1]	*Spillway*[a]	*Chinook salmon*	*10-12*	*310*	*93-96*	*3.4-5.1*	*99.3*	*99.7*	*99.3*	*98.7*
	Spillway[a]	*Chinook salmon*	*10-12*	*225*	*94-96*	*4.3-8.5*	*99.3*	*99.1*	*99.3*	*99.5*
	Spillway[a]	*Chinook salmon*	*10-12*	*120*	*96-97*	*8.5*	*99.3*	*100.0*	*99.3*	*98.7*
Rock Island, WA	Spillway[b,d]	Chinook salmon	4	250	41	1.9	NA	98.0	NA	95.1
	Spillway[b]	Chinook salmon	4	250	41	10.0	NA	100.0	NA	98.4
	Spillway[b]	Chinook salmon	13-14	200	41-49	2.5	100.0	99.5	99.5	99.5
	Spillway[b]	Chinook salmon	13-14	200	41-49	10.0	100.0	100.0	99.5	99.5
	Spillway[a,b,e]	Chinook salmon	14-15	200	40-43	2.5	100.0	99.5	100.0	99.0
	Spillway[a,b]	Chinook salmon	14-15	200	40-43	2.5	100.0	100.0	100.0	100.0
North Fork, OR	Spillway	Chinook/coho	9-11	126	135	0.7	100.0	100.0	93.6	87.3
	Spillway	Chinook/coho	9-11	129	135	2.0	100.0	99.2	86.1	80.1
	Spillway	Steelhead	9-11	129	135	0.7	100.0	100.0	98.4	85.6
	Spillway	Steelhead	9-11	128	135	2.0	100.0	100.0	92.3	96.5

a Spillbay with flow deflector.
a* Spillbay with deep flow deflector.
b Overflow weir or slot to attract surface oriented juvenile salmonids.
c Fish released into head pond vortices upstream of tainter gates.
d Spill directed onto concrete slab; survival is relative to survival at another spillbay.
e Periphery release.
1 Spring tests only.

Table 2-6

Summary of fish transports from hatcheries and holding tank data collected during spillbay passage survival experiments at Ice Harbor Dam, April and May (spring) and July (summer) 2003.

	Spring (Chinook salmon)
Source	Leavenworth Hatchery
Transported	1,208 (April 20, April 26)
Dead fish removed from supply tank	0 (April 22 to 29)
Culled* from supply tank	0
Supply tank water temperature (°C)	10.5-11.0
	Summer (Subyearling chinook salmon)
Source	John Day Fish Facility
Transported	475 (July 11)
Dead fish removed from supply tank	7 (July 12 to 15)
Culled* from supply tank	25 (July 12 to 15)
Supply tank water temperature (°C)	20.0-20.5
	Summer (Rainbow trout)
Source	Trout Lodge (near Moses Lake, Washington)
Transported	500 (July 11)
Dead fish removed from supply tank	0
Culled* from supply tank	0
Supply tank water temperature (°C)	20.0-20.5

* Fish with scale loss or symptoms of disease were culled.

Table 2-7

Condition codes assigned to fish and dislodged balloon tags for fish passage survival evaluation.

FISH CODES

A	No visible marks on fish
B	Flesh tear at tag site(s)
C	Minor scale loss, 3 to 20% (%s for entire body in immediate recovery; for detailed injury examination %s are for section only)
D	Scale loss, >20% per side
E	Laceration(s); tear(s) on body
F	Severed body parts
G	Hemorrhaging, bruised
H	Stressed (lethargic, swimming poorly or sporadically)
I	Spasmodic movement of body
J	Very weak, barely gilling, died within 60 minutes of recovery
K	Failed to enter system
L	Fish likely preyed on based on telemetry, and/or circumstances relative to Turb'N recapture
M	Substantial bleeding at tag site
N	Bulging or missing eye(s)
P	Observed predator attack or marks indicative of predator
Q	Other information
R	Replaced due to entrapment in unrecoverable locations (i.e., in rocks, gate slot; recovery time expired)
T	Trapped inside tunnel/gate well
V	Fins damaged (ripped, split, torn) or pulled from origin
W	Abrasion/scrape
X	No recovery information at all; fish remains unrecovered
Z	Radio telemetry or other information; fish remains unrecovered

DISSECTION CODES

B	Swim bladder ruptured or expanded
D	Kidneys damaged (hemorrhaging)
E	Broken bones obvious
F	Hemorrhaging internally
L	Organ displacement
N	Heart damage, ruptured, hemorrhaging, etc.
O	Liver damage, ruptured, hemorrhaging, etc.
R	Necropsied, no obvious injuries
S	Necropsied, internal injuries observed
W	Head removed, i.e., otolith

TURB'N TAG CODES (not used in database)

A	Fully inflated
B	Partially inflated
C	Pinhole, leaking
D	Burst
E	Not inflated at all

Table 3-1

Summary of tag-recapture data of juvenile chinook salmon released through shallow (7 ft above ogee) and deep (3 ft above ogee) release sites in Spillbay 5 at 50%, 100%, and special spill patterns and controls released downstream of Spillbay 1 or via the juvenile fish facility bypass pipe at Ice Harbor Dam, April and May 2003. Proportions given in parentheses.

	50% Spill		100% Spill		Special Spill		Control		
	Shallow*	Deep	Shallow	Deep	Shallow	Deep	Spillbay 1	Bypass Pipe	Combined
Number released	5	305	77	148	60	60	140	150	290
Number recaptured alive	5 (1.000)	300 (0.984)	76 (0.987)	147 (0.993)	60 (1.000)	59 (0.983)	139 (0.993)	149 (0.993)	288 (0.993)
Number recaptured dead	0 (0.000)	4 (0.013)	1 (0.013)	0 (0.000)	0 (0.000)	1 (0.017)	0 (0.000)	0 (0.000)	0 (0.000)
Number assigned dead**	0 (0.000)	1 (0.003)	0 (0.000)	0 (0.000)	0 (0.000)	0 (0.000)	0 (0.000)	1 (0.007)	1 (0.003)
Unknown	0 (0.000)	0 (0.000)	0 (0.000)	1 (0.007)	0 (0.000)	0 (0.000)	1 (0.007)	0 (0.000)	1 (0.003)
Number held	5	300	76	147	60	59	139	149	288
Number alive at 48 h	5	300	76	146	59	59	139	149	288

* Too few fish released for reliable survival estimation.

** Includes dislodged tags, predation, and stationary signals (see Section 2.6).

Table 3-2

Summary of tag-recapture data on subyearling chinook salmon released through shallow (7 ft above ogee) and deep (3 ft above ogee) release sites in Spillbay 5 at bulk and dispersed spill patterns and controls released via the juvenile fish facility bypass pipe at Ice Harbor Dam, July 2003. Proportions given in parentheses. Data used for survival estimation. Juvenile rainbow trout were also released at bulk spill.

	Bulk Spill		**Dispersed Spill**	
	Shallow	**Deep**	**(Deep)**	**Control**
		Subyearling chinook salmon		
Number released	119	60	100	125
Number recaptured alive	104 (0.874)	54 (0.900)	96 (0.960)	124 (0.992)
Number recaptured dead	4 (0.034)	1 (0.017)	1 (0.010)	0 (0.000)
Number assigned dead*	10 (0.084)	4 (0.067)	2 (0.020)	1 (0.008)
Unknown	1 (0.008)	1 (0.017)	1 (0.010)	0 (0.000)
Number held	104	54	96	124
Number alive at 48 h**	71	32	56	85
		Rainbow trout		
Number released	20	20	--	--
Number recaptured alive	19 (0.950)	18 (0.900)	--	--
Number recaptured dead	0 (0.000)	2 (0.100)	--	--
Number assigned dead*	1 (0.050)	0 (0.000)	--	--
Unknown	0 (0.000)	0 (0.000)	--	--
Number held	19	18	--	--
Number alive at 48 h***	19	17	--	--

* Includes dislodged tags, predation and stationary signals (see Section 2.6).

** High mortality of control and treatment groups precluded reliable survial estimation.

*** Too few fish for reliable survival estimation; no concurrent controls were released.

Table 3-3

Estimated 1 h and 48 h direct survival probabilities ($\hat{\tau}$) of juvenile chinook salmon smolts in passage through shallow (7 ft above ogee) and deep (3 ft above ogee) release sites in Spillbay 5 at Ice Harbor Dam, April and May (spring) and July (summer) 2003. The standard errors (bold and italicized) and 90% confidence intervals are shown in parentheses.

	50% Spill	100% Spill			Special Spill		
	Deep*	Shallow	Deep	Pooled	Shallow	Deep	Pooled
				April and May			
1 h	0.987	0.990	1.0	0.999	1.0	0.987	0.995
	(0.008)	***(0.013)***	***(0.004)***	***(0.006)***	***(0.004)***	***(0.017)***	***(0.009)***
	(0.974-1.0)	(0.968-1.0)	(0.998-1.0)	(0.986-1.0)	(0.998-1.0)	(0.959-1.0)	(0.973-1.0)
48 h	0.987	0.990	0.997	0.994	0.987	0.987	0.987
	(0.008)	***(0.013)***	***(0.008)***	***(0.007)***	***(0.017)***	***(0.017)***	***(0.012)***
	(0.974-1.0)	(0.968-1.0)	(0.984-1.0)	(0.979-1.0)	(0.959-1.0)	(0.959-1.0)	(0.959-1.0)

July

	Bulk Spill			Dispersed Spill
	Shallow	Deep	Pooled	Deep
1 h	0.889	0.923	0.895	0.978
	(0.031)	***(0.037)***	***(0.025)***	***(0.019)***
	(0.838-0.939)	(0.861-0.984)	(0.851-0.934)	(0.946-1.0)

* Only deep release survival calculated because of limited (only five fish) shallow releases (See Table 3-1).

Table 3-4

Types of passage-related visible injuries observed on recaptured juvenile chinook salmon passed through Spillbay 5 at shallow (7 ft above ogee) and deep (3 ft above ogee) release sites at 50%, 100%, and special spill patterns and controls released downstream of Spillbay 1 or via the juvenile fish facility bypass pipe, Ice Harbor Dam, April and May 2003. Some fish had multiple injuries.

				Injury Type				
	Number Released	Number Examined	Visible Injuries	Damaged/ Hemorrhaged Eye(s)*	Gill/ Opercular Damage**	Bruised/ Hemorrhaged Head/Body	Tears/ Lacerations Head/Body	Internal Injury
50% Spill								
Shallow	5	5	1 (20.0%)	0 (0.0%)	1 (20.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Deep	305	304	63 (20.7%)	46 (15.1%)	12 (3.9%)	16 (5.3%)	6 (2.0%)	3 (1.0%)
100% Spill								
Shallow	77	77	1 (1.3%)	1 (1.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Deep	148	147	18 (12.2%)	14 (9.5%)	4 (2.7%)	3 (2.0%)	1 (0.7%)	0 (0.0%)
Special Spill								
Shallow	60	60	5 (8.3%)	4 (6.7%)	1 (1.7%)	2 (3.3%)	0 (0.0%)	0 (0.0%)
Deep	60	60	13 (21.7%)	10 (16.7%)	3 (5.0%)	1 (1.7%)	0 (0.0%)	1 (1.7%)
Control								
Spillbay 1	140	139	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Bypass Pipe	150	149	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	290	288	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

* Hemorrhaged, ruptured, bulging, or missing.

** Hemorrhage to gill, tears, scrapes, folds to operculum.

Table 3-5

Types of passage-related visible injuries observed on recaptured juvenile chinook salmon passed through Spillbay 5 at shallow (7 ft above ogee) and deep (3 ft above ogee) release sites at bulk and dispersed spill and controls released via the juvenile fish facility bypass pipe, Ice Harbor Dam, July 2003. Juvenile rainbow trout were also released at bulk spill. Some fish had multiple injuries.

				Injury Type			
	Number Released	**Number Examined**	**Visible Injuries**	**Damaged/ Hemorrhaged Eye(s)***	**Gill/ Opercular Damage****	**Bruised/ Hemorrhaged Head/Body**	**Tears/ Lacerations Head/Body**
			Subyearling chinook salmon				
Bulk Spill[1]							
Shallow	119	108	7 (6.5%)	1 (0.9%)	1 (0.9%)	4 (3.7%)	2 (1.9%)
Deep	60	55	11 (20.0%)	5 (9.1%)	4 (7.3%)	5 (9.1%)	3 (5.5%)
Dispersed Spill[2]							
Deep	100	97	21 (21.6%)	14 (14.4%)	9 (9.3%)	2 (2.1%)	0 (0.0%)
Control							
Bypass Pipe	125	124	2 (1.6%)	1 (0.8%)	0 (0.0%)	1 (0.8%)	0 (0.0%)
			Rainbow trout				
Bulk Spill[1]							
Shallow	20	19	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Deep	20	20	1 (5.0%)	0 (0.0%)	1 (5.0%)	1 (5.0%)	0 (0.0%)
Total	40	39	1 (2.6%)	0 (0.0%)	1 (2.6%)	1 (2.6%)	0 (0.0%)

* Hemorrhaged, ruptured, bulging, or missing.

** Hemorrhage to gill, tears, scrapes, folds to operculum.

1 Majority of the spill (13.6k cfs) diverted through Spillbay 5, remaining spill concentrated in one or two adjacent spillbays.

2 3.4k cfs through Spillbay 5, remaining spill dispersed nearly equally among the other spillbays.

Table 3-6

Summary malady data for juvenile chinook salmon released through shallow (7 ft above ogee) and deep (3 ft above ogee) release sites in Spillbay 5 at 50%, 100%, and special spill patterns and controls released downstream of Spillbay 1 or via the juvenile fish facility bypass pipe at Ice Harbor Dam, April and May 2003.

	50% Spill			100% Spill			Special Spill			Combined		
	Shallow	**Deep**	**Total**	**Shallow**	**Deep**	**Total**	**Shallow**	**Deep**	**Total**	**Shallow**	**Deep**	**Control**
Released	5	305	310	77	148	225	60	60	120	142	513	290
Examined	5	304	309	77	147	224	60	60	120	142	511	288
Passage related maladies	1 (20.0%)	65 (21.4%)	66 (21.4%)	2 (2.6%)	21 (14.3%)	23 (10.3%)	6 (10.0%)	13 (21.7%)	19 (15.8%)	9 (6.3%)	99 (19.4%)	0 (0.0%)
Visible injuries	1 (20.0%)	63 (20.7%)	64 (20.7%)	1 (1.3%)	18 (12.2%)	19 (8.5%)	5 (8.3%)	13 (21.7%)	18 (15.0%)	7 (4.9%)	94 (18.4%)	0 (0.0%)
Loss of equilibrium only	0 (0.0%)	2 (0.7%)	2 (0.6%)	1 (1.3%)	2 (1.4%)	3 (1.3%)	1 (1.7%)	0 (0.0%)	1 (0.8%)	2 (1.4%)	4 (0.8%)	0 (0.0%)
Scale loss only	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)	1 (0.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.2%)	0 (0.0%)
Without maladies	4 (80.0%)	239 (78.6%)	243 (78.6%)	75 (97.4%)	126 (85.7%)	201 (89.7%)	54 (90.0%)	47 (78.3%)	101 (84.2%)	133 (93.7%)	412 (80.6%)	288 (100.0%)
Without maladies that died	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Table 3-7

Summary malady rate data for juvenile chinook salmon and rainbow trout released through shallow (7 ft above ogee) and deep (3 ft above ogee) release sites in Spillbay 5 at bulk and dispersed spill and controls released via the juvenile fish facility bypass pipe at Ice Harbor Dam, July 2003.

	Bulk Spill		Dispersed Spill	
	Shallow	Deep	(Deep)	Control
	Chinook salmon			
Released	119	60	100	125
Examined	108	55	97	124
Passage related maladies	9 (8.3%)	13 (23.6%)	25 (25.8%)	5 (4.0%)
Visible injuries	7 (6.5%)	11 (20.0%)	21 (21.6%)	2 (1.6%)
Loss of equilibrium only	2 (1.9%)	0 (0.0%)	3 (3.1%)	2 (1.6%)
Scale loss only	0 (0.0%)	2 (3.6%)	1 (1.0%)	1 (0.8%)
Without maladies	99 (91.7%)	42 (76.4%)	72 (74.2%)	119 (96.0%)
Without maladies that died	28	11	25	32
	Rainbow Trout			
Released	20	20	--	--
Examined	19	20	--	--
Passage related maladies	0 (0.0%)	1 (5.0%)	--	--
Visible injuries	0 (0.0%)	1 (5.0%)	--	--
Loss of equilibrium only	0 (0.0%)	0 (0.0%)	--	--
Scale loss only	0 (0.0%)	0 (0.0%)	--	--
Without maladies	19 (100.0%)	19 (95.0%)	--	--
Without maladies that died	0	2	--	--

Table 3-8

Estimated clean fish probabilities (CFE) of juvenile chinook salmon smolts in passage through shallow (7 ft above ogee) and deep (3 ft above ogee) release sites in Spillbay 5 at Ice Harbor Dam, April and May (spring) and July (summer) 2003. The standard errors (bold and italicized) and 90% confidence intervals are shown in parentheses. Values given herein are based on the reduced model (H_O:P_A=P_D).

	50% Spill	100% Spill		Special Spill	
	Deep*	Shallow	Deep	Shallow	Deep
		April and May			
CFE	0.793 ***(0.023)*** (0.744-0.830)	0.987 ***(0.013)*** (0.966-1.0)	0.878 ***(0.027)*** (0.833-0.922)	0.917 ***(0.036)*** (0.858-0.975)	0.783 ***(0.053)*** (0.696-0.871)

July

	Bulk Spill		Dispersed Spill
	Shallow	Deep	Deep
CFE	0.951 ***(0.026)*** (0.907-0.994)	0.813 ***(0.056)*** (0.722-0.905)	0.796 ***(0.044)*** (0.725-0.868)

* Only deep release calculated because of limited (only five fish) shallow released (See Table 3-6).

FIGURES

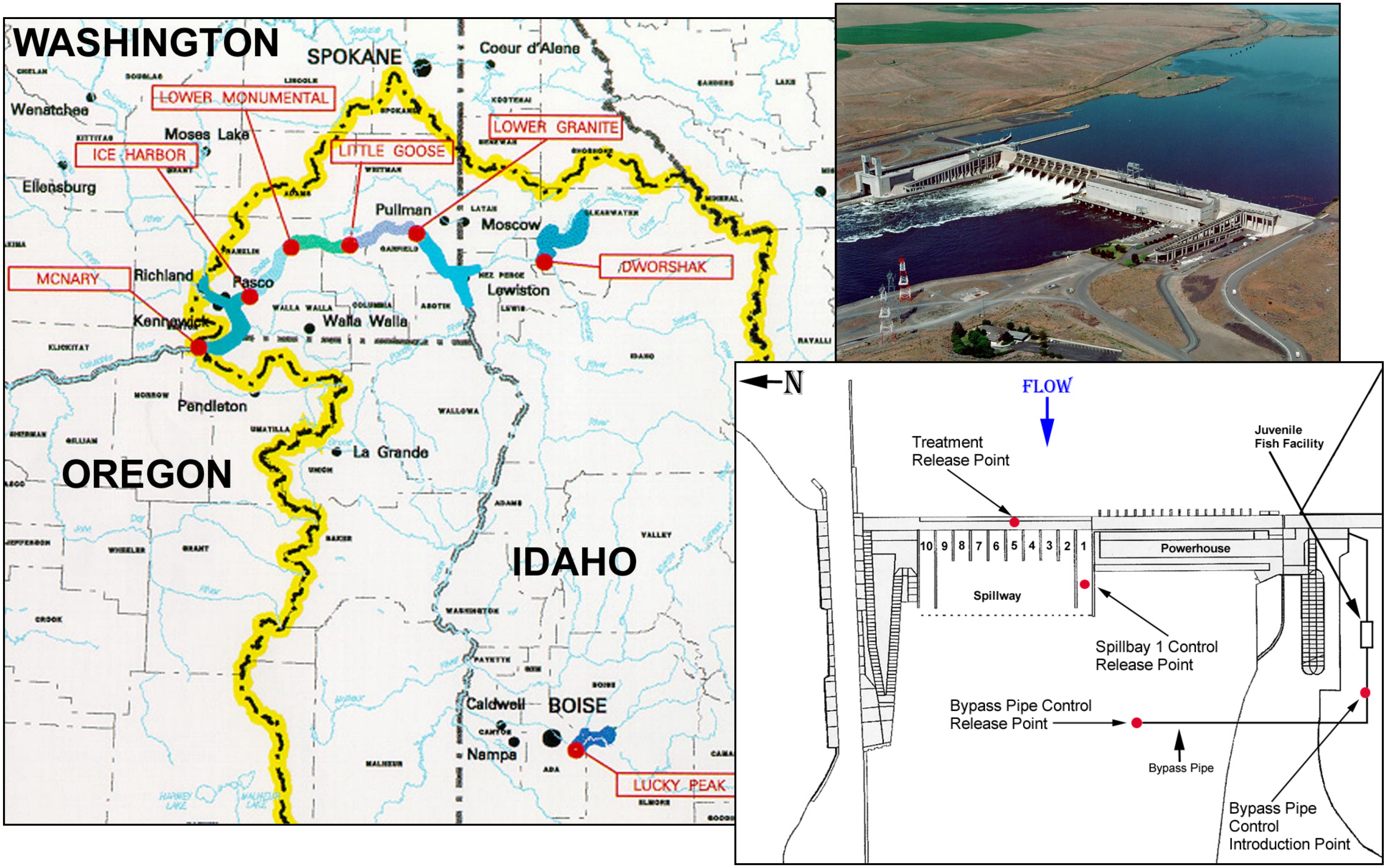


Figure 1-1

General location and layout of Ice Harbor Dam; showing treatment and release locations of fish during April/May and July, 2003.

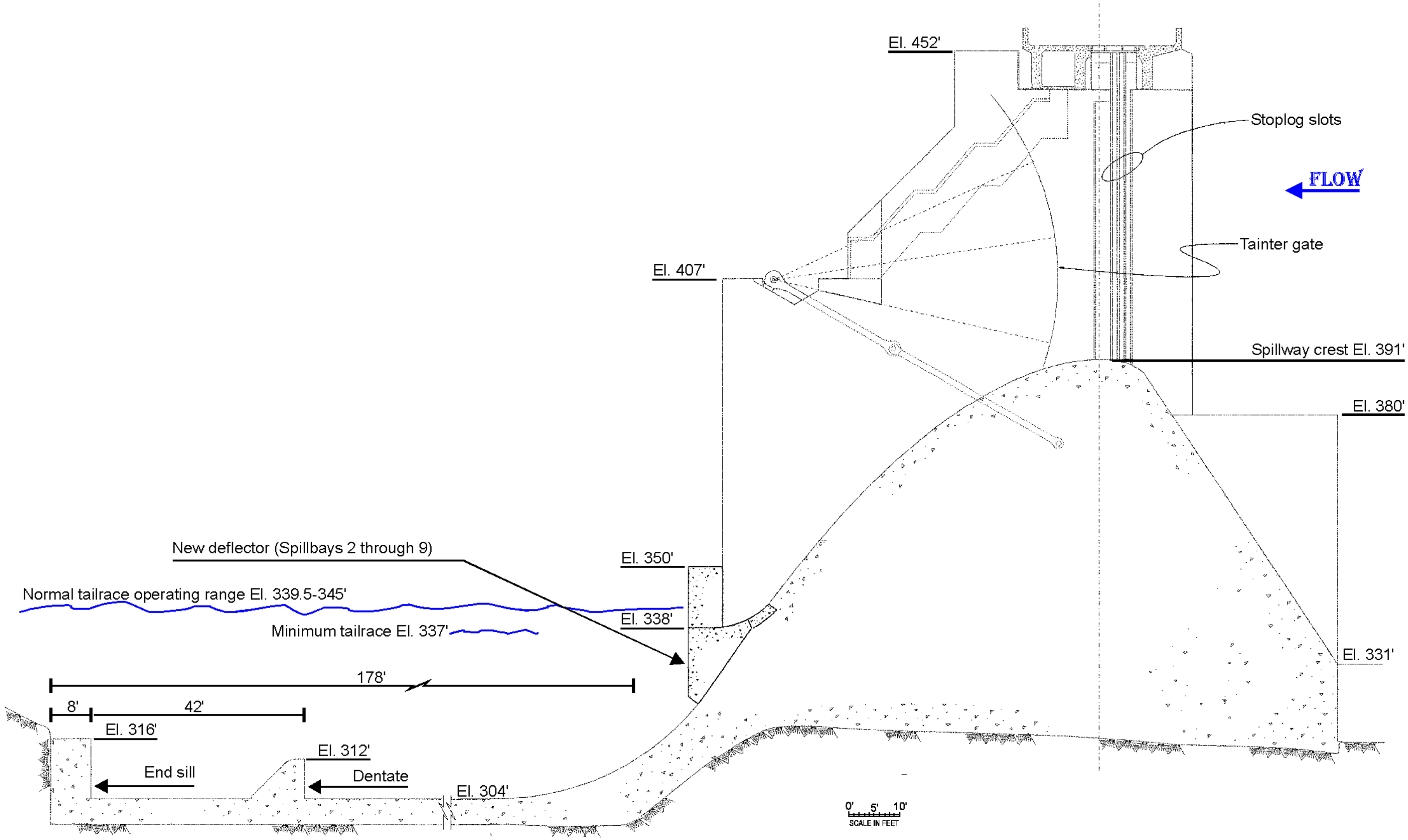


Figure 1-2

Cross section of Spillbay 5, Ice Harbor Dam.

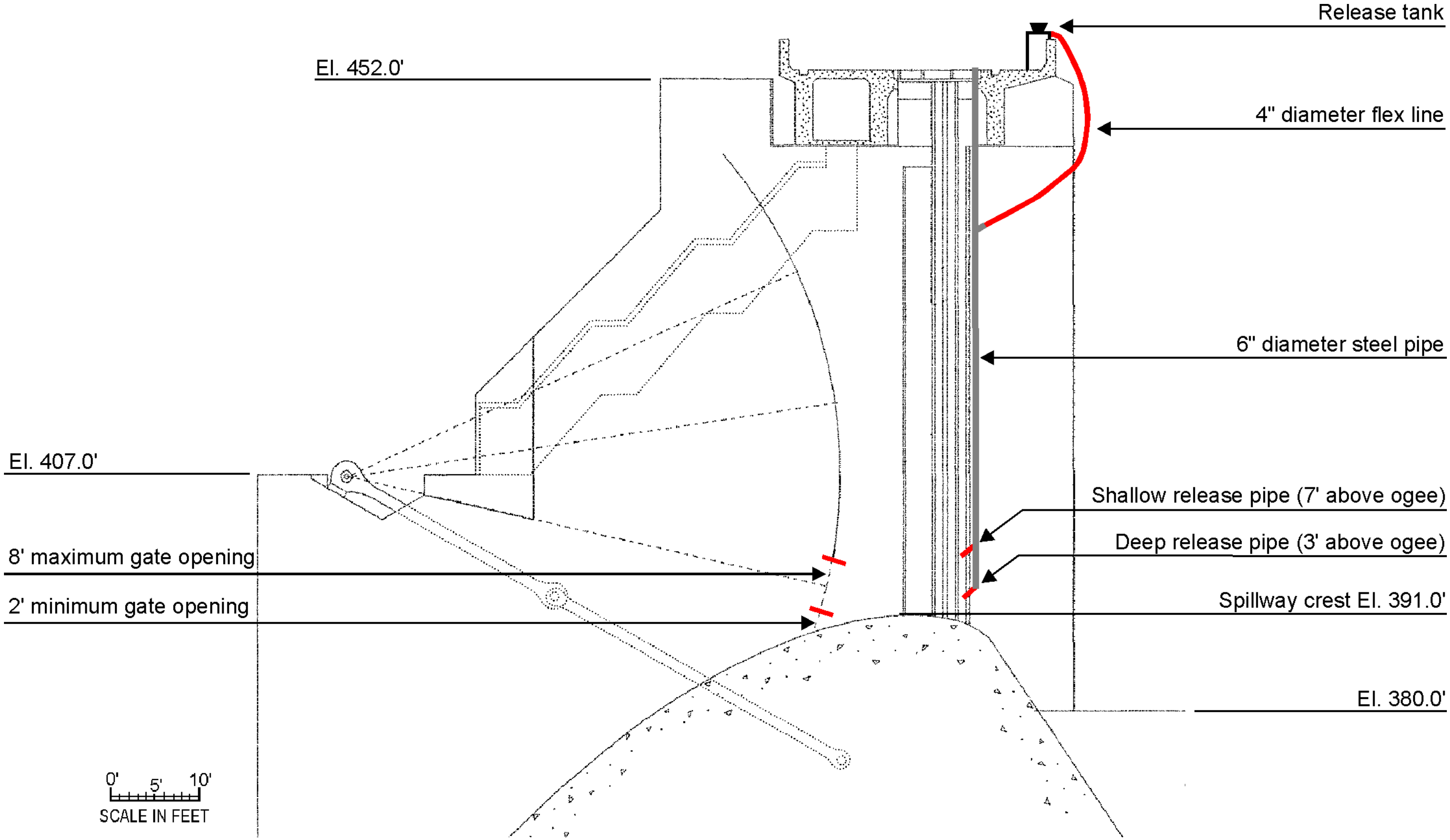


Figure 2-1

Cross section of spillbay showing release locations for juvenile salmon passed through Spillbay 5 at Ice Harbor Dam, April/May (spring) and July (summer), 2003.

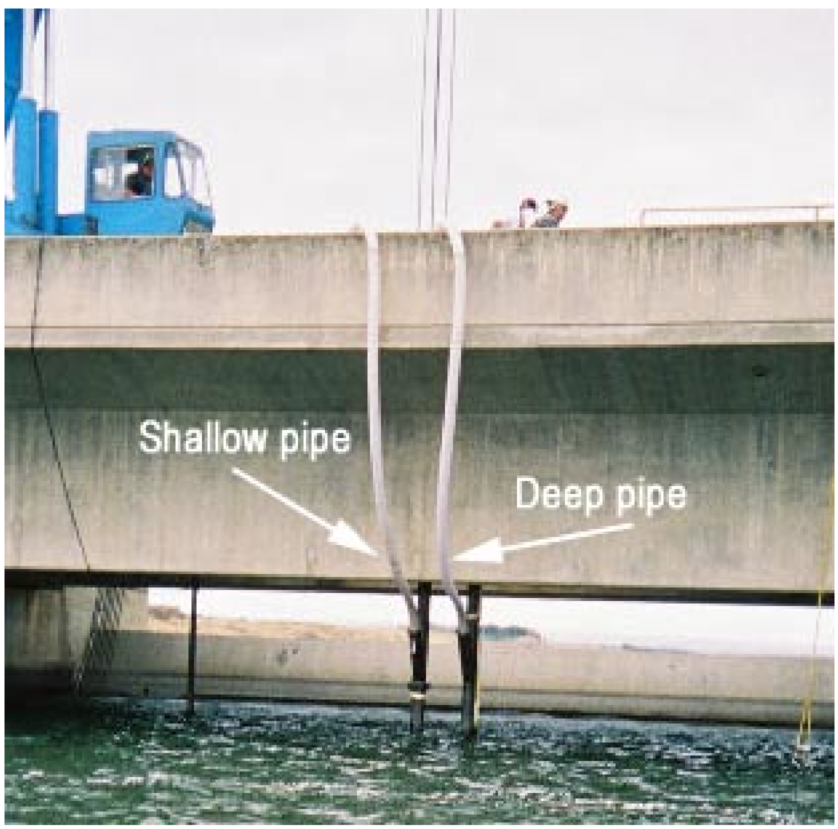
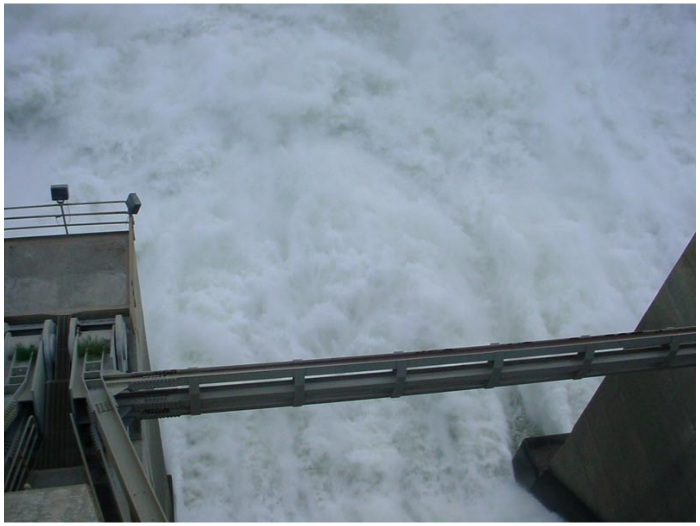


Figure 2-2

Steel support pipe (16 inches diameter) and release hose (4 inches diameter) deployment to introduce fish approximately 3 ft (deep pipe) and 7 ft (shallow pipe) above the ogee of Spillbay 5, Ice Harbor Dam.

50% spill, 2.5stops, 4.2k cfs (Bay 5), 44k cfs (total)



100%, 5 stops, 8.5k cfs (Bay 5), 77.8k (total)

Special spill, 5stops, 8.5k cfs (Bay 5), 45k cfs (total)

Bulk spill, 8stops, 13.6k cfs (Bay 5), 23k cfs (total)

Figure 2-3

Characteristics of the Spillbay 5 discharge upon interception of the flow deflector during the direct survival/injury tests conducted at Ice Harbor Dam, April/May and July, 2003.

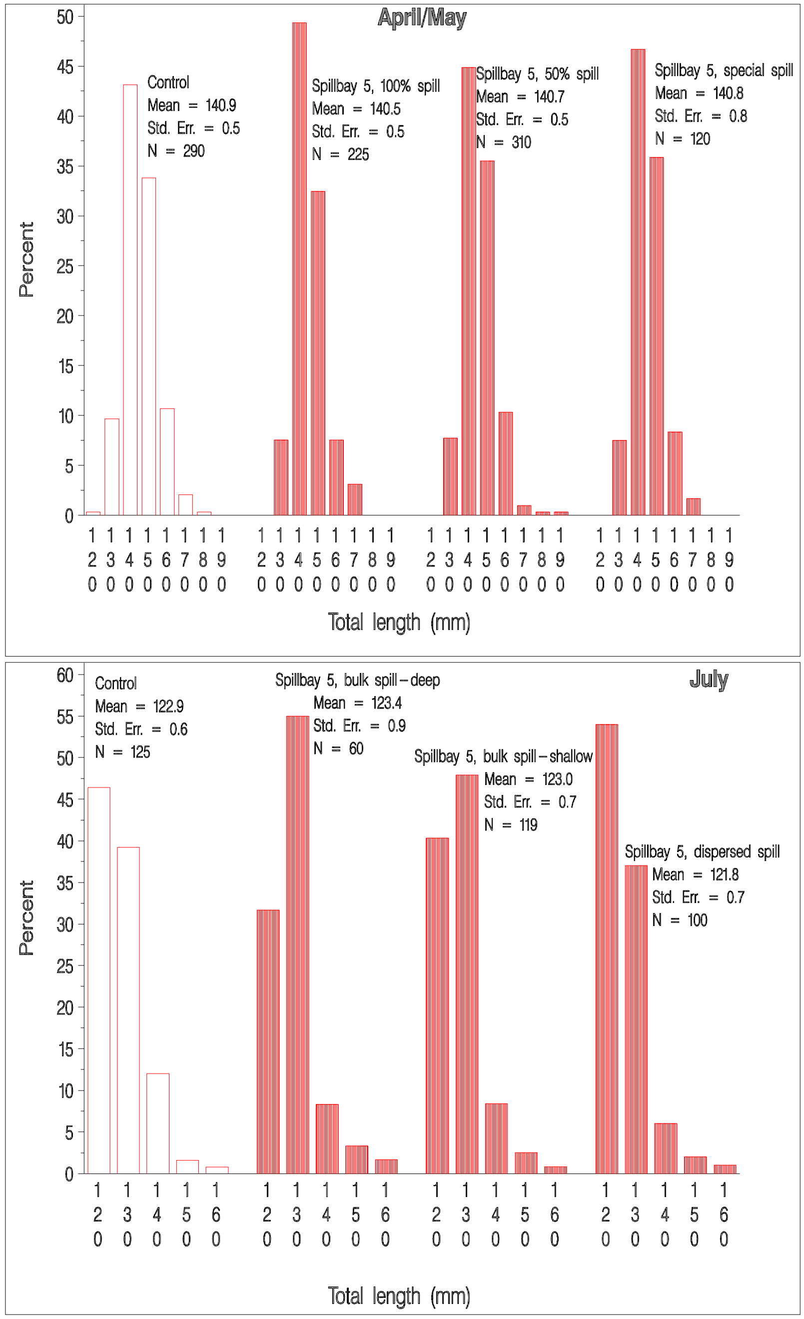
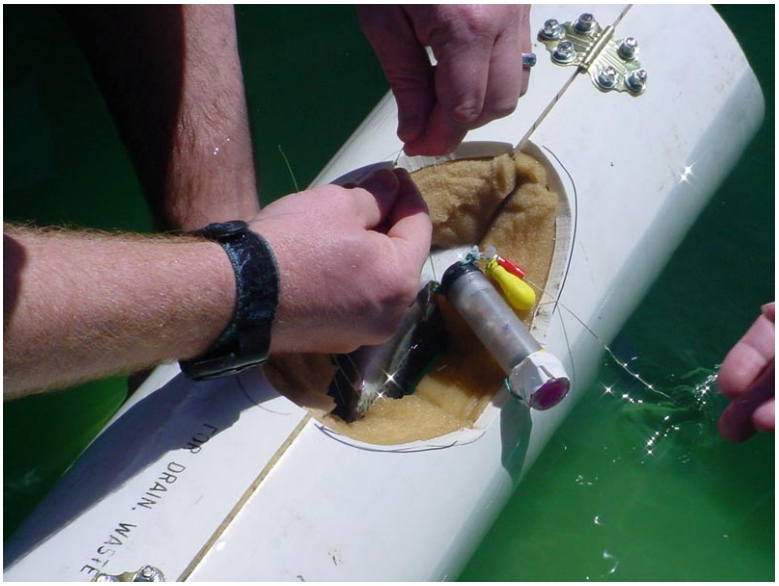


Figure 2-4 Total length (mm) frequency distribution of treatment and control juvenile chinook salmon released at 50%, 100% and special spills in April /May and of bulk and dispersed spills in July 2003 at Spillbay 5 of Ice Harbor Dam.



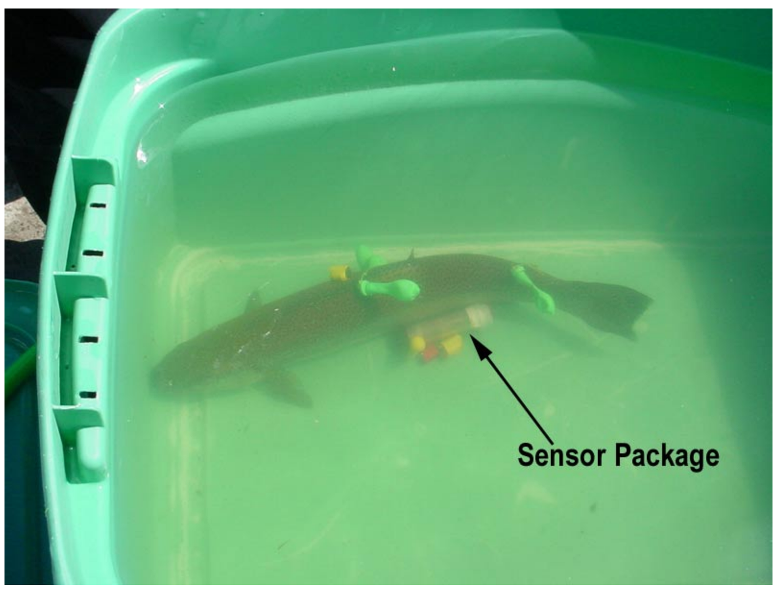


Figure 2-5

Attaching sensor fish package to adult rainbow trout while in stress reduction cylinder (top photo) and a trout (approximately 500 mm) equipped with HI-Z tags and sensor package (bottom photo).

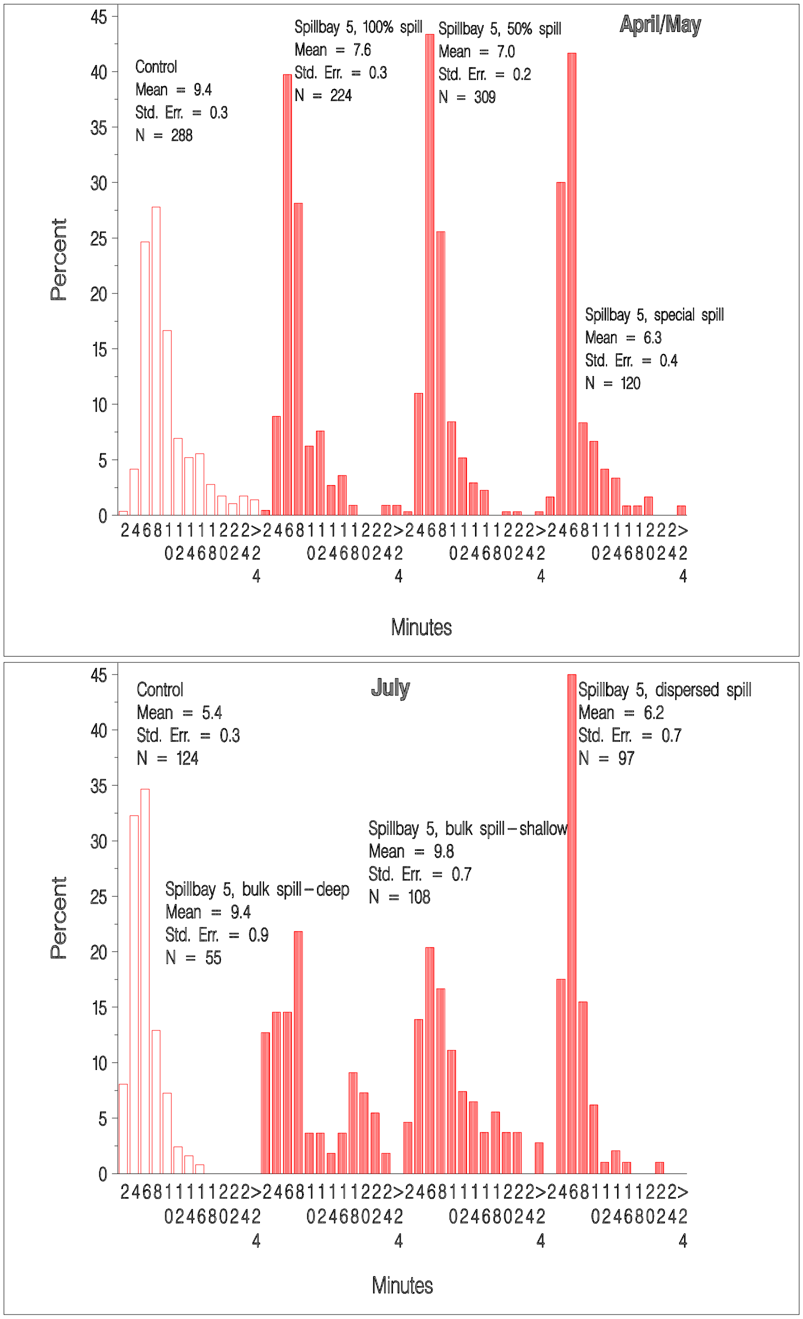
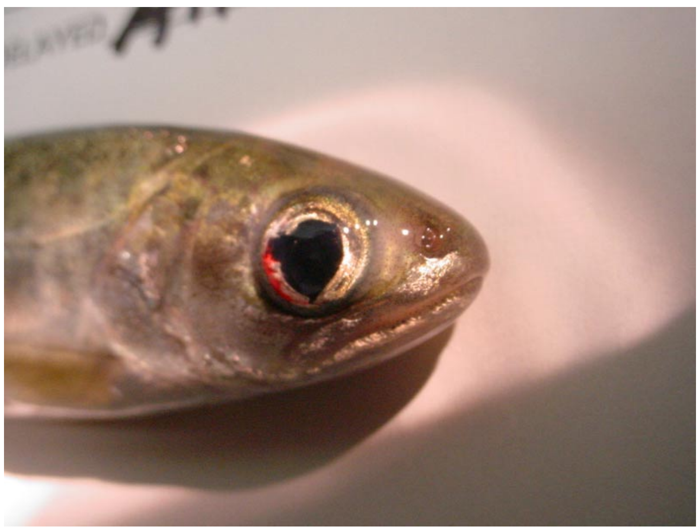


Figure 3-1 Frequency distribution of recapture times (minutes) of treatment and control juvenile chinook salmon released at 50%, 100% and special spills in April/May and of bulk and dispersed spills in July 2003 at Spillbay 5 of Ice Harbor Dam.

TM7 - minor hemorrhage right eye

LV7 – missing right eye



UJ3 – minor hemorrhage, ruptured pupil

HE5 – major hemorrhage left eye

Figure 3-2

Examples of eye injuries to juvenile salmon passed through Spillbay 5 at Ice Harbor Dam, 2003.

FN7 - torn operculum

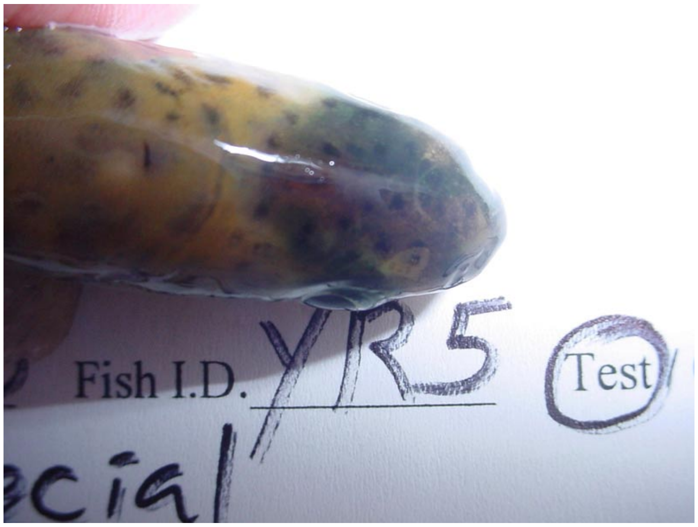
HR4 - torn left operculum (attachment point)

TU4 - torn operculum

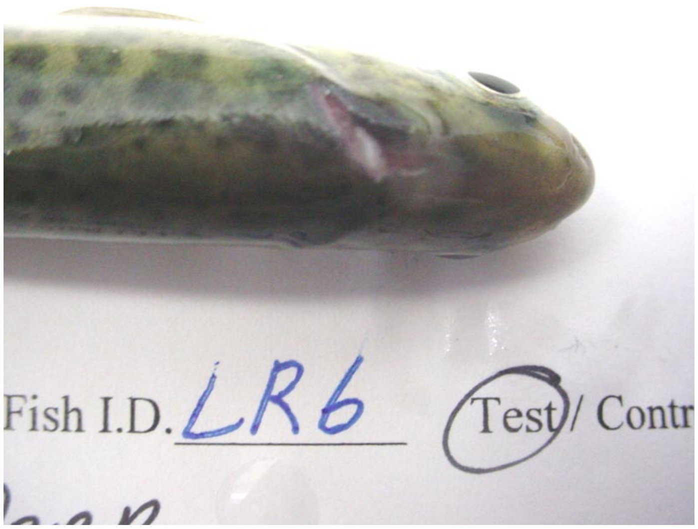
YX4 - torn left operculum

Figure 3-3

Examples of opercular damage to juvenile salmon passed through Spillbay 5 at Ice Harbor Dam, 2003.



YR5 - bruised head



LR6 - cut on head

HX1 - damaged snout

Figure 3-4

Examples of bruises and cuts to juvenile salmon passed through Spillbay 5 at Ice Harbor Dam, 2003.

APPENDIX A

HYDRAULIC/PHYSICAL CONDITIONS DURING TESTING AND SUPPLY AND TAGGING TANK INFORMATION

Appendix Table A-1

Average forebay, tailwater, head (ft), and spill conditions at Spillbay 5 during conduct of passage survival and condition investigation with juvenile chinook salmon at Ice Harbor Dam, 23 April to 2 May and 13 to 15 July 2003. Bay 5 discharge (kcfs) obtained by multiplying stops by 1.7. Impact velocities to be provided by Duncan Hay.

Date	Condition Number*	Hour	Elevation (ft) Forebay	Elevation (ft) Tailwater	Net Head (ft)	Spillbay 5 Impact Velocity (fps)	Spillbay 5 Stops	Spillbay 5 Discharge (kcfs)	Total Spill Discharge (kcfs)	Total Project Discharge (kcfs)
23 Apr	1	17	438.5	344.4	94.1	70.3	2.5	4.25	44.8	86.6
23 Apr	1	18	438.4	344.4	94.0	70.2	2.5	4.25	47.9	89.8
23 Apr	2	19	438.5	344	94.5	71.6	5	8.50	77.2	88.1
23 Apr	2	20	438.8	343.9	94.9	71.6	5	8.50	76.4	86.1
23 Apr	2	21	438.5	343.9	94.6	71.6	5	8.50	76.4	87.7
		Average	***438.5***	***344.1***	***94.4***	***71.1***			***64.5***	***87.7***
24 Apr	6	16	438.3	345.8	92.5	70.2	2.5	4.25	44.9	101.0
24 Apr	6	17	438.3	345.8	92.5	70.2	2.5	4.25	45.6	103.1
24 Apr	6	18	438.2	345.6	92.6	70.2	2.5	4.25	45.6	100.7
24 Apr	2	19	438.1	344.2	93.9	71.0	4	6.80	73.2	89.5
24 Apr	2	20	438.1	343.6	94.5	71.0	4	6.80	70.5	84.2
24 Apr	2	21	438	343.3	94.7	71.0	4	6.80	64.6	79.8
		Average	***438.2***	***344.7***	***93.5***	***70.6***			***57.4***	***93.1***
25 Apr	6	16	438.5	345.4	93.1	70.3	2.5	4.25	44.6	93.1
25 Apr	6	17	438.4	345.4	93.0	70.2	2.5	4.25	44.5	90.8
25 Apr	6	18	438.4	345.2	93.2	70.2	2.5	4.25	45.4	90.8
25 Apr	2	19	438.2	344.7	93.5	70.2	2.5	4.25	75.1	91.1
25 Apr	2	20	438.3	344.7	93.6	71.5	5	8.50	79.0	92.8
		Average	***438.4***	***345.1***	***93.3***	***70.5***			***57.7***	***91.7***
26 Apr	1	9	438.9	345.9	93.0	70.6	3	5.10	49.9	101.4
26 Apr	1	10	438.7	345.9	92.8	70.6	3	5.10	49.9	99.8
26 Apr	6	11	438.7	345.9	92.8	70.6	3	5.10	49.8	99.8
26 Apr	6	12	438.7	345.9	92.8	70.6	3	5.10	50.7	101.5
26 Apr	6	13	438.8	345.9	92.9	70.6	3	5.10	49.8	99.0
26 Apr	1	14	438.6	345.9	92.7	70.5	3	5.10	49.9	99.1
26 Apr	1	15	438.7	345.7	93.0	70.6	3	5.10	48.6	97.7
26 Apr	1	16	438.6	345.4	93.2	70.3	2.5	4.25	44.5	90.5
		Average	***438.7***	***345.8***	***92.9***	***70.5***			***49.1***	***98.6***
28 Apr	6	17	438.4	344.1	94.3	70.2	2.5	4.25	44.8	81.1
28 Apr	6	18	438.7	344.2	94.5	70.3	2.5	4.25	45.6	82.2
28 Apr	2	19	438.6	342.3	96.3	70.3	2.5	4.25	42.3	60.7
28 Apr	2	20	438.6	342.9	95.7	70.5	3	5.10	54.7	67.9
		Average	***438.6***	***343.4***	***95.2***	***70.3***			***46.9***	***73.0***
29 Apr	6	15	437.8	344	93.8	70.1	2.5	4.25	45.7	83.4
29 Apr	6	16	438.2	342.7	95.5	70.2	2.5	4.25	44.8	64.8
29 Apr	6	17	438	342.9	95.1	70.2	2.5	4.25	44.8	70.6
29 Apr	-	18	438.3	342.6	95.7	70.2	2.5	4.25	44.7	64.4
29 Apr	2	19	438.3	342.2	96.1	70.5	3	5.10	49.6	60.6
29 Apr	2	20	438.7	342.6	96.1	70.8	3.5	5.95	53.6	65.2
		Average	***438.2***	***342.8***	***95.4***	***70.3***			***47.2***	***68.2***

Appendix Table A-1

Continued.

Date	Condition Number*	Hour	Elevation (ft) Forebay	Elevation (ft) Tailwater	Net Head (ft)	Spillbay 5 Impact Velocity (fps)	Spillbay 5 Stops	Spillbay 5 Discharge (kcfs)	Total Spill Discharge (kcfs)	Total Project Discharge (kcfs)
30 Apr	1	9	438.6	344.3	94.3	70.3	2.5	4.25	41.3	83.0
30 Apr	1	10	438.4	344.5	93.9	70.2	2.5	4.25	41.3	84.5
30 Apr	1	11	438.4	344.3	94.1	70.2	2.5	4.25	41.2	83.1
30 Apr	1	12	438.4	344.5	93.9	70.2	2.5	4.25	41.9	85.7
30 Apr	6	13	438.5	343.7	94.8	70.3	2.5	4.25	37.8	75.6
30 Apr	6	14	438.6	343.6	95.0	70.3	2.5	4.25	37.0	74.1
30 Apr	6	15	438.4	342.7	95.7				31.0	62.5
		Average	***438.5***	***343.9***	***94.5***	***70.3***			***38.8***	***78.4***
01 May	6	10	438.8	343.2	95.6	70.1	2	3.40	35.0	71.9
01 May	6	11	438.7	344.3	94.4	70.3	2.5	4.25	42.0	84.3
01 May	6,1	12	438.8	344.6	94.2	70.3	2.5	4.25	42.1	86.8
01 May	1	13	438.7	344.6	94.1	70.3	2.5	4.25	42.1	88.3
01 May	1	14	438.6	344.5	94.1	70.3	2.5	4.25	42.7	85.7
01 May	1	15	438.6	344.6	94.0	70.3	2.5	4.25	43.6	87.5
		Average	***438.7***	***344.3***	***94.4***	***70.3***			***41.3***	***84.1***
5/2/03*	3	14	438.7	343	95.7	71.6	5	8.50	44.4	71.5
5/2/03*	3	15	438.7	342.6	96.1	71.6	5	8.50	44.5	67.2
5/2/03*	3	16	438.6	342.8	95.8	71.6	5	8.50	44.5	68.6
5/2/03*	3	17	438.7	342.3	96.4	71.6	5	8.50	44.5	63.3
5/2/03*	3	18	438.7	342.2	96.5	71.6	5	8.50	45.4	64.0
		Average	***438.7***	***342.6***	***96.1***	***71.6***			***44.7***	***66.9***
7/13/03	4	10	438.2	339	99.2	73.1	8	13.6	13.6	17.0
7/13/03	4	11	438.3	339.4	98.9	73.1	8	13.6	13.6	14.4
7/13/03	4	12	438.4	339.1	99.3	73.2	8	13.6	13.6	14.5
7/13/03	4	13	438.8	339.2	99.6	73.2	8	13.6	13.6	17.4
7/13/03	4	14	438.8	339.2	99.6	73.2	8	13.6	13.6	17.0
7/13/03	4	15	438.9	339.1	99.8	73.2	8	13.6	13.6	15.2
7/13/03	4	16	439	339.4	99.6	73.3	8	13.6	13.6	18.1
7/13/03	-	17	439	338.9	100.1	73.3	8	13.6	13.6	20.6
7/13/03	6	18	439.1	339	100.1	73.3	8	13.6	13.6	28.8
		Average	***438.7***	***339.1***	***99.6***	***73.2***			***13.6***	***18.1***
7/14/03	5	10	438.6	340.2	98.4	70.0	2	3.4	32.2	43.1
7/14/03	5	11	438.6	340	98.6	70.0	2	3.4	32.9	42.4
7/14/03	5	12	438.5	339.9	98.6	70.0	2	3.4	31.9	41.3
7/14/03	6	13	438.9	339.5	99.4	70.1	2	3.4	14.2	23.5
7/14/03	6	14	438.6	341.1	97.5	70.0	2	3.4	42.2	51.5
7/14/03	6	15	439.1	340.1	99.0	70.1	2	3.4	22.5	31.8
7/14/03	5	16	438.5	340.3	98.2	70.0	2	3.4	37.1	48.1
7/14/03	5,6	17	438.7	340.1	98.6	70.0	2	3.4	30.5	40.0
7/14/03	5	18	438.5	340.3	98.2	70.0	2	3.4	33.3	44.3
7/14/03	6	19	438.4	338.8	99.6	70.0	2	3.4	13.7	24.6
		Average	***438.6***	***340.0***	***98.6***	***70.0***			***29.1***	***39.1***

Appendix Table A-1

Continued.

Date	Condition Number*	Hour	Elevation (ft) Forebay	Elevation (ft) Tailwater	Net Head (ft)	Spillbay 5 Impact Velocity (fps)	Spillbay 5 Stops	Spillbay 5 Discharge (kcfs)	Total Spill Discharge (kcfs)	Total Project Discharge (kcfs)
7/15/03	6	10	439.2	339.6	99.6	73.3	8	13.6	32.7	43.6
7/15/03	6	11	439	340.5	98.5	73.3	8	13.6	31.3	40.7
7/15/03	6	12	439.1	338.2	100.9	73.3	8	13.6	19.0	28.4
7/15/03	6	13	439.5	338.7	100.8	73.3	8	13.6	25.0	35.8
7/15/03	4	14	439.3	339.3	100.0	73.3	8	13.6	31.6	42.5
7/15/03	4	15	439.1	340.8	98.3	73.3	8	13.6	37.8	47.1
7/15/03	4	16	439.1	341.1	98.0	73.3	8	13.6	45.1	54.4
7/15/03	4	17	439.4	339.1	100.3	73.3	8	13.6	22.7	32.1
7/15/03[1]	4	18	439.1	340.9	98.2	73.3	8	13.6	44.4	53.6
7/15/03[1]	4	19	438.8	341.1	97.7	73.2	8	13.6	45.0	56.1
7/15/03[1]	4	20	438.6	338.3	100.3	73.2	8	13.6	22.8	33.7
		Average	***439.1***	***339.8***	***99.3***	***73.3***			***32.5***	***42.5***

Key to condition number:

1 - 50% Spill
2 - 100% Spill
3 - Special Spill (more water diverted to Spillbay 5, see Table 2-3)
4 - Bulk Spill
5 - Dispersed Spill
6 - Control

[1] Rainbow trout releases only

Appendix Table A-2

Supply and tagging tank fish disposition data for the Ice Harbor Dam spring (April and May) and summer (July) 2003 spillway passage survival study.

Date	Supply Tank Temperature (°C)	Number Transported to Supply	Dead Fish Removed from Supply	Number of Fish from Supply to Tagging	Dead Fish Removed from Tagging	Fish Culled from Study	Number Remaining for Testing	Remarks/Comments
20 Apr	11.0	408	0	0	0	0		Steve Hays transported 408 chinook salmon from Leavenworth Hatchery to Ice Harbor Dam
22 Apr	11.0		2	100	0	0	306	Placed into tagging tank #1
23 Apr	11.0		0	115	0	0	191	Placed into tagging tank #2
24 Apr	11.0		0	120	0	0	71	Placed into tagging tank #1
25 Apr	10.5		1	70	0	0	0	Supply tank cleaned out; Steve Hays will bring more fish on 4-26-03
26 Apr	10.5	800	0	0	0	0	798	Steve Hays transported 800 chinook salmon from Leavenworth Hatchery to Ice Harbor Dam
26 Apr	10.5		2	160	0	0	636	Fish placed into tagging tank #1
26 Apr	10.5		0	0	0	0	606	30 fish escaped from supply tank by swimming out the
27 Apr	10.5							Did not work - Allowing fish to acclimate to ambient conditions
28 Apr	10.5		2	100	1	0	503	Fish placed into tagging tank #2
29 Apr	10.5		1	Tank 1 - 135; Tank 2 - 40	0	0	327	135 fish placed in tank #1 and 40 fish placed in tank #2
30 Apr								Remaining 327 fish were released into the river
11 Jul	20.0	475±						Chinook salmon came from John Day Fish Facility
12 Jul	20.0		1	140	1	0	401	160 fish placed in tagging tank #1 for testing tomorrow
13 Jul	20.0		2	180	1	5	198	Fish placed in tagging tank #2
14 Jul	20.0		1	150	1	10	26	Fish placed in tagging tank #1
15 Jul	20.5		0	0	0	10	0	
11 Jul	20.0	500	0	0	0	0		500 rainbow trout came from Trout Lodge near Moses Lake, Washington
14 Jul	20.0			60 rainbow trout	0	0	440	Brought up 60 rainbow trout for testing on 7-15-03
15 Jul	20.5		0	0	0	0	460	Took remaining 20 fish back down to supply tank

APPENDIX B

INDIVIDUAL TRIAL DATA AND FISH INJURY DATA

Appendix Table B-1

Incidence of injury, scale loss, and temporary loss of equilibrium (LOE) observed on juvenile chinook salmon passed through shallow (7 ft above ogee) and deep (3 ft above ogee) release sites in Spillbay 5 at 50%, 100%, and special spill patterns and controls released downstream of Spillbay 1 or via the fish bypass pipe, Ice Harbor Dam, April and May 2003.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
		50% Spill, Shallow Release				
23 Apr	UF3	Scrape on left operculum	Alive 48 h	Contact	Major	Yes
		50% Spill, Deep Release				
26 Apr	FM4	Bulged right eye	Alive 48 h	Shear	Major	No
26 Apr	FM9	Torn left operculum	Alive 48 h	Shear	Major	No
26 Apr	FN2	Hemorrhaged left eye, LOE	Alive 48 h	Shear	Major	Yes
26 Apr	FN7	Torn left operculum	Alive 48 h	Shear	Major	Yes
26 Apr	FP5	Hemorrhaged left eye	Alive 48 h	Shear	Major	Yes
26 Apr	FP7	Bruise on head	Alive 48 h	Contact	Major	No
26 Apr	FP9	Bruise from left eye to dorsal fin	Alive 48 h	Contact	Major	No
26 Apr	HE5	Bleeding from left gills, hemorrhaged left eye, LOE	Alive 48 h	Shear	Major	Yes
26 Apr	HL0	Hemorrhaged right eye	Alive 48 h	Shear	Minor	Yes
26 Apr	HL1	Internal hemorrhage, LOE	Dead 1 h	Shear	Major	No
26 Apr	WU0	Torn right operculum, LOE	Alive 48 h	Shear	Major	No
26 Apr	WU4	Hemorrhaged left eye	Alive 48 h	Shear	Minor	No
26 Apr	WU6	Laceration on head	Alive 48 h	Contact	Major	Yes
26 Apr	WV3	Hemorrhaged left eye	Alive 48 h	Shear	Minor	Yes
26 Apr	WV7	LOE	Alive 48 h			No
26 Apr	WW3	Hemorrhaged right eye	Alive 48 h	Shear	Major	Yes
26 Apr	WW4	Hemorrhaged eyes	Dead 1 h	Shear	Major	Yes
26 Apr	WW6	Slightly hemorrhaged right eye	Alive 48 h	Shear	Minor	Yes
26 Apr	WW8	Hemorrhaged left eye	Alive 48 h	Shear	Major	Yes
26 Apr	WX8	Slightly hemorrhaged right side, descaled both sides	Alive 48 h	Contact	Major	No

Appendix Table B-1

Continued.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
26 Apr	WX9	Hemorrhaged right eye, LOE	Alive 48 h	Shear	Minor	Yes
30 Apr	HV0	Bruise on head, bulged and hemorrhaged left eye, LOE	Alive 48 h	Shear/Contact	Major	Yes
30 Apr	HV3	Hemorrhaged left eye	Alive 48 h	Shear	Minor	No
30 Apr	HW4	Torn left operculum	Alive 48 h	Shear	Major	No
30 Apr	HX1	Abrasion to nose	Alive 48 h	Contact	Major	Yes
30 Apr	HX2	LOE	Alive 48 h			No
30 Apr	HX4	Ruptured left eye	Alive 48 h	Shear	Major	Yes
30 Apr	HX6	Ruptured left eye	Alive 48 h	Shear	Major	Yes
30 Apr	HX8	Torn gills, left operculum missing	Alive 48 h	Shear	Major	Yes
30 Apr	HZ3	Abrasion to nose, eye half popped out	Alive 48 h	Contact/Shear	Major	No
30 Apr	HZ4	Ruptured left eye, damaged left operculum, LOE	Alive 48 h	Shear	Major	Yes
30 Apr	HZ8	Torn operculum, laceration on top of head	Alive 48 h	Contact/Shear	Major	Yes
30 Apr	JN5	Slightly hemorrhaged left eye	Alive 48 h	Shear	Minor	Yes
30 Apr	JP2	Hemorrhaged left eye, tear at corner of mouth	Alive 48 h	Shear/Contact	Major	Yes
30 Apr	JP4	Hemorrhaged left eye	Alive 48 h	Shear	Minor	Yes
30 Apr	JP5	Bruise behind head	Alive 48 h	Contact	Major	No
30 Apr	JP8	Scrape on nose, hemorrhaged right eye, LOE	Alive 48 h	Contact/Shear	Major	Yes
30 Apr	JR2	Ruptured left eye	Alive 48 h	Shear	Major	Yes
30 Apr	JS0	Hemorrhaged right eye	Alive 48 h	Shear	Minor	Yes
30 Apr	JS1	Hemorrhaged right eye	Alive 48 h	Shear	Minor	No
30 Apr	JS5	Bruise on head, LOE	Alive 48 h	Contact	Major	No
30 Apr	JS6	Hemorrhaged right eye, damaged right operculum	Alive 48 h	Shear	Major	Yes
01 May	KR7	Hemorrhaged right eye	Alive 48 h	Shear	Major	Yes
01 May	LR0	Ruptured right eye, slight tear on right operculum, LOE	Alive 48 h	Shear	Major	Yes
01 May	LR1	Bruise on head	Alive 48 h	Contact	Minor	No
01 May	LR6	Laceration on nape, LOE	Alive 48 h	Contact	Major	Yes
01 May	LR7	Bruised head, torn right operculum, slightly hemorrhaged eyes, LOE	Alive 48 h	Contact/Shear	Major	Yes

Appendix Table B-1

Continued.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
01 May	LS2	Hemorrhaged left eye	Alive 48 h	Shear	Minor	Yes
01 May	LS3	Bruise on head, hemorrhaged left eye, LOE	Alive 48 h	Contact	Minor	Yes
01 May	LS6	Left eye missing, tear behind operculum, ruptured air bladder	Dead 1 h	Shear/Contact	Major	Yes
01 May	LS8	Bulged right eye, torn right operculum	Alive 48 h	Shear	Major	Yes
01 May	LT0	Hemorrhaged left eye, slightly torn right operculum	Alive 48 h	Shear	Major	Yes
01 May	LT1	Hemorrhaged right eye, bruise on head	Alive 48 h	Shear/Contact	Minor	No
01 May	LU7	Bruise on head, LOE	Alive 48 h	Contact	Minor	No
01 May	LV6	Tear on left operculum, slightly hemorrhaged left side	Alive 48 h	Shear	Major	Yes
01 May	LV7	Laceration on top of head, bulged and missing eyes	Dead 1 h	Contact/Shear	Major	Yes
01 May	LW0	Slightly hemorrhaged right eye	Alive 48 h	Shear	Minor	No
01 May	LW9	Ruptured left eye, LOE	Alive 48 h	Shear	Major	Yes
01 May	LY0	Abrasion on snout, hemorrhaged right eye	Alive 48 h	Shear/Contact	Major	Yes
01 May	LY1	Slightly hemorrhaged left eye, LOE	Alive 48 h	Shear	Minor	Yes
01 May	LY4	Ruptured right eye	Alive 48 h	Shear	Major	Yes
01 May	LY7	Hemorrhaged left eye	Alive 48 h	Shear	Major	Yes
01 May	LZ7	Hemorrhaged right eye, LOE	Alive 48 h	Shear	Major	Yes
01 May	YM3	Hemorrhaged left eye	Alive 48 h	Shear	Minor	Yes
01 May	YM4	Slightly hemorrhaged right eye	Alive 48 h	Shear	Minor	Yes
		100% Spill, Shallow Release				
23 Apr	UL9	Ruptured left eye	Alive 48 h	Shear	Major	Yes
25 Apr	EZ5	LOE	Dead 1 h			No
		100% Spill, Deep Release				
23 Apr	UH1	Slightly hemorrhaged right eye	Alive 48 h	Shear	Minor	Yes
23 Apr	UH3	Ruptured right eye, LOE	Dead 24 h	Shear	Major	Yes
23 Apr	UJ3	Slightly hemorrhaged right eye, damaged pupil	Alive 48 h	Shear	Major	Yes
24 Apr	EM7	LOE	Alive 48 h			No

Appendix Table B-1

Continued.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
24 Apr	EN3	Hemorrhaged left eye, major scale loss	Alive 48 h	Shear/Contact	Major	Yes
24 Apr	EP1	Hemorrhaged right eye, LOE	Alive 48 h	Shear	Minor	Yes
24 Apr	EP2	Ruptured left eye, torn right operculum, scrape on head	Alive 48 h	Shear/Contact	Major	Yes
24 Apr	EP3	Hemorrhaged left eye, scrape left side of head	Alive 48 h	Shear/Contact	Minor	No
25 Apr	EV4	LOE	Alive 48 h			No
25 Apr	EW5	Hemorrhaged right eye	Alive 48 h	Shear	Minor	Yes
28 Apr	FV7	Slightly hemorrhaged left eye	Alive 48 h	Shear	Minor	Yes
28 Apr	FW5	Slightly hemorrhaged left eye	Alive 48 h	Shear	Minor	Yes
28 Apr	FV4	Hemorrhaged right eye	Alive 48 h	Shear	Major	Yes
28 Apr	FV9	Ruptured right eye	Alive 48 h	Shear	Major	Yes
28 Apr	FV1	Hemorrhaged left eye	Alive 48 h	Shear	Major	Yes
28 Apr	FW1	Major scale loss	Alive 48 h	Contact	Major	Yes
29 Apr	HP2	Laceration on head, bruised left side, major scale loss, LOE	Alive 48 h	Contact	Major	Yes
29 Apr	HR2	Torn right operculum	Alive 48 h	Shear	Major	Yes
29 Apr	HR4	Operculum damage left side	Alive 48 h	Shear	Major	Yes
29 Apr	HU4	Torn right operculum	Alive 48 h	Shear	Major	Yes
29 Apr	HU5	Hemorrhaged right eye, LOE	Alive 48 h	Shear	Minor	Yes
		Special Spill, Shallow Release				
02 May	YN4	Hemorrhaged left eye	Alive 48 h	Shear	Minor	Yes
02 May	YR5	Bruise on head, LOE	Dead 24 h	Contact	Major	Yes
02 May	YS3	Hemorrhaged and bulged right eye, LOE	Alive 48 h	Shear	Major	Yes
02 May	YS9	Torn right operculum, hemorrhaged right eye	Alive 48 h	Shear	Major	Yes
02 May	YZ0	Bruise on head, hemorrhaged right eye, LOE	Alive 48 h	Shear/Contact	Minor	No
02 May	YZ4	LOE	Alive 48 h			No

Appendix Table B-1

Continued.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
		Special Spill, Deep Release				
02 May	TM7	Hemorrhaged right eye	Alive 48 h	Shear	Minor	Yes
02 May	YT3	Ruptured right eye	Alive 48 h	Shear	Major	No
02 May	YT5	Bulged left eye	Alive 48 h	Shear	Major	Yes
02 May	YT8	Torn right operculum	Alive 48 h	Contact	Major	Yes
02 May	YV1	Hemorrhaged right eye, LOE	Alive 48 h	Shear	Minor	No
02 May	YV5	Severely hemorrhaged left eye, LOE	Alive 48 h	Shear	Major	Yes
02 May	YW2	Bulged right eye	Alive 48 h	Shear	Minor	No
02 May	YW4	Hemorrhaged right eye	Alive 48 h	Shear	Minor	No
02 May	YW6	Severely hemorrhaged right eye, LOE	Alive 48 h	Shear	Major	Yes
02 May	YW8	Bleeding from gills, ruptured left eye, LOE	Alive 48 h	Shear	Major	Yes
02 May	YX3	Bulged left eye, scrape on nose	Alive 48 h	Shear/Contact	Minor	No
02 May	YX4	Torn left operculum	Alive 48 h	Contact	Major	Yes
02 May	YX5	Severely torn operculum	Dead 1 h	Shear	Major	Yes

Appendix Table B-2

Incidence of injury, scale loss, and temporary loss of equilibrium (LOE) observed on juvenile chinook salmon and rainbow trout passed through shallow (7 ft above ogee) and deep (3 ft above ogee) release sites in Spillbay 5 under bulk (13.6k cfs) and dispersed (3.4k cfs) patterns, Ice Harbor Dam, July 2003.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
		Bulk spill, Shallow Release, Chinook salmon				
13 Jul	AP8	No visible internal or external injuries	Dead 48 h			No
13 Jul	TM0	Bloody nose	Dead 48 h	Contact	Major	Yes
13 Jul	TM2	No visible internal or external injuries	Dead 48 h			No
13 Jul	TM4	No visible internal or external injuries	Dead 24 h			No
13 Jul	TM8	No visible internal or external injuries	Dead 48 h			No
13 Jul	TN0	No visible internal or external injuries	Dead 48 h			No
13 Jul	TN2	No visible internal or external injuries	Dead 48 h			No
13 Jul	TN3	Tear at dorsal tag site*	Dead 48 h			Yes
13 Jul	TN6	No visible internal or external injuries	Dead 48 h			No
13 Jul	TP1	No visible internal or external injuries	Dead 48 h			No
13 Jul	TP1	No visible internal or external injuries	Dead 48 h			No
13 Jul	TP4	No visible internal or external injuries	Dead 48 h			No
13 Jul	TP8	No visible internal or external injuries	Dead 24 h			No
13 Jul	TP9	No visible internal or external injuries	Dead 48 h			No
13 Jul	TR1	No visible internal or external injuries	Dead 48 h			No
13 Jul	TR2	Tear at tag site*	Dead 48 h			No
13 Jul	TR5	No visible internal or external injuries	Dead 48 h			No
13 Jul	TR6	No visible internal or external injuries	Dead 48 h			No
13 Jul	TS3	Bruise from eye down dorsal side, LOE, tear at tag site	Dead 1 h	Contact	Major	No
13 Jul	TS9	No visible internal or external injuries	Dead 24 h			No
13 Jul	TT3	No visible internal or external injuries	Dead 48 h			No
13 Jul	TT5	No visible internal or external injuries	Dead 48 h			No
13 Jul	TT6	Bleeding from cut on left side of nose	Dead 48 h	Contact	Major	No
13 Jul	YL8	Vertical scrapes on both sides, LOE	Dead 24 h	Contact	Major	Yes
15 Jul	WR2	Hemorrhaged pelvic fins	Dead 48 h	Shear		No

Appendix Table B-2

Continued.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
15 Jul	WR3	No visible internal or external injuries	Dead 24 h			No
15 Jul	WS1	No visible internal or external injuries	Dead 48 h			No
15 Jul	WS2	Right eye bulged	Dead 48 h	Shear	Major	No
15 Jul	WS3	No visible internal or external injuries	Dead 48 h			No
15 Jul	WS5	No visible internal or external injuries	Dead 1 h			No
15 Jul	WS8	No visible internal or external injuries	Dead 1 h			No
15 Jul	WS9	Major scale loss right side behind dorsal fin, LOE	Dead 24 h	Contact		No
15 Jul	WT1	Major scale loss both sides	Dead 1 h	Contact		No
15 Jul	WU4	No visible internal or external injuries	Dead 24 h			No
15 Jul	WU6	Torn right operculum, bruise on head	Dead 1 h	Contact/Shear	Major	No
15 Jul	WV5	No visible internal or external injuries	Dead 48 h			No
15 Jul	WV7	No visible internal or external injuries	Dead 48 h			No
15 Jul	WV8	No visible internal or external injuries	Dead 48 h			No
15 Jul	WW6	No visible internal or external injuries	Dead 24 h			No
		Bulk spill, Deep Release, Chinook salmon				
13 Jul	TU2	Hemorrhaged and ruptured left eye, LOE	Dead 1 h	Shear	Major	Yes
13 Jul	TU4	Right operculum damage	Dead 48 h	Shear	Major	Yes
13 Jul	TU5	Slightly hemorrhaged left eye	Dead 24 h	Shear	Major	Yes
13 Jul	TU8	LOE	Dead 24 h			No
13 Jul	TU9	No visible internal or external injuries	Dead 48 h			No
13 Jul	TV4	No visible internal or external injuries	Dead 24 h			No
13 Jul	TV7	Slightly bent right operculum, LOE	Dead 24 h	Shear	Major	No
13 Jul	TV8	No visible internal or external injuries	Dead 48 h			No
13 Jul	TW2	No visible internal or external injuries	Dead 48 h			No
13 Jul	TW4	No visible internal or external injuries	Dead 24 h			No
13 Jul	TW6	Hemorrhaged left gill, LOE, tear at caudal tag site	Dead 24 h	Shear	Major	No
13 Jul	TW8	LOE	Dead 24 h			No
13 Jul	TX0	Bleeding from cut on ventral side, LOE	Alive 48 h	Contact	Major	No

Appendix Table B-2

Continued.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
13 Jul	TX3	No visible internal or external injuries	Dead 48 h			No
13 Jul	TX8	No visible internal or external injuries	Dead 48 h			No
13 Jul	TX9	Hemorrhaged left eye	Dead 24 h	Shear	Major	Yes
13 Jul	TY1	Hemorrhaged left eye	Dead 24 h	Shear	Major	Yes
13 Jul	TY3	No visible internal or external injuries	Dead 48 h			No
13 Jul	TY4	Blood at base of anal fin, slight tear on right operculum	Dead 48 h	Contact	Major	No
13 Jul	TY5	No visible internal or external injuries	Dead 48 h			No
13 Jul	TY7	Slight injury to left operculum, bruises on back, tear at tag site	Dead 24 h	Contact	Major	No
13 Jul	TZ0	Hemorrhaged right eye, damaged pupil, LOE	Dead 24 h	Shear	Major	Yes
13 Jul	TZ3	No visible internal or external injuries	Dead 48 h			No
13 Jul	TZ5	No visible internal or external injuries	Dead 48 h			No
		Dispersed Spill, Deep Release, Chinook salmon				
14 Jul	UP0	Hemorrhaged left eye, bulged right eye	Dead 48 h	Shear	Major	No
14 Jul	UP1	No visible internal or external injuries	Dead 48 h			No
14 Jul	UP2	No visible internal or external injuries	Dead 48 h			No
14 Jul	UP4	No visible internal or external injuries	Dead 48 h			No
14 Jul	UP6	No visible internal or external injuries	Dead 48 h			No
14 Jul	UR0	No visible internal or external injuries	Dead 48 h			No
14 Jul	UR4	No visible internal or external injuries	Dead 24 h			Yes
14 Jul	UR5	Slight hemorrhage in right eye	Dead 24 h	Shear	Major	No
14 Jul	UR6	Bulged left eye, hemorrhaged right eye	Dead 24 h	Shear	Major	No
14 Jul	UR7	Severely hemorrhaged left eye	Dead 24 h	Shear	Major	Yes
14 Jul	UR8	Hemorrhaged left eye and ruptured pupil, torn left operculum	Dead 48 h	Shear	Major	No
14 Jul	US0	No visible internal or external injuries	Dead 48 h			No
14 Jul	US1	No visible internal or external injuries	Dead 48 h			No
14 Jul	US2	No visible internal or external injuries	Dead 48 h			No
14 Jul	US3	No visible internal or external injuries	Dead 48 h			No
14 Jul	US4	No visible internal or external injuries	Dead 48 h			No

Appendix Table B-2

Continued.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
14 Jul	US7	No visible internal or external injuries	Dead 48 h			No
14 Jul	US8	No visible internal or external injuries	Dead 48 h			No
14 Jul	US9	No visible internal or external injuries	Dead 48 h			No
14 Jul	UT0	No visible internal or external injuries	Dead 48 h			No
14 Jul	UT4	Bruise on head and torn left operculum	Alive 48 h	Contact/Shear	Major	No
14 Jul	UT5	Torn right operculum, LOE	Dead 24 h	Shear	Major	Yes
14 Jul	UT6	Torn right operculum, hemorrhaged right gills	Dead 48 h	Shear	Major	No
14 Jul	UT7	Scale loss right side	Dead 24 h	Contact		Yes
14 Jul	UT8	No visible internal or external injuries	Dead 24 h			No
14 Jul	UT9	Broken back, right opercle crushed, damaged right eye	Dead 1 h	Contact/Shear	Major	Yes
14 Jul	UU0	No visible internal or external injuries	Dead 48 h			No
14 Jul	UU1	No visible internal or external injuries	Dead 48 h			No
14 Jul	UU2	Bulged left eye	Alive 48 h	Shear		No
14 Jul	UU9	Tear on right operculum, LOE	Dead 48 h	Shear	Major	No
14 Jul	VM1	Hemorrhaged left eye, scrape on operculum	Dead 1 h	Shear	Major	Yes
14 Jul	VM2	No visible internal or external injuries	Dead 48 h			No
14 Jul	VM4	No visible internal or external injuries	Dead 48 h			No
14 Jul	VM5	LOE	Dead 24 h			No
14 Jul	VM8	No visible internal or external injuries	Dead 48 h			No
14 Jul	VM9	Bruise on nose, LOE	Dead 24 h	Contact	Major	Yes
14 Jul	VN0	Both eyes hemorrhaged, LOE	Alive 48 h	Shear	Major	No
14 Jul	VN1	No visible internal or external injuries	Dead 24 h			No
14 Jul	VN2	No visible internal or external injuries	Dead 48 h			No
14 Jul	VN3	Hemorrhaged left eye, eroded lower caudal fin, LOE	Dead 24 h	Shear	Major	No
14 Jul	VN8	Major hemorrhage in left eye, LOE	Dead 24 h	Shear	Major	Yes
14 Jul	VN9	Tear on left operculum, LOE	Alive 48 h	Shear	Major	No
14 Jul	VP3	Hemorrhaged right eye, both pupils damaged	Alive 48 h	Shear	Major	No
14 Jul	VP5	Major hemorrhage in left eye, LOE	Dead 24 h	Shear	Major	Yes
14 Jul	VP6	Hemorrhaged right eye	Alive 48 h	Shear		No

Appendix Table B-2

Continued.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
14 Jul	VR3	No visible internal or external injuries	Dead 48 h			No
14 Jul	VR4	LOE	Alive 48 h			No
14 Jul	VR5	Right operculum. bent back and torn at the top	Alive 48 h	Shear		No
14 Jul	VS4	LOE	Dead 24 h			No
14 Jul	VS7	No visible internal or external injuries	Dead 48 h			No
		Controls, Fish Bypass Pipe, Chinook salmon				
13 Jul	UN5	No visible internal or external injuries	Dead 48 h			No
14 Jul	UW5	No visible internal or external injuries	Dead 48 h			No
14 Jul	UW6	Major scale loss both sides	Dead 48 h	Contact		No
14 Jul	UW7	No visible internal or external injuries	Dead 48 h			No
14 Jul	UW9	No visible internal or external injuries	Dead 48 h			No
14 Jul	UX4	No visible internal or external injuries	Dead 48 h			No
14 Jul	UX5	No visible internal or external injuries	Dead 24 h			No
14 Jul	UX9	No visible internal or external injuries	Dead 24 h			No
14 Jul	UZ4	No visible internal or external injuries	Dead 48 h			No
14 Jul	UZ8	Bruise on head	Dead 24 h	Contact	Major	Yes
14 Jul	UZ9	Both eyes bulged and hemorrhaged	Alive 48 h	Shear	Major	No
14 Jul	YF7	No visible internal or external injuries	Dead 24 h			No
14 Jul	YL2	No visible internal or external injuries	Dead 48 h			No
15 Jul	WM2	No visible internal or external injuries	Dead 24 h			No
15 Jul	WM4	LOE	Dead 24 h			No
15 Jul	WM5	No visible internal or external injuries	Dead 48 h			No
15 Jul	WP0	No visible internal or external injuries	Dead 48 h			No
15 Jul	WP3	No visible internal or external injuries	Dead 48 h			No
15 Jul	WP4	No visible internal or external injuries	Dead 48 h			No
15 Jul	YH1	No visible internal or external injuries	Dead 48 h			No
15 Jul	YH3	No visible internal or external injuries	Dead 48 h			No
15 Jul	YH4	No visible internal or external injuries	Dead 48 h			No

Appendix Table B-2

Continued.

Date	Fish ID	Malady Description	Status	Probable Cause of Injury	Injury Designation	Photo
15 Jul	YH5	No visible internal or external injuries	Dead 48 h			No
15 Jul	YH6	No visible internal or external injuries	Dead 24 h			No
15 Jul	YH8	No visible internal or external injuries	Dead 48 h			No
15 Jul	YH9	No visible internal or external injuries	Dead 48 h			No
15 Jul	YJ1	No visible internal or external injuries	Dead 48 h			No
15 Jul	YJ4	No visible internal or external injuries	Dead 48 h			No
15 Jul	YJ5	No visible internal or external injuries	Dead 48 h			No
15 Jul	YJ9	No visible internal or external injuries	Dead 48 h			No
15 Jul	YK0	No visible internal or external injuries	Dead 48 h			No
15 Jul	YK1	No visible internal or external injuries	Dead 48 h			No
15 Jul	YK3	LOE	Dead 24 h			No
15 Jul	YK4	No visible internal or external injuries	Dead 48 h			No
15 Jul	YK7	No visible internal or external injuries	Dead 48 h			No
15 Jul	YK9	No visible internal or external injuries	Dead 48 h			No
		Bulk Spill, Deep Release, Rainbow Trout				
15 Jul	YA0	No visible internal or external injuries	Dead 24 h			No
15 Jul	YA6	No visible internal or external injuries	Dead 1 h			No
15 Jul	YA9	Hemorrhaged isthmus and gills (both sides)	Dead 1 h	Shear	Major	No

* Not passage related

Appendix Table B-3

Daily tag-recapture data for juvenile chinook salmon passed through shallow (7 ft above ogee, designated "S") and deep (3 ft above ogee, designated "D") release sites in Spillbay 5 at 50%, 100%, and special spill patterns and controls released downstream of Spillbay 1 (designated "Sp1") or via the juvenile fish facility bypass pipe (designated "BP") at Ice Harbor Dam, April and May 2003.

	4/23		4/24		4/25		4/26		4/27		4/28		4/29		4/30		5/1		5/2		Totals		Grand
	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	Total
50% Spill																							
Released	5	5	--	--	--	--	--	100	--	--	--	--	--	--	--	100	--	100	--	--	**5**	**305**	**310**
Recovered alive	5	5	--	--	--	--	--	97	--	--	--	--	--	--	--	100	--	98	--	--	**5**	**300**	**305**
Recovered dead	0	0	--	--	--	--	--	2	--	--	--	--	--	--	--	0	--	2	--	--	**0**	**4**	**4**
Assigned dead*																							
Dislodged tags	0	0	--	--	--	--	--	1	--	--	--	--	--	--	--	0	--	0	--	--	**0**	**1**	**1**
Stationary radio signal	0	0	--	--	--	--	--	0	--	--	--	--	--	--	--	0	--	0	--	--	**0**	**0**	**0**
Unknown	0	0	--	--	--	--	--	0	--	--	--	--	--	--	--	0	--	0	--	--	**0**	**0**	**0**
Held	5	5	--	--	--	--	--	97	--	--	--	--	--	--	--	100	--	98	--	--	**5**	**300**	**305**
Alive at 48 h	5	5	--	--	--	--	--	97	--	--	--	--	--	--	--	100	--	98	--	--	**5**	**300**	**305**
100% Spill																							
Released	28	20	19	29	30	20	--	--	--	--	--	20	--	59	--	--	--	--	--	--	**77**	**148**	**225**
Recovered alive	28	20	19	29	29	20	--	--	--	--	--	20	--	58	--	--	--	--	--	--	**76**	**147**	**223**
Recovered dead	0	0	0	0	1	0	--	--	--	--	--	0	--	0	--	--	--	--	--	--	**1**	**0**	**1**
Assigned dead*																							
Dislodged tags	0	0	0	0	0	0	--	--	--	--	--	0	--	0	--	--	--	--	--	--	**0**	**0**	**0**
Stationary radio signal	0	0	0	0	0	0	--	--	--	--	--	0	--	0	--	--	--	--	--	--	**0**	**0**	**0**
Unknown	0	0	0	0	0	0	--	--	--	--	--	0	--	1	--	--	--	--	--	--	**0**	**1**	**1**
Held	28	20	19	29	29	20	--	--	--	--	--	20	--	58	--	--	--	--	--	--	**76**	**147**	**223**
Alive at 48 h	28	19	19	29	29	20	--	--	--	--	--	20	--	58	--	--	--	--	--	--	**76**	**146**	**222**
Special Spill																							
Released	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60	60	**60**	**60**	**120**
Recovered alive	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60	59	**60**	**59**	**119**
Recovered dead	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	1	**0**	**1**	**1**
Assigned dead*																							
Dislodged tags	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	**0**	**0**	**0**
Stationary radio signal	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	**0**	**0**	**0**
Unknown	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	**0**	**0**	**0**
Held	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60	59	**60**	**59**	**119**
Alive at 48 h	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	59	59	**59**	**59**	**118**

Appendix Table B-3

Continued.

	4/23		4/24		4/25		4/26		4/27		4/28		4/29		4/30		5/1		5/2		Totals		Grand
	Sp1	**BP**	**Sp1**	**BP**	**Sp1**	**BP**	**Sp1**	**BP**	**Sp1**	**BP**	**Sp1**	**BP**	**Sp1**	**BP**	**Sp1**	**BP**	**Sp1**	**BP**	**Sp1**	**BP**	**Sp1**	**BP**	**Total**
Control (50% Spill)																							
Released	--	--	--	--	--	--	20	30	--	--	--	--	--	--	20	30	30	20	--	--	**70**	**80**	**150**
Recovered alive	--	--	--	--	--	--	20	29	--	--	--	--	--	--	20	30	30	20	--	--	**70**	**79**	**149**
Recovered dead	--	--	--	--	--	--	0	0	--	--	--	--	--	--	0	0	0	0	--	--	**0**	**0**	**0**
Assigned dead*																							
Dislodged tags	--	--	--	--	--	--	0	0	--	--	--	--	--	--	0	0	0	0	--	--	**0**	**0**	**0**
Stationary radio signal	--	--	--	--	--	--	0	1	--	--	--	--	--	--	0	0	0	0	--	--	**0**	**1**	**1**
Unknown	--	--	--	--	--	--	0	0	--	--	--	--	--	--	0	0	0	0	--	--	**0**	**0**	**0**
Held	--	--	--	--	--	--	20	29	--	--	--	--	--	--	20	30	30	20	--	--	**70**	**79**	**149**
Alive at 48 h	--	--	--	--	--	--	20	29	--	--	--	--	--	--	20	30	30	20	--	--	**70**	**79**	**149**
Control (100% Spill)																							
Released	--	--	10	20	20	20	--	--	--	--	20	10	20	20	--	--	--	--	--	--	**70**	**70**	**140**
Recovered alive	--	--	10	20	20	20	--	--	--	--	19	10	20	20	--	--	--	--	--	--	**69**	**70**	**139**
Recovered dead	--	--	0	0	0	0	--	--	--	--	0	0	0	0	--	--	--	--	--	--	**0**	**0**	**0**
Assigned dead*																							
Dislodged tags	--	--	0	0	0	0	--	--	--	--	0	0	0	0	--	--	--	--	--	--	**0**	**0**	**0**
Stationary radio signal	--	--	0	0	0	0	--	--	--	--	0	0	0	0	--	--	--	--	--	--	**0**	**0**	**0**
Unknown	--	--	0	0	0	0	--	--	--	--	1	0	0	0	--	--	--	--	--	--	**1**	**0**	**1**
Held	--	--	10	20	20	20	--	--	--	--	19	10	20	20	--	--	--	--	--	--	**69**	**70**	**139**
Alive at 48 h	--	--	10	20	20	20	--	--	--	--	19	10	20	20	--	--	--	--	--	--	**69**	**70**	**139**

* Fish assigned dead in survival estimation.

Appendix Table B-4

Daily tag-recapture data for juvenile chinook salmon and rainbow trout passed through shallow (7 ft above ogee) and deep (3 ft above ogee) release sites in Spillbay 5 at bulk and dispersed spill patterns and controls released via the juvenile fish facility bypass pipe at Ice Harbor Dam, July 2003. Numbers in parentheses indicate recovered fish with predation marks or unrecovered fish presumed ingested by a predator.

	7/13		7/14		7/15		Totals		Grand
	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Total
Bulk Spill (Chinook salmon)									
Released	60	60	--	--	59	--	**119**	**60**	**179**
Recovered alive	54	54	--	--	50	--	**104**	**54**	**158**
Recovered dead	1	1	--	--	3	--	**4**	**1**	**5**
Assigned dead*									
Dislodged tags	5	3	--	--	--	--	**5**	**3**	**8**
Stationary radio signal	0	1	--	--	5(3)	--	**5(3)**	**1**	**6(3)**
Unknown	0	1	--	--	1	--	**1**	**1**	**2**
Held	54	54	--	--	50	--	**104**	**54**	**158**
Alive at 48 h	32	32	--	--	39	--	**71**	**32**	**103**
Dispersed Spill (Chinook salmon)									
Released	--	--	--	100	--	--	**0**	**100**	**100**
Recovered alive	--	--	--	96	--	--	**0**	**96**	**96**
Recovered dead	--	--	--	1	--	--	**0**	**1**	**1**
Assigned dead*									
Dislodged tags	--	--	--	--	--	--	**0**	**0**	**0**
Stationary radio signal	--	--	--	2(1)	--	--	**0**	**2(1)**	**2(1)**
Unknown	--	--	--	1	--	--	**0**	**1**	**1**
Held	--	--	--	96	--	--	**0**	**96**	**96**
Alive at 48 h	--	--	--	56	--	--	**0**	**56**	**56**
Control (Chinook salmon)									
Released	5		60		60			**125**	
Recovered alive	5		59		60			**124**	
Recovered dead	0		0		0			**0**	
Assigned dead*									
Dislodged tags	0		0		0			**0**	
Stationary radio signal	0		1		0			**1**	
Unknown	0		0		0			**0**	
Held	5		59		60			**124**	
Alive at 48 h	4		47		34			**85**	
Bulk Spill (Rainbow trout)									
Released	--	--	--	--	20	20	**20**	**20**	**40**
Recovered alive	--	--	--	--	19	18	**19**	**18**	**37**
Recovered dead	--	--	--	--	0	2	**0**	**2**	**2**
Assigned dead*									
Dislodged tags	--	--	--	--	1	0	**1**	**0**	**1**
Stationary radio signal	--	--	--	--	0	0	**0**	**0**	**0**
Unknown	--	--	--	--	0	0	**0**	**0**	**0**
Held	--	--	--	--	19	18	**19**	**18**	**37**
Alive at 48 h	--	--	--	--	19	17	**19**	**17**	**36**

* Fish assigned dead in survival estimation.

Appendix Table B-5

Daily malady data for juvenile chinook salmon passed through shallow (7 ft above ogee, designated "S") and deep (3 ft above ogee, designated "D") release sites in Spillbay 5 at 50%, 100%, and special spill patterns and controls released downstream of Spillbay 1 or via the juvenile fish facility bypass pipe at Ice Harbor Dam, April and May 2003.

	4/23		4/24		4/25		4/26		4/27		4/28		4/29		4/30		5/1		5/2		Totals		Grand
	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	Total
50% Spill																							
Released	5	5	--	--	--	--	--	100	--	--	--	--	--	--	--	100	--	100	--	--	**5**	**305**	**310**
Examined	5	5	--	--	--	--	--	99	--	--	--	--	--	--	--	100	--	100	--	--	**5**	**304**	**309**
Passage related maladies	1	0	--	--	--	--	--	21	--	--	--	--	--	--	--	21	--	23	--	--	**1**	**65**	**66**
Visible injuries	1	0	--	--	--	--	--	20	--	--	--	--	--	--	--	20	--	23	--	--	**1**	**63**	**64**
Loss of equilibrium only	0	0	--	--	--	--	--	1	--	--	--	--	--	--	--	1	--	0	--	--	**0**	**2**	**2**
Scale loss only	0	0	--	--	--	--	--	0	--	--	--	--	--	--	--	0	--	0	--	--	**0**	**0**	**0**
Without maladies	4	5	--	--	--	--	--	78	--	--	--	--	--	--	--	79	--	77	--	--	**4**	**239**	**243/0**
Without maladies that died	0	--	--	--	--	--	--	0	--	--	--	--	--	--	--	0	--	0	--	--	**0**	**0**	**0**
100% Spill																							
Released	28	20	19	29	30	20	--	--	--	--	--	20	--	59	--	--	--	--	--	--	**77**	**148**	**225**
Examined	28	20	19	29	30	20	--	--	--	--	--	20	--	58	--	--	--	--	--	--	**77**	**147**	**224**
Passage related maladies	1	3	0	5	1	2	--	--	--	--	--	6	--	5	--	--	--	--	--	--	**2**	**21**	**23**
Visible injuries	1	3	0	4	0	1	--	--	--	--	--	1	--	5	--	--	--	--	--	--	**1**	**14**	**15**
Loss of equilibrium only	0	0	0	1	1	1	--	--	--	--	--	0	--	0	--	--	--	--	--	--	**1**	**2**	**3**
Scale loss only	0	0	0	0	0	0	--	--	--	--	--	1	--	0	--	--	--	--	--	--	**0**	**1**	**1**
Without maladies	27	17	19	24	29	18	--	--	--	--	--	14	--	53	--	--	--	--	--	--	**75**	**126**	**201/0**
Without maladies that died	0	0	0	0	0	0	--	--	--	--	--	0	--	0	--	--	--	--	--	--	**0**	**0**	**0**
Special Spill																							
Released	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60	60	**60**	**60**	**120**
Examined	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60	60	**60**	**60**	**120**
Passage related maladies	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	13	**6**	**13**	**19**
Visible injuries	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	13	**5**	**13**	**18**
Loss of equilibrium only	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	0	**1**	**0**	**1**
Scale loss only	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	**0**	**0**	**0**
Without maladies	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	54	47	**54**	**47**	**101/0**
Without maladies that died	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0	**0**	**0**	**0**

Appendix Table B-5

Continued.

	4/23	4/24	4/25	4/26	4/27	4/28	4/29	4/30	5/1	5/2	Total
Control (50% Spill)											
Released	--	--	--	50	--	--	--	50	50	--	**150**
Examined	--	--	--	49	--	--	--	50	50	--	**149**
Passage related maladies	--	--	--	0	--	--	--	0	0	--	**0**
Visible injuries	--	--	--	0	--	--	--	0	0	--	**0**
Loss of equilibrium only	--	--	--	0	--	--	--	0	0	--	**0**
Scale loss only	--	--	--	0	--	--	--	0	0	--	**0**
Without maladies	--	--	--	49	--	--	--	50	50	--	**149**
Without maladies that died	--	--	--	0	--	--	--	0	0	--	**0**
Control (100% Spill)											
Released	--	30	40	--	--	30	40	--	--	--	**140**
Examined	--	30	40	--	--	29	40	--	--	--	**139**
Passage related maladies	--	0	0	--	--	0	0	--	--	--	**0**
Visible injuries	--	0	0	--	--	0	0	--	--	--	**0**
Loss of equilibrium only	--	0	0	--	--	0	0	--	--	--	**0**
Scale loss only	--	0	0	--	--	0	0	--	--	--	**0**
Without maladies	--	30	40	--	--	29	40	--	--	--	**139**
Without maladies that died	--	0	0	--	--	0	0	--	--	--	**0**

Appendix Table B-6

Daily malady data for juvenile chinook salmon and rainbow trout passed through shallow (7 ft above ogee) and deep (3 ft above ogee) release sites in Spillbay 5 at bulk and dispersed spill patterns and controls released via the juvenile fish facility bypass pipe at Ice Harbor Dam, July 2003.

	7/13		7/14		7/15		Totals		Grand
	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Total
Bulk Spill (Chinook salmon)									
Released	60	60	--	--	59	--	**119**	**60**	**179**
Examined	55	55	--	--	53	--	**108**	**55**	**163**
Passage related maladies	4	13	--	--	5	--	**9**	**13**	**22**
Visible injuries	4	11			3		**7**	**11**	**18**
Loss of equilibrium only	0	0	--	--	2	--	**2**	**0**	**2**
Scale loss only	0	2	--	--	0	--	**0**	**2**	**2**
Without maladies	51(2*)	42	--	--	48	--	**99(2*)**	**42**	**141(2*)**
Without maladies that died	18	11	--	--	10	--	**28**	**11**	**39**
Dispersed Spill (Chinook salmon)									
Released	--	--	--	100	--	--	--	**100**	**100**
Examined	--	--	--	97	--	--	--	**97**	**97**
Passage related maladies	--	--	--	25	--	--	--	**25**	**25**
Visible injuries	--	--	--	21	--	--	--	**21**	**21**
Loss of equilibrium only	--	--	--	3	--	--	--	**3**	**3**
Scale loss only	--	--	--	1	--	--	--	**1**	**1**
Without maladies	--	--	--	72	--	--	--	**72**	**72**
Without maladies that died	--	--	--	25	--	--	--	**25**	**25**
Control (Chinook salmon)									
Released	5		60		60			**125**	
Examined	5		59		60			**124**	
Passage related maladies	0		3		2			**5**	
Visible injuries	0		2		0			**2**	
Loss of equilibrium only	0		0		2			**2**	
Scale loss only	0		1		0			**1**	
Without maladies	5		56		58			**119**	
Without maladies that died	1		10		21			**32**	
Bulk Spill (Rainbow trout)									
Released	--	--	--	--	20	20	**20**	**20**	**40**
Examined	--	--	--	--	19	20	**19**	**20**	**39**
Passage related maladies	--	--	--	--	0	1	**0**	**1**	**1**
Visible injuries					0	1	**0**	**1**	**1**
Loss of equilibrium only	--	--	--	--	0	0	**0**	**0**	**0**
Scale loss only	--	--	--	--	0	0	**0**	**0**	**0**
Without maladies	--	--	--	--	19	19	**19**	**19**	**38**
Without maladies that died	--	--	--	--	0	2	**0**	**2**	**2**

* Includes fish with maladies attributed to predators and/or tags (*i.e.* , tear at tag site).

APPENDIX C

DERIVATION OF PRECISION, SAMPLE SIZE, AND MAXIMUM LIKELIHOOD PARAMETERS, AND STATISTICAL OUTPUTS

DERIVATION OF PRECISION, SAMPLE SIZE, AND MAXIMUM LIKELIHOOD PARAMETERS

The statistical description below is excerpted from Normandeau Associates and Skalski (2000a). For the sake of brevity, references within the text have been removed. However, interested readers can look up these citations in the report prepared by Normandeau Associates and Skalski (2000a).

The estimation for the likelihood model parameters and sample size requirements discussed in the text are given herein. Additionally, the results of statistical analyses for evaluating homogeneity in recapture and survival probabilities, and in testing hypotheses of equality in parameter estimates under the simplified (H_O:P_A=P_D) versus the most generalized model (H_A:$P_A \neq P_D$) are given.

The following terms are defined for the equations and likelihood functions which follow:

R_C	=	Number of control fish released
R_T	=	Number of treatment fish released
R	=	R_C=R_T
n	=	Number of replicate estimates $\hat{\tau}_i$ (i=1,…,n)
a_C	=	Number of control fish recaptured alive
d_C	=	Number of control fish recaptured dead
a_T	=	Number of treatment fish recaptured alive
d_T	=	Number of treatment fish recaptured dead
S	=	Probability fish survive from the release point of the controls to recapture
P_A	=	Probability an alive fish is recaptured
P_D	=	Probability a dead fish is recaptured
τ	=	Probability a treatment fish survives to the point of the control releases (*i.e.*, passage survival)
1-τ	=	Passage-related mortality.

The precision of the estimate was defined as:

$$P(-\varepsilon < \hat{\tau} - \tau < \varepsilon) = 1 - \alpha$$

or equivalently

$$P(-\varepsilon < |\hat{\tau} - \tau| < \varepsilon) = 1 - \alpha$$

where the absolute errors in estimation, *i.e.*, $|\hat{\tau} - \tau|$, is <ε (1-α) 100% of the time, $\hat{\tau}$ is the estimated passage survival, and ε is the half-width of a (1-α) 100% confidence interval for $\hat{\tau}$ or 1-$\hat{\tau}$. A precision of ±5%, 90% of the time is expressed as P($|\hat{\tau} - \tau|$<0.05)=0.90.

Using the above precision definition and assuming normality of $\hat{\tau} - \tau$, the required total sample size (R) is as follows:

$$P\left(\frac{-\varepsilon}{\sqrt{Var(\hat{\tau})}} < Z < \frac{\varepsilon}{\sqrt{Var(\hat{\tau})}}\right) = 1 - \alpha$$

$$P\left(Z < \frac{-\varepsilon}{\sqrt{Var(\hat{\tau})}} \right) = \alpha / 2$$

$$\Phi\left(\frac{-\varepsilon}{\sqrt{Var(\hat{\tau})}} \right) = \alpha / 2$$

$$\frac{-\varepsilon}{\sqrt{Var(\hat{\tau})}} = Z_{\alpha/2}$$

$$Var(\hat{\tau}) = \frac{\varepsilon^2}{Z^2_{1-\frac{\alpha}{2}}}$$

$$\frac{\tau}{SP_A}\left[\frac{(1 - S\tau P_A)}{R_T} + \frac{(1 - SP_A)\tau}{R_C} \right] = \frac{\varepsilon^2}{Z^2_{1-\frac{\alpha}{2}}} \ .$$

where Z is a standard normal deviate satisfying the relationship $P(Z>Z_{1-\alpha/2})=\alpha/2$, and Φ is the cumulative distribution function for a standard normal deviate.

If data can be pooled across trials and letting $R_C=R_T=R$, the sample size for each release is

$$R = \frac{\tau}{SP_A}\left[1 + \tau - 2S\tau P_A \right] \frac{Z^2_{1-\alpha/2}}{\varepsilon^2} \ .$$

By rearranging, this equation can be solved to predetermine the anticipated precision given the available number of fish for a study. In most previous investigations (Normandeau Associates and Skalski 2000a) this equation has been used to calculate sample sizes because of homogeneity between trials; in the present investigation sample size was predetermined using this equation.

If data cannot be pooled across trials the precision is based on

$$\sum_{i=1}^{n} (1 - \hat{\tau}_i)/n = 1 - \sum_{i=1}^{n} \hat{\tau}_i / n = 1 - \bar{\hat{\tau}} \ .$$

Precision is defined as

$$P(|\bar{\hat{\tau}} - \bar{\tau}| < \varepsilon) = 1 - \alpha$$

$$P(-\varepsilon < \bar{\hat{\tau}} - \bar{\tau} | < \varepsilon) = 1 - \alpha$$

$$P\left(\frac{-\varepsilon}{\sqrt{Var(\bar{\hat{\tau}})}} < t_{n-1} < \frac{\varepsilon}{\sqrt{Var(\bar{\hat{\tau}})}} \right) = 1 - \alpha$$

$$P\left(t_{n-1} < \frac{-\varepsilon}{\sqrt{Var(\bar{\hat{\tau}})}}\right) = \alpha / 2$$

$$\Phi\left(\frac{-\varepsilon}{Var(\bar{\hat{\tau}})}\right) = \alpha / 2$$

$$\frac{-\varepsilon}{\sqrt{Var(\bar{\hat{\tau}})}} = t_{\alpha/2,n-1}$$

$$Var(\bar{\hat{\tau}}) = \frac{\varepsilon^2}{t^2_{1-\alpha/2,n-1}}$$

$$\frac{\sigma_\tau^2 + \frac{\tau}{SP_A}\left[\frac{(1-S\tau P_A)}{R_T} + \frac{(1-SP_A)\tau}{R_C}\right]}{n} = \frac{\varepsilon^2}{t^2_{1-\alpha/2,n-1}}$$

where σ_τ^2=natural variation in passage-related mortality.

Now letting $R_T=R_C$

$$\frac{\sigma_\tau^2 + \frac{\tau}{SP_A}\left[\frac{(1-S\tau P_A)}{R} + \frac{(1-SP_A)\tau}{R}\right]}{n} = \frac{\varepsilon^2}{t^2_{1-\alpha/2,n-1}}$$

which must be iteratively solved for n given R. Or R given n where

$$R = \frac{\frac{\tau}{SP_A}\left[(1-S\tau P_A) + (1-SP_A)\tau\right]}{\left[\frac{n\varepsilon^2}{t^2_{1-\alpha/2,n-1}} - \sigma_\tau^2\right]}$$

$$R = \frac{\frac{\tau(1+\tau)}{SP_A}}{\left[\frac{n\varepsilon^2}{t^2_{1-\alpha/2,n-1}} - \sigma_\tau^2\right]}$$

$$R = \frac{\tau(1+\tau)}{SP_A}\left[\frac{t^2_{1-\alpha/2,n-1}}{n\varepsilon^2 - \sigma_\tau^2 t^2_{1-\alpha/2,n-1}}\right].$$

The joint likelihood for the passage-related mortality is:

$$L\,(S,\ \tau,\ P_A,\ P_D \mid R_C,\ R_T,\ a_C,\ a_T,\ d_C,\ d_T)=$$

$$\binom{R_C}{a_c d_C}(SP_A)^{a_C}((1-S)P_D)^{d_C}(1-SP_A-(1-S)P_D)^{R_C-a_C-d_C}$$

$$\times\binom{R_T}{a_T d_T}(S\tau P_A)^{a_T}((1-S\tau)P_D)^{d_T}(1-S\tau P_A-(1-S\tau)P_D)^{R_T-a_T-d_T}\ .$$

The likelihood model is based on the following assumptions: (1) fate of each fish is independent, (2) the control and treatment fish come from the same population of inference and share that same survival probability, (3) all alive fish have the same probability, P_A, of recapture, (4) all dead fish have the same probability, P_D, of recapture, and (5) passage survival (τ) and survival (S) to the recapture point are conditionally independent. The likelihood model has four parameters (P_A, P_D, S, τ) and four minimum sufficient statistics (a_C, d_C, a_T, d_T).

Because any two treatment releases were made concurrently with a single shared control group we used the likelihood model which took into account dependencies within the study design (Normandeau Associates *et al.* 1995). For any two treatment groups (denoted T_1 and T_2), the likelihood model is as follows:

$$L(S,\tau_1,\tau_2,P_A,P_D \mid R_C,R_{T_1},R_{T_2},a_C,d_c,a_{T_1},d_{T_1},a_{T_2},d_{T_2})=$$

$$\binom{R_C}{a_c d_C}(SP_A)^{a_C}((1-S)P_D)^{d_C}(1-SP_A-(1-S)P_D)^{R_C-a_C-d_C}$$

$$\times\binom{R_{T_1}}{a_{T_1} d_{T_1}}(S\tau_1 P_A)^{a_{T_1}}((1-S\tau_1)P_D)^{d_{T_1}}(1-S\tau_1 P_A-(1-S\tau_1)P_D)^{R_{T_1}-a_{T_1}-d_{T_1}}$$

$$\times\binom{R_{T_2}}{a_{T_2} d_{T_2}}(S\tau_2 P_A)^{a_{T_2}}((1-S\tau_2)P_D)^{d_{T_2}}(1-S\tau_2 P_A-(1-S\tau_2)P_D)^{R_{T_2}-a_{T_2}-d_{T_2}}\ .$$

This likelihood model has the same assumptions as stated in Normandeau Associates and Skalski (2000a) but has five estimable parameters (S, τ_1, τ_2, P_A, and P_D). The survival rate for treatment T_1 is estimated by τ_1 and for treatment T_2, by τ_2. A likelihood ratio test with 1 degree of freedom was used to test for equality in survival rates between treatments τ_1 and τ_2 based on the hypothesis H_O: $\tau_1=\tau_2$ versus H_a: $\tau_1\neq\tau_2$.

Likelihood models are based on the following assumptions: (a) the fate of each fish is independent; (b) the control and treatment fish come from the same population of inference and share the same natural survival probability, S; (c) all alive fish have the same probability, P_A, of recapture; (d) all dead fish have the same probability, P_D, of recapture; and (e) passage survival (τ) and natural survival (S) to the recapture point are conditionally independent.

The estimators associated with the likelihood model are:

$$\hat{\tau}=\frac{a_T R_C}{R_T a_C}$$

$$\hat{S} = \frac{R_T d_C a_C - R_C d_T a_C}{R_C d_C a_T - R_C d_T a_C}$$

$$\hat{P}_A = \frac{d_C a_T - d_T a_C}{R_T d_C - R_C d_T}$$

$$\hat{P}_D = \frac{d_C a_T - d_T a_C}{R_C a_T - R_T a_C} \ .$$

The variance (Var) and standard error (SE) of the estimated passage mortality ($1 - \hat{\tau}$) or survival ($\hat{\tau}$) are:

$$Var(1-\hat{\tau}) = Var(\hat{\tau}) = \frac{\tau}{SP_A}\left[\frac{(1-S\tau P_{A)}}{R_T} + \frac{(1-SP_A)\tau}{R_C}\right]$$

$$SE(1-\hat{\tau}) = SE(\hat{\tau}) = \sqrt{Var(1-\hat{\tau})} \ .$$

DERIVATION OF VARIANCE FOR WEIGHTED AVERAGE SURVIVAL ESTIMATE

The variance of a weighted average is estimated by the formula

$$\hat{\bar{\theta}}_W = \frac{\sum_{i=1}^{n} W_i \hat{\theta}_i}{\sum_{i=1}^{n} W_i}$$

with

$$\widehat{\mathrm{Var}}\left(\hat{\bar{\theta}}_W\right) = \frac{\sum_{i=1}^{n} W_i \left(\hat{\theta}_i - \hat{\bar{\theta}}_W\right)^2}{(n-1)\sum_{i=1}^{n} W_i}$$

where $\hat{\bar{\theta}}_W$ = the weighted average,

$\hat{\theta}_i$ = the parameter estimate for the *i*th replicate,

W_i = weight.

Appendix C

Chi square tests of homogeneity for the recovery of chinook salmon juveniles released through units at the Ice Harbor Dam, April/May 2003.

--------------------------------- spill=_100 ---

The FREQ Procedure

Table of release by cond

release	Frequency / Expected / Cell Chi-Square	alive	dead	unkn	Total
deep_100 1	Frequency	20	0	0	20
	Expected	19.822	0.0889	0.0889	
	Cell Chi-Square	0.0016	0.0889	0.0889	
deep_100 2	Frequency	29	0	0	29
	Expected	28.742	0.1289	0.1289	
	Cell Chi-Square	0.0023	0.1289	0.1289	
deep_100 3	Frequency	20	0	0	20
	Expected	19.822	0.0889	0.0889	
	Cell Chi-Square	0.0016	0.0889	0.0889	
deep_100 6	Frequency	20	0	0	20
	Expected	19.822	0.0889	0.0889	
	Cell Chi-Square	0.0016	0.0889	0.0889	
deep_100 7	Frequency	58	0	1	59
	Expected	58.476	0.2622	0.2622	
	Cell Chi-Square	0.0039	0.2622	2.0758	
shallow_1001	Frequency	28	0	0	28
	Expected	27.751	0.1244	0.1244	
	Cell Chi-Square	0.0022	0.1244	0.1244	
shallow_1002	Frequency	19	0	0	19
	Expected	18.831	0.0844	0.0844	
	Cell Chi-Square	0.0015	0.0844	0.0844	
shallow_1003	Frequency	29	1	0	30
	Expected	29.733	0.1333	0.1333	
	Cell Chi-Square	0.0181	5.6333	0.1333	
Total		223	1	1	225

Statistics for Table of release by cond

Statistic	DF	Value	Prob
Chi-Square	14	9.3464	0.8082
Likelihood Ratio Chi-Square	14	6.7399	0.9443
Mantel-Haenszel Chi-Square	1	0.6812	0.4092
Phi Coefficient		0.2038	
Contingency Coefficient		0.1997	
Cramer's V		0.1441	

WARNING: 67% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

The FREQ Procedure

Statistics for Table of release by cond

Fisher's Exact Test

Table Probability (P)	0.0351
Pr <= P	0.9321

Sample Size = 225

Appendix C

Chi square tests of homogeneity for the recovery of chinook salmon juveniles released through units at the Ice Harbor Dam, April/May 2003.

```
------------------------------- spill=_50 --------------------------------------------

                                The FREQ Procedure
                             Table of release by cond

                      release         cond

                      Frequency      ,
                      Expected       ,
                      Cell Chi-Square,alive   ,dead    ,  Total

                      deep_50    1   ,      5 ,      0 ,      5
                                     , 4.9194 , 0.0806 ,
                                     , 0.0013 , 0.0806 ,

                      deep_50    2   ,     97 ,      3 ,    100
                                     , 98.387 , 1.6129 ,
                                     , 0.0196 , 1.1929 ,

                      deep_50    8   ,    100 ,      0 ,    100
                                     , 98.387 , 1.6129 ,
                                     , 0.0264 , 1.6129 ,

                      deep_50    9   ,     98 ,      2 ,    100
                                     , 98.387 , 1.6129 ,
                                     , 0.0015 , 0.0929 ,

                      shallow_50 1   ,      5 ,      0 ,      5
                                     , 4.9194 , 0.0806 ,
                                     , 0.0013 , 0.0806 ,

                      Total               305        5      310

                       Statistics for Table of release by cond

                Statistic                     DF       Value      Prob

                Chi-Square                     4      3.1102    0.5396
                Likelihood Ratio Chi-Square    4      4.6340    0.3270
                Mantel-Haenszel Chi-Square     1      0.2617    0.6089
                Phi Coefficient                       0.1002
                Contingency Coefficient               0.0997
                Cramer's V                            0.1002

WARNING: 70% of the cells have expected counts less than 5. Chi-Square may not be a valid
test.

                              Fisher's Exact Test

                        Table Probability (P)       0.0347
                        Pr <= P                     0.4717

                                Sample Size = 310
```

Chi square tests of homogeneity for the recovery of chinook salmon juveniles released through units at the Ice Harbor Dam, April/May 2003.

```
------------------------ desc=deep_100 ----------------------------------------------

                                   The FREQ Procedure
                                Table of release by cond

                       release         cond

                       Frequency      ,
                       Expected       ,
                       Cell Chi-Square,alive   ,unkn    ,  Total

                       deep_100   1   ,     20 ,      0 ,     20
                                      , 19.865 , 0.1351 ,
                                      , 0.0009 , 0.1351 ,

                       deep_100   2   ,     29 ,      0 ,     29
                                      , 28.804 , 0.1959 ,
                                      , 0.0013 , 0.1959 ,

                       deep_100   3   ,     20 ,      0 ,     20
                                      , 19.865 , 0.1351 ,
                                      , 0.0009 , 0.1351 ,

                       deep_100   6   ,     20 ,      0 ,     20
                                      , 19.865 , 0.1351 ,
                                      , 0.0009 , 0.1351 ,

                       deep_100   7   ,     58 ,      1 ,     59
                                      , 58.601 , 0.3986 ,
                                      , 0.0062 , 0.9071 ,

                       Total               147        1      148


                        Statistics for Table of release by cond

                 Statistic                    DF       Value      Prob

                 Chi-Square                    4      1.5187    0.8233
                 Likelihood Ratio Chi-Square   4      1.8496    0.7634
                 Mantel-Haenszel Chi-Square    1      1.0461    0.3064
                 Phi Coefficient                      0.1013
                 Contingency Coefficient              0.1008
                 Cramer's V                           0.1013

WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid
test.

                                 Fisher's Exact Test

                         Table Probability (P)       0.3986
                         Pr <= P                     1.0000

                                   Sample Size = 148
```

Appendix C

Chi square tests of homogeneity for the recovery of chinook salmon juveniles released through units at the Ice Harbor Dam, April/May 2003.

```
----------------------- desc=deep_50 ----------------------------------------------

                                The FREQ Procedure
                             Table of release by cond

                    release         cond

                    Frequency      ,
                    Expected       ,
                    Cell Chi-Square,alive   ,dead    ,  Total

                    deep_50    1   ,      5 ,      0 ,      5
                                   ,  4.918 ,  0.082 ,
                                   , 0.0014 ,  0.082 ,

                    deep_50    2   ,     97 ,      3 ,    100
                                   , 98.361 , 1.6393 ,
                                   , 0.0188 , 1.1293 ,

                    deep_50    8   ,    100 ,      0 ,    100
                                   , 98.361 , 1.6393 ,
                                   , 0.0273 , 1.6393 ,

                    deep_50    9   ,     98 ,      2 ,    100
                                   , 98.361 , 1.6393 ,
                                   , 0.0013 , 0.0793 ,

                    Total              300        5      305

                     Statistics for Table of release by cond

              Statistic                    DF       Value      Prob

              Chi-Square                    3      2.9788    0.3949
              Likelihood Ratio Chi-Square   3      4.4701    0.2150
              Mantel-Haenszel Chi-Square    1      0.1967    0.6574
              Phi Coefficient                      0.0988
              Contingency Coefficient              0.0983
              Cramer's V                           0.0988

WARNING: 63% of the cells have expected counts less than 5. Chi-Square may not be a valid
test.

                               Fisher's Exact Test

                        Table Probability (P)       0.0376
                        Pr <= P                     0.4267

                                Sample Size = 305
```

Appendix C

Chi square tests of homogeneity for the recovery of chinook salmon juveniles released through units at the Ice Harbor Dam, April/May 2003.

--------------------- desc=shallow_100 ---

The FREQ Procedure
Table of release by cond

```
release         cond

Frequency      ,
Expected       ,
Cell Chi-Square,alive   ,dead    ,  Total

shallow_1001   ,     28 ,      0 ,     28
               , 27.636 , 0.3636 ,
               , 0.0048 , 0.3636 ,

shallow_1002   ,     19 ,      0 ,     19
               , 18.753 , 0.2468 ,
               , 0.0032 , 0.2468 ,

shallow_1003   ,     29 ,      1 ,     30
               ,  29.61 , 0.3896 ,
               , 0.0126 , 0.9563 ,

Total               76        1       77
```

Statistics for Table of release by cond

Statistic	DF	Value	Prob
Chi-Square	2	1.5873	0.4522
Likelihood Ratio Chi-Square	2	1.9059	0.3856
Mantel-Haenszel Chi-Square	1	1.2606	0.2615
Phi Coefficient		0.1436	
Contingency Coefficient		0.1421	
Cramer's V		0.1436	

WARNING: 50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Fisher's Exact Test

Table Probability (P)	0.3896
Pr <= P	1.0000

Sample Size = 77

Appendix C

Chi square tests of homogeneity for the recovery of controls chinook salmon juveniles released through the by-pass pipe and below Spillbay 1 at the Ice Harbor Dam, April/May 2003.

The FREQ Procedure
Table of release by cond

release		cond			
Frequency / Expected / Cell Chi-Square		alive	dead	unkn	Total
bp_100	4	20	0	0	20
		19.862	0.069	0.069	
		0.001	0.069	0.069	
bp_100	5	20	0	0	20
		19.862	0.069	0.069	
		0.001	0.069	0.069	
bp_100	6	10	0	0	10
		9.931	0.0345	0.0345	
		0.0005	0.0345	0.0345	
bp_100	7	20	0	0	20
		19.862	0.069	0.069	
		0.001	0.069	0.069	
bp_50	1	29	1	0	30
		29.793	0.1034	0.1034	
		0.0211	7.7701	0.1034	
bp_50	2	30	0	0	30
		29.793	0.1034	0.1034	
		0.0014	0.1034	0.1034	
bp_50	3	20	0	0	20
		19.862	0.069	0.069	
		0.001	0.069	0.069	
Total		288	1	1	290

(Continued)

Appendix C

Chi square tests of homogeneity for the recovery of controls chinook salmon juveniles released through the by-pass pipe and below Spillbay 1 at the Ice Harbor Dam, April/May 2003.

The FREQ Procedure
Table of release by cond

release		cond: alive	dead	unkn	Total
Frequency / Expected / Cell Chi-Square					
sb1_100	4	10	0	0	10
		9.931	0.0345	0.0345	
		0.0005	0.0345	0.0345	
sb1_100	5	20	0	0	20
		19.862	0.069	0.069	
		0.001	0.069	0.069	
sb1_100	6	19	0	1	20
		19.862	0.069	0.069	
		0.0374	0.069	12.569	
sb1_100	7	20	0	0	20
		19.862	0.069	0.069	
		0.001	0.069	0.069	
sb1_50	1	20	0	0	20
		19.862	0.069	0.069	
		0.001	0.069	0.069	
sb1_50	2	20	0	0	20
		19.862	0.069	0.069	
		0.001	0.069	0.069	
sb1_50	3	30	0	0	30
		29.793	0.1034	0.1034	
		0.0014	0.1034	0.1034	
Total		288	1	1	290

Statistics for Table of release by cond

Statistic	DF	Value	Prob
Chi-Square	26	22.2367	0.6757
Likelihood Ratio Chi-Square	26	9.9564	0.9981
Mantel-Haenszel Chi-Square	1	0.0402	0.8412
Phi Coefficient		0.2769	
Contingency Coefficient		0.2669	
Cramer's V		0.1958	

WARNING: 67% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

The FREQ Procedure

Statistics for Table of release by cond

Fisher's Exact Test

Table Probability (P)	0.0072
Pr <= P	0.9044

Sample Size = 290

Appendix C

Chi square tests of homogeneity of recovery of juvenile chinook salmon released through different spillbays at the Ice Harbor Dam, July 2003.

The FREQ Procedure
Table of release by cond

release / cond (Frequency, Expected, Cell Chi-Square)	alive	dead	unkn	Total
deep_blk 1	54	5	1	60
	52.961	6.3687	0.6704	
	0.0204	0.2942	0.1621	
shallow_blk1	54	6	0	60
	52.961	6.3687	0.6704	
	0.0204	0.0213	0.6704	
shallow_blk2	50	8	1	59
	52.078	6.2626	0.6592	
	0.0829	0.482	0.1762	
Total	158	19	2	179

Statistics for Table of release by cond

Statistic	DF	Value	Prob
Chi-Square	4	1.9298	0.7487
Likelihood Ratio Chi-Square	4	2.5401	0.6375
Mantel-Haenszel Chi-Square	1	0.6089	0.4352
Phi Coefficient		0.1038	
Contingency Coefficient		0.1033	
Cramer's V		0.0734	

WARNING: 33% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

Sample Size = 179

Appendix C

One hour survival rates for juvenile chinook salmon released through Spillbay 5 at deep release sites at 50% and 100% spill patterns at Ice Harbor Dam, April-May 2003. Controls: 290 released, 288 alive, 1 dead. 50% spill test: 305 released, 5 dead. 100% spill test: 148 released, 147 alive, 0 dead. (Values from Table 3-1).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	0.9965	(0.0035)	Control group survival
Pa = Pd	0.9973	(0.0019)	Recovery probability
S2 =	0.9836	(0.0073)	50% spill, deep release survival
S3 =	1.0	N/A	100% spill, deep release survival*

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -46.0103

Tau = 0.9870 (0.0081) 50% spill, deep release/Control ratio
Tau = 1.0035 (0.0035) 100% spill, deep release/Control ratio

Z statistic for the equality of equal turbine survivals: 1.8742

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00001193	0.00000000	0.00000000	0.00000000
0.00000000	0.00000361	0.00000000	0.00000000
0.00000000	0.00000000	0.00005287	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000

Confidence intervals:

	50% spill, deep release Tau	100% spill, deep release Tau
90 percent:	(0.9738, 1.0003)	(0.9978, 1.0092)
95 percent:	(0.9712, 1.0028)	(0.9967, 1.0103)
99 percent:	(0.9663, 1.0078)	(0.9945, 1.0124)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.0256

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Forty-eight hour survival rates for juvenile chinook salmon released through Spillbay 5 at deep release sites at 50% and 100% spill patterns at Ice Harbor Dam, April-May 2003. Controls: 290 released, 288 alive, 1 dead. 50% spill test: 305 released , 5 dead. 100% spill test: 148 released, 146 alive, 1 dead. (Values from Table 3-1).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

estim. std. err.
S1 = 0.9965 (0.0035) Control group survival
Pa = Pd 0.9973 (0.0019) Recovery probability
S2 = 0.9836 (0.0073) 50% spill, deep release survival
S3 = 0.9932 (0.0068) 100% spill, deep release survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -51.9973

Tau = 0.9870 (0.0081) 50% spill, deep release/Control ratio
Tau = 0.9966 (0.0076) 100% spill, deep release/Control ratio

Z statistic for the equality of equal turbine survivals: 0.8672

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00001193	0.00000000	0.00000000	0.00000000
0.00000000	0.00000361	0.00000000	0.00000000
0.00000000	0.00000000	0.00005287	0.00000000
0.00000000	0.00000000	0.00000000	0.00004596

Confidence intervals:

	50% spill, deep release Tau	100% spill, deep release Tau
90 percent:	(0.9738, 1.0003)	(0.9841, 1.0092)
95 percent:	(0.9712, 1.0028)	(0.9817, 1.0116)
99 percent:	(0.9663, 1.0078)	(0.9770, 1.0163)

===

Likelihood ratio statistic for equality of recovery probabilities: 0.0174

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

One hour survival rates for juvenile chinook salmon released through Spillbay 5 at deep release sites at 100% and special spill patterns at Ice Harbor Dam, April-May 2003. Controls: 290 released, 288 alive, 1 dead. Special spill test: 60 released , 59 alive, 1 dead. 100% spill test: 148 released, 147 alive, 0 dead. (Values from Table 3-1).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	0.9965	(0.0035)	Control group survival
Pa = Pd	0.9960	(0.0028)	Recovery probability
S2 =	1.0	N/A	100% spill, deep release survival*
S3 =	0.9833	(0.0165)	Special spill, deep release survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -24.7815

Tau = 1.0035 (0.0035) 100% spill, deep release/Control ratio
Tau = 0.9867 (0.0169) Special spill, deep release/Control ratio

Z statistic for the equality of equal turbine survivals: 0.9675

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00001193	0.00000000	0.00000000	0.00000000
0.00000000	0.00000803	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00027315

Confidence intervals:

	100% spill, deep release Tau	Special spill, deep release Tau
90 percent:	(0.9978, 1.0092)	(0.9589, 1.0146)
95 percent:	(0.9967, 1.0103)	(0.9536, 1.0199)
99 percent:	(0.9945, 1.0124)	(0.9431, 1.0304)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.0092

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Forty-eight hour survival rates for juvenile chinook salmon released through Spillbay 5 at deep release sites at 100% and special spill patterns at Ice Harbor Dam, April-May 2003. Controls: 290 released, 288 alive, 1 dead. Special spill test: 60 released , 59 alive, 1 dead. Deep release test: 148 released, 146 alive, 1 dead. (Values from Table 3-1).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim. std. err.	
S1 =	0.9965 (0.0035)	Control group survival
Pa = Pd	0.9960 (0.0028)	Recovery probability
S2 =	0.9932 (0.0068)	100% spill, deep release survival
S3 =	0.9833 (0.0165)	special spill, deep release survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -30.7686

Tau = 0.9966 (0.0076) 100% spill, deep release/Control ratio
Tau = 0.9867 (0.0169) special spill, deep release/Control ratio

Z statistic for the equality of equal turbine survivals: 0.5329

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00001193	0.00000000	0.00000000	0.00000000
0.00000000	0.00000803	0.00000000	0.00000000
0.00000000	0.00000000	0.00004596	0.00000000
0.00000000	0.00000000	0.00000000	0.00027315

Confidence intervals:

	100% spill, deep release Tau	Special spill, deep release Tau
90 percent:	(0.9841, 1.0092)	(0.9589, 1.0146)
95 percent:	(0.9817, 1.0116)	(0.9536, 1.0199)
99 percent:	(0.9770, 1.0163)	(0.9431, 1.0304)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.0037

Compare with quantiles of the chi-squared distribution with 1 d.f.:

For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

One hour survival rates for juvenile chinook salmon released through Spillbay 5 at deep and shallow release sites at 100% spill pattern at Ice Harbor Dam, April-May 2003. Controls: 290 released, 288 alive, 1 dead. Shallow test: 77 released, 76 alive, 1 dead. Deep release test: 148 released, 147 alive, 0 dead. (Values from Table 3-1).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	0.9965	(0.0035)	Control group survival
Pa = Pd	0.9961	(0.0027)	Recovery probability
S2 =	0.9870	(0.0129)	100% spill, shallow release survival
S3 =	1.0	N/A	100% spill, deep release survival*

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -25.1001

Tau = 0.9904 (0.0134) 100% spill, shallow release/Control ratio
Tau = 1.0035 (0.0035) 100% spill, deep release/Control ratio

Z statistic for the equality of equal turbine survivals: 0.9417

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00001193	0.00000000	0.00000000	0.00000000
0.00000000	0.00000751	0.00000000	0.00000000
0.00000000	0.00000000	0.00016647	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000

Confidence intervals:

	100% spill, shallow release Tau	100% spill, deep release Tau
90 percent:	(0.9684, 1.0125)	(0.9978, 1.0092)
95 percent:	(0.9642, 1.0167)	(0.9967, 1.0103)
99 percent:	(0.9559, 1.0249)	(0.9945, 1.0124)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.0087

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Forty-eight hour survival rates for juvenile chinook salmon released through Spillbay 5 at shallow and deep release sites at 100% spill pattern at Ice Harbor Dam, April-May 2003. Controls: 290 released, 288 alive, 1 dead. Shallow release test: 77 released , 76 alive, 1 dead. Deep release test: 148 released, 146 alive, 1 dead. (Values from Table 3-1).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	0.9965	(0.0035)	Control group survival
Pa = Pd	0.9961	(0.0027)	Recovery probability
S2 =	0.9870	(0.0129)	100% spill, shallow release survival
S3 =	0.9932	(0.0068)	100% spill, deep release survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -31.0872

Tau = 0.9904 (0.0134) 100% spill, shallow release/Control ratio
Tau = 0.9966 (0.0076) 100% spill, deep release/Control ratio

Z statistic for the equality of equal turbine survivals: 0.4026

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00001193	0.00000000	0.00000000	0.00000000
0.00000000	0.00000751	0.00000000	0.00000000
0.00000000	0.00000000	0.00016647	0.00000000
0.00000000	0.00000000	0.00000000	0.00004596

Confidence intervals:

	100% spill, shallow release Tau	100% spill, deep release Tau
90 percent:	(0.9684, 1.0125)	(0.9841, 1.0092)
95 percent:	(0.9642, 1.0167)	(0.9817, 1.0116)
99 percent:	(0.9559, 1.0249)	(0.9770, 1.0163)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.0029

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

One hour survival rates for juvenile chinook salmon released through Spillbay 5 at shallow and deep release sites at special spill patterns at Ice Harbor Dam, April-May 2003. Controls: 290 released, 288 alive, 1 dead. Deep release test: 60 released, 59 alive, 1 dead. Shallow test: 60 released, 60 alive, 0 dead. (Values from Table 3-1).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	0.9965	(0.0035)	Control group survival
Pa = Pd	0.9976	(0.0024)	Recovery probability
S2 =	1.0	N/A	Special spill, shallow release survival*
S3 =	0.9833	(0.0165)	Special spill, deep release survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -18.7656

Tau = 1.0035 (0.0035) Special spill, shallow release/Control ratio
Tau = 0.9867 (0.0169) Special spill, deep release/Control ratio

Z statistic for the equality of equal turbine survivals: 0.9675

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00001193	0.00000000	0.00000000	0.00000000
0.00000000	0.00000593	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00027315

Confidence intervals:

	Special spill, shallow release Tau	Special spill, deep release Tau
90 percent:	(0.9978, 1.0092)	(0.9589, 1.0146)
95 percent:	(0.9967, 1.0103)	(0.9536, 1.0199)
99 percent:	(0.9945, 1.0124)	(0.9431, 1.0304)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.0029

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Forty-eight hour survival rates for juvenile chinook salmon released through Spillbay 5 at shallow and deep release sites at a special spill pattern at Ice Harbor Dam, April-May 2003. Controls: 290 released, 288 alive, 1 dead. Shallow release test: 60 released , 59 alive, 1 dead. Deep release test: 60 released, 59 alive, 1 dead. (Values from Table 3-1).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim. std. err.	
S1 =	0.9965 (0.0035)	Control group survival
Pa = Pd	0.9976 (0.0024)	Recovery probability
S2 =	0.9833 (0.0165)	Special spill, shallow release survival
S3 =	0.9833 (0.0165)	Special spill, deep release survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -23.8516

Tau = 0.9867 (0.0169) Special spill, shallow release/Control ratio
Tau = 0.9867 (0.0169) Special spill, deep release/Control ratio

Z statistic for the equality of equal turbine survivals: 0.0000

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00001193	0.00000000	0.00000000	0.00000000
0.00000000	0.00000593	0.00000000	0.00000000
0.00000000	0.00000000	0.00027315	0.00000000
0.00000000	0.00000000	0.00000000	0.00027315

Confidence intervals:

	Special spill, shallow release Tau	Special spill, deep release Tau
90 percent:	(0.9589, 1.0146)	(0.9589, 1.0146)
95 percent:	(0.9536, 1.0199)	(0.9536, 1.0199)
99 percent:	(0.9431, 1.0304)	(0.9431, 1.0304)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.0078

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

One hour survival estimates of juvenile chinook salmon smolts passed through Spillbay 5 at shallow and deep release sites and 100% spill at Ice Harbor Dam, April/May, 2003. Controls: 290 released, 288 alive, 1 dead. Test fish: 225 released, 223 alive, 1 dead.

RESULTS FOR FULL MODEL (UNEQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S =	0.9931	(0.0000)	Control group survival
Pa =	1.0	N/A	Live recovery probability*
Pd =	0.5000	(0.2500)	Dead recovery probability
Tau =	0.9980	(0.0080)	Spillbay 5 survival
1-Tau =	0.0020	(0.0080)	Spillbay 5 mortality

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -26.156135

Variance-Covariance matrix for estimated probabilities:

-0.00008 0.00000 -0.00002
0.00000 0.06250 0.00000
0.00008 0.00000 0.00006

Profile likelihood intervals:

	Spillbay 5 survival	Spillbay 5 mortality
90 percent:	(0.9821, 1.0000)	(0.0000, 0.0179)
95 percent:	(0.9782, 1.0000)	(0.0000, 0.0218)
99 percent:	(0.9697, 1.0000)	(0.0000, 0.0303)

==

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S =	0.9965	(0.0035)	Control group survival
Pa = Pd	0.9961	(0.0027)	Recovery probability
Tau =	0.9990	(0.0057)	Spillbay 5 survival
1-Tau =	0.0010	(0.0057)	Spillbay 5 mortality

log-likelihood : -26.172256

Variance-Covariance matrix for estimated probabilities:

0.00001 0.00000 -0.00001
0.00000 0.00001 -0.00000
-0.00001 -0.00000 0.00003

Profile likelihood intervals:

	Spillbay 5 survival	Spillbay 5 mortality
90 percent:	(0.9865, 1.0000)	(0.0000, 0.0135)
95 percent:	(0.9832, 1.0000)	(0.0000, 0.0168)
99 percent:	(0.9755, 1.0000)	(0.0000, 0.0245)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.032242

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Forty-eight hour survival estimates of juvenile chinook salmon smolts passed through Spillbay 5 at shallow and deep release sites and 100% spill at Ice Harbor Dam, April/May, 2003. Controls: 290 released, 288 alive, 1 dead. Test fish: 225 released, 222 alive, 2 dead.

RESULTS FOR FULL MODEL (UNEQUAL LIVE/DEAD RECOVERY)

estim. std. err.
S = 0.9959 (0.0058) Control group survival
Pa = 0.9972 (0.0064) Live recovery probability
Pd = 0.8429 (0.7508) Dead recovery probability
Tau = 0.9935 (0.0091) Spillbay 5 survival
1-Tau = 0.0065 (0.0091) Spillbay 5 mortality

log-likelihood : -31.174767

Variance-Covariance matrix for estimated probabilities:
0.00003 -0.00003 0.00308 -0.00000
-0.00003 0.00004 -0.00433 -0.00002
0.00308 -0.00433 0.56368 0.00287
-0.00000 -0.00002 0.00287 0.00008

Profile likelihood intervals:

	Spillbay 5 survival	Spillbay 5 mortality
90 percent:	(0.9756, 1.0000)	(0.0000, 0.0244)
95 percent:	(0.9713, 1.0000)	(0.0000, 0.0287)
99 percent:	(0.9620, 1.0000)	(0.0000, 0.0380)

==

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

estim. std. err.
S = 0.9965 (0.0035) Control group survival
Pa = Pd 0.9961 (0.0027) Recovery probability
Tau = 0.9945 (0.0072) Spillbay 5 survival
1-Tau = 0.0055 (0.0072) Spillbay 5 mortality

log-likelihood : -31.190888

Variance-Covariance matrix for estimated probabilities:
0.00001 -0.00000 -0.00001
-0.00000 0.00001 0.00000
-0.00001 0.00000 0.00005

Profile likelihood intervals:

	Spillbay 5 survival	Spillbay 5 mortality
90 percent:	(0.9793, 1.0000)	(0.0000, 0.0207)
95 percent:	(0.9754, 1.0000)	(0.0000, 0.0246)
99 percent:	(0.9669, 1.0000)	(0.0000, 0.0331)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.032242

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

One hour survival rates for juvenile chinook salmon released through Spillbay 5 at shallow release sites at 100% and special spill patterns at Ice Harbor Dam, April-May 2003. Controls: 290 released, 288 alive, 1 dead. 100% spill test: 77 released, 76 alive, 1 dead. Special spill test: 60 released, 60 alive, 0 dead. (Values from Table 3-1).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	0.9965	(0.0035)	Control group survival
Pa = Pd	0.9977	(0.0023)	Recovery probability
S2 =	0.9870	(0.0129)	100% spill, shallow release survival
S3 =	1.0	N/A	Special spill, shallow release survival*

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -19.0576

Tau = 0.9904 (0.0134) 100% spill, shallow release/Control ratio
Tau = 1.0035 (0.0035) Special spill, shallow release/Control ratio

Z statistic for the equality of equal turbine survivals: 0.9417

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00001193	0.00000000	0.00000000	0.00000000
0.00000000	0.00000547	0.00000000	0.00000000
0.00000000	0.00000000	0.00016647	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000

Confidence intervals:

	100% spill, shallow release Tau	Special spill, shallow release Tau
90 percent:	(0.9684, 1.0125)	(0.9978, 1.0092)
95 percent:	(0.9642, 1.0167)	(0.9967, 1.0103)
99 percent:	(0.9559, 1.0249)	(0.9945, 1.0124)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.0025

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Forty-eight hour survival rates for juvenile chinook salmon released through Spillbay 5 at shallow release sites at 100% and special spill patterns at Ice Harbor Dam, April-May 2003. Controls: 290 released, 288 alive, 1 dead. 10% spill test: 77 released, 76 alive, 1 dead. Special spill test: 60 released, 59 alive, 1 dead. (Values from Table 3-1).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim. std. err.	
S1 =	0.9965 (0.0035)	Control group survival
Pa = Pd	0.9977 (0.0023)	Recovery probability
S2 =	0.9870 (0.0129)	100% spill, shallow release survival
S3 =	0.9833 (0.0165)	Special spill, shallow release survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -24.1436

Tau = 0.9904 (0.0134) 100% spill, shallow release/Control ratio
Tau = 0.9867 (0.0169) Special spill, shallow release/Control ratio

Z statistic for the equality of equal turbine survivals: 0.1710

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00001193	0.00000000	0.00000000	0.00000000
0.00000000	0.00000547	0.00000000	0.00000000
0.00000000	0.00000000	0.00016647	0.00000000
0.00000000	0.00000000	0.00000000	0.00027315

Confidence intervals:

	100% spill, shallow release Tau	Special spill, shallow release Tau
90 percent:	(0.9684, 1.0125)	(0.9589, 1.0146)
95 percent:	(0.9642, 1.0167)	(0.9536, 1.0199)
99 percent:	(0.9559, 1.0249)	(0.9431, 1.0304)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.0072

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

One hour survival estimates of juvenile chinook salmon smolts passed through Spillbay 5 at shallow and deep release sites and special spill at Ice Harbor Dam, April/May, 2003. Controls: 290 released, 288 alive, 1 dead. Test fish: 120 released, 119 alive, 1 dead.

RESULTS FOR FULL MODEL (UNEQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S =	0.9966	(0.0034)	Control group survival
Pa =	0.9975	(0.0024)	Live recovery probability
Pd =	1.0	N/A	Dead recovery probability*
Tau =	0.9951	(0.0090)	Spillbay 5 survival
1-Tau =	0.0049	(0.0090)	Spillbay 5 mortality

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -19.461509

Variance-Covariance matrix for estimated probabilities:

0.00001 -0.00000 -0.00001
-0.00000 0.00001 0.00000
-0.00001 0.00000 0.00008

Profile likelihood intervals:

	Spillbay 5 survival	Spillbay 5 mortality
90 percent:	(0.9729, 1.0000)	(0.0000, 0.0271)
95 percent:	(0.9667, 1.0000)	(0.0000, 0.0333)
99 percent:	(0.9528, 1.0000)	(0.0000, 0.0472)

===

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S =	0.9965	(0.0035)	Control group survival
Pa = Pd	0.9976	(0.0024)	Recovery probability
Tau =	0.9951	(0.0090)	Spillbay 5 survival
1-Tau =	0.0049	(0.0090)	Spillbay 5 mortality

log-likelihood : -19.462945

Variance-Covariance matrix for estimated probabilities:

0.00001 0.00000 -0.00001
0.00000 0.00001 -0.00000
-0.00001 -0.00000 0.00008

Profile likelihood intervals:

	Spillbay 5 survival	Spillbay 5 mortality
90 percent:	(0.9729, 1.0000)	(0.0000, 0.0271)
95 percent:	(0.9667, 1.0000)	(0.0000, 0.0333)
99 percent:	(0.9528, 1.0000)	(0.0000, 0.0472)

===

Likelihood ratio statistic for equality of recovery probabilities: 0.002872

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Forty-eight hour survival estimates of juvenile chinook salmon smolts passed through Spillbay 5 at shallow and deep release sites and special spill at Ice Harbor Dam, April/May, 2003. Controls: 290 released, 288 alive, 1 dead. Test fish: 120 released, 118 alive, 2 dead.

RESULTS FOR FULL MODEL (UNEQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S =	0.9966	(0.0034)	Control group survival
Pa =	0.9975	(0.0025)	Live recovery probability
Pd =	1.0	N/A	Dead recovery probability*
Tau =	0.9867	(0.0122)	Spillbay 5 survival
1-Tau =	0.0133	(0.0122)	Spillbay 5 mortality

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -23.847668

Variance-Covariance matrix for estimated probabilities:
0.00001 -0.00000 -0.00001
-0.00000 0.00001 -0.00000
-0.00001 -0.00000 0.00015

Profile likelihood intervals:

	Spillbay 5 survival	Spillbay 5 mortality
90 percent:	(0.9594, 1.0000)	(0.0000, 0.0406)
95 percent:	(0.9523, 1.0000)	(0.0000, 0.0477)
99 percent:	(0.9369, 1.0000)	(0.0000, 0.0631)

===

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S =	0.9965	(0.0035)	Control group survival
Pa = Pd	0.9976	(0.0024)	Recovery probability
Tau =	0.9867	(0.0122)	Spillbay 5 survival
1-Tau =	0.0133	(0.0122)	Spillbay 5 mortality

log-likelihood : -23.851560

Variance-Covariance matrix for estimated probabilities:
0.00001 0.00000 -0.00001
0.00000 0.00001 -0.00000
-0.00001 -0.00000 0.00015

Profile likelihood intervals:

	Spillbay 5 survival	Spillbay 5 mortality
90 percent:	(0.9594, 1.0000)	(0.0000, 0.0406)
95 percent:	(0.9523, 1.0000)	(0.0000, 0.0477)
99 percent:	(0.9369, 1.0000)	(0.0000, 0.0631)

===

Likelihood ratio statistic for equality of recovery probabilities: 0.007786

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

One hour survival rates for juvenile chinook salmon released through Spillbay 5 at deep release sites at bulk and dispersed spill patterns at Ice Harbor Dam, July 2003. Controls: 125 released, 124 alive, 1 dead. Bulk spill test: 60 released, 54 alive, 5 dead. Dispersed spill test: 100 released, 96 alive, 3 dead. (Values from Table 3-2).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim. std. err.	
S1 =	0.9920 (0.0080)	Control group survival
Pa = Pd	0.9930 (0.0049)	Recovery probability
S2 =	0.9697 (0.0172)	Dispersed spill, deep release survival
S3 =	0.9153 (0.0363)	Bulk spill, deep release survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -48.3019

Tau = 0.9775 (0.0191) Dispersed spill, deep release/Control ratio
Tau = 0.9226 (0.0373) Bulk spill, deep release/Control ratio

Z statistic for the equality of equal spill pattern survivals: 1.3104

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00006349	0.00000000	0.00000000	0.00000000
0.00000000	0.00002445	0.00000000	0.00000000
0.00000000	0.00000000	0.00029682	0.00000000
0.00000000	0.00000000	0.00000000	0.00131464

Confidence intervals:

	Dispersed spill, deep release Tau	Bulk spill, deep release Tau
90 percent:	(0.9462, 1.0089)	(0.8613, 0.9840)
95 percent:	(0.9402, 1.0149)	(0.8495, 0.9957)
99 percent:	(0.9284, 1.0266)	(0.8266, 1.0187)

===

Likelihood ratio statistic for equality of recovery probabilities: 1.9254

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

One hour survival rates for juvenile chinook salmon released through Spillbay 5 at deep and shallow release sites at bulk spill patterns at Ice Harbor Dam, July 2003. Controls: 125 released, 124 alive, 1 dead. Deep release test: 60 released, 54 alive, 5 dead. Shallow release test: 119 released, 104 alive, 14 dead. (Values from Table 3-2).

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim. std. err.	
S1 =	0.9920 (0.0080)	Control group survival
Pa = Pd	0.9934 (0.0046)	Recovery probability
S2 =	0.8814 (0.0298)	Bulk spill, shallow release survival
S3 =	0.9153 (0.0363)	Bulk spill, deep release survival

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -77.9652

Tau = 0.8885 (0.0308) Bulk spill, shallow release/Control ratio
Tau = 0.9226 (0.0373) Bulk spill, deep release/Control ratio

Z statistic for the equality of equal release sites survivals: 0.7061

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00006349	0.00000000	0.00000000	0.00000000
0.00000000	0.00002150	0.00000000	0.00000000
0.00000000	0.00000000	0.00088617	0.00000000
0.00000000	0.00000000	0.00000000	0.00131464

Confidence intervals:

	Bulk spill, shallow release Tau	Bulk spill, deep release Tau
90 percent:	(0.8377, 0.9392)	(0.8613, 0.9840)
95 percent:	(0.8280, 0.9489)	(0.8495, 0.9957)
99 percent:	(0.8090, 0.9679)	(0.8266, 1.0187)

===

Likelihood ratio statistic for equality of recovery probabilities: 1.7112

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

One hour survival estimates of juvenile chinook salmon smolts passed through Spillbay 5 at shallow and deep release sites and bulk spill at Ice Harbor Dam, July, 2003. Controls: 125 released, 124 alive, 1 dead. Test fish: 179 released, 159 alive, 19 dead.

RESULTS FOR FULL MODEL (UNEQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S =	0.9920	(0.0080)	Control group survival
Pa =	1.0	N/A	Live recovery probability*
Pd =	0.9524	(0.0465)	Dead recovery probability
Tau =	0.8954	(0.0248)	Spillbay 5 survival
1-Tau =	0.1046	(0.0248)	Spillbay 5 mortality

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -72.516274

Variance-Covariance matrix for estimated probabilities:

0.00006 0.00000 -0.00006
0.00000 0.00216 0.00000
-0.00006 0.00000 0.00062

Profile likelihood intervals:

	Spillbay 5 survival	Spillbay 5 mortality
90 percent:	(0.8514, 0.9342)	(0.0658, 0.1486)
95 percent:	(0.8422, 0.9416)	(0.0584, 0.1578)
99 percent:	(0.8236, 0.9570)	(0.0430, 0.1764)

===

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S =	0.9920	(0.0080)	Control group survival
Pa = Pd	0.9967	(0.0033)	Recovery probability
Tau =	0.9005	(0.0244)	Spillbay 5 survival
1-Tau =	0.0995	(0.0244)	Spillbay 5 mortality

log-likelihood : -72.997047

Variance-Covariance matrix for estimated probabilities:

0.00006 0.00000 -0.00006
0.00000 0.00001 0.00000
-0.00006 0.00000 0.00060

Profile likelihood intervals:

	Spillbay 5 survival	Spillbay 5 mortality
90 percent:	(0.8570, 0.9387)	(0.0613, 0.1430)
95 percent:	(0.8479, 0.9460)	(0.0540, 0.1521)
99 percent:	(0.8294, 0.9614)	(0.0386, 0.1706)

===

Likelihood ratio statistic for equality of recovery probabilities: 0.961546

Compare with quantiles of the chi-squared distribution with 1 d.f.:

For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Clean fish rates for juvenile chinook salmon released through Spillbay 5 at shallow release sites at special and 100% spill patterns at Ice Harbor Dam, April and May 2003. Controls: 288 examined, 0 maladies. Special spill test: 77 examined, 1 fish with maladies. 100% spill test: 60 examined, 5 with maladies. (Values from Table 3-4.)

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	1.0	N/A	Control group without maladies*
Pa = Pd	1.0	N/A	Recovery probability*
S2 =	0.9870	(0.0129)	100% spill without maladies
S3 =	0.9167	(0.0357)	special spill without maladies

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -22.5474

Tau = 0.9870 (0.0129) 100% spill/Control ratio
Tau = 0.9167 (0.0357) special spill/Control ratio

Z statistic for the equality between spill patterns without maladies: 1.8540

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00016647	0.00000000
0.00000000	0.00000000	0.00000000	0.00127315

Confidence intervals:

	100% spill Tau	Special spill Tau
90 percent:	(0.9658, 1.0082)	(0.8580, 0.9754)
95 percent:	(0.9617, 1.0123)	(0.8467, 0.9866)
99 percent:	(0.9538, 1.0202)	(0.8248, 1.0085)

===

Likelihood ratio statistic for equality of recovery probabilities: -0.0001

Compare with quantiles of the chi-squared distribution with 1 d.f.:

For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Clean fish rates for juvenile chinook salmon released through Spillbay 5 at deep release sites at 50% and 100% spill patterns at Ice Harbor Dam, April and May 2003. Controls: 288 examined, 0 maladies. 50% spill test: 304 examined, 63 fish with maladies. 100% spill test: 147 examined, 18 with maladies. (Values from Table 3-4.)

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	1.0	N/A	Control group without maladies*
Pa = Pd	1.0	N/A	Recovery probability*
S2 =	0.7928	(0.0232)	50% spill without maladies
S3 =	0.8776	(0.0270)	100% spill without maladies

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -209.7740

Tau = 0.7928 (0.0232) 50% spill/Control ratio
Tau = 0.8776 (0.0270) 100% spill/Control ratio

Z statistic for the equality between spill patterns without maladies: 2.3779

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00054043	0.00000000
0.00000000	0.00000000	0.00000000	0.00073099

Confidence intervals:

	50% spill Tau	100% spill Tau
90 percent:	(0.7545, 0.8310)	(0.8331, 0.9220)
95 percent:	(0.7472, 0.8383)	(0.8246, 0.9305)
99 percent:	(0.7329, 0.8526)	(0.8079, 0.9472)

===

Likelihood ratio statistic for equality of recovery probabilities: -0.0001

Compare with quantiles of the chi-squared distribution with 1 d.f.:

For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Clean fish rates for juvenile chinook salmon released through Spillbay 5 at deep release sites at special and 100% spill patterns at Ice Harbor Dam, April and May 2003. Controls: 288 examined, 0 maladies. Special spill test: 60 examined, 13 fish with maladies. 100% spill test: 147 examined, 18 with maladies. (Values from Table 3-4.)

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	1.0	N/A	Control group without maladies*
Pa = Pd	1.0	N/A	Recovery probability*
S2 =	0.8776	(0.0270)	100% spill without maladies
S3 =	0.7833	(0.0532)	special spill without maladies

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -86.0105

Tau = 0.8776 (0.0270) 100% spill/Control ratio
Tau = 0.7833 (0.0532) special spill/Control ratio

Z statistic for the equality between spill patterns without maladies: 1.5792

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00073099	0.00000000
0.00000000	0.00000000	0.00000000	0.00282870

Confidence intervals:

	100% spill Tau	Special spill Tau
90 percent:	(0.8331, 0.9220)	(0.6958, 0.8708)
95 percent:	(0.8246, 0.9305)	(0.6791, 0.8876)
99 percent:	(0.8079, 0.9472)	(0.6464, 0.9203)

==

Likelihood ratio statistic for equality of recovery probabilities: -0.0002

Compare with quantiles of the chi-squared distribution with 1 d.f.:

For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Clean fish rates for juvenile chinook salmon released through Spillbay 5 at deep and shallow release sites at 100% spill patterns at Ice Harbor Dam, April and May 2003. Controls: 288 examined, 0 maladies. Shallow release test: 77 examined, 1 fish with maladies. deep release test: 147 examined, 18 with maladies. (Values from Table 3-4.)

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	1.0	N/A	Control group without maladies*
Pa = Pd	1.0	N/A	Recovery probability*
S2 =	0.8776	(0.0270)	deep release without maladies
S3 =	0.9870	(0.0129)	shallow release without maladies

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -59.9884

Tau = 0.8776 (0.0270) deep release/Control ratio
Tau = 0.9870 (0.0129) shallow release/Control ratio

Z statistic for the equality between release depths without maladies: 3.6539

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00073099	0.00000000
0.00000000	0.00000000	0.00000000	0.00016647

Confidence intervals:

	Deep release Tau	Shallow release Tau
90 percent:	(0.8331, 0.9220)	(0.9658, 1.0082)
95 percent:	(0.8246, 0.9305)	(0.9617, 1.0123)
99 percent:	(0.8079, 0.9472)	(0.9538, 1.0202)

===

Likelihood ratio statistic for equality of recovery probabilities: -0.0002

Compare with quantiles of the chi-squared distribution with 1 d.f.:

For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Clean fish rates for juvenile chinook salmon released through Spillbay 5 at deep and shallow release sites at special spill patterns at Ice Harbor Dam, April and May 2003. Controls: 288 examined, 0 maladies. Shallow release test: 60 examined, 5 fish with maladies. deep release test: 60 examined, 13 with maladies. (Values from Table 3-4.)

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

```
        estim.  std. err.
S1 =     1.0     N/A       Control group without maladies*
Pa = Pd  1.0     N/A       Recovery probability*
S2 =     0.7833 (0.0532)   deep release without maladies
S3 =     0.9167 (0.0357)   shallow release without maladies
```

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -48.5696

Tau = 0.7833 (0.0532) deep release/Control ratio
Tau = 0.9167 (0.0357) shallow release/Control ratio

Z statistic for the equality between release depths without maladies: 2.0818

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00282870	0.00000000
0.00000000	0.00000000	0.00000000	0.00127315

Confidence intervals:

	Deep release Tau	Shallow release Tau
90 percent:	(0.6958, 0.8708)	(0.8580, 0.9754)
95 percent:	(0.6791, 0.8876)	(0.8467, 0.9866)
99 percent:	(0.6464, 0.9203)	(0.8248, 1.0085)

==

Likelihood ratio statistic for equality of recovery probabilities: -0.0001

Compare with quantiles of the chi-squared distribution with 1 d.f.:

For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Clean fish rates for juvenile chinook salmon released through Spillbay 5 at deep release sites at bulk and dispersed spill patterns at Ice Harbor Dam, July 2003. Controls: 124 examined, 2 maladies. Dispersed spill test: 97 examined, 21 fish with maladies. Bulk spill test: 55 examined, 11 with maladies. (Values from Table 3-5.)

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	0.9839	(0.0113)	{Control group without maladies
Pa = Pd	1.0	N/A	Recovery probability*
S2 =	0.8000	(0.0539)	bulk spill without maladies
S3 =	0.7835	(0.0418)	dispersed spill without maladies

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -88.4364

Tau = 0.8131 (0.0556) bulk spill/Control ratio
Tau = 0.7963 (0.0435) dispersed spill/Control ratio

Z statistic for the equality between release depths without maladies: 0.2375

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00012797	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00290909	0.00000000
0.00000000	0.00000000	0.00000000	0.00174871

Confidence intervals:

	Bulk spill Tau	Dispersed spill Tau
90 percent:	(0.7216, 0.9046)	(0.7248, 0.8679)
95 percent:	(0.7041, 0.9221)	(0.7111, 0.8816)
99 percent:	(0.6699, 0.9563)	(0.6844, 0.9083)

==

Likelihood ratio statistic for equality of recovery probabilities: 0.0000

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

Appendix C

Clean fish rates for juvenile chinook salmon released through Spillbay 5 at deep and shallow release sites at bulk spill patterns at Ice Harbor Dam, July 2003. Controls: 124 examined, 2 maladies. shallow release test: 108 examined, 7 fish with maladies. deep release test: 55 examined, 11 with maladies. (Values from Table 3-5.)

RESULTS FOR REDUCED MODEL (EQUAL LIVE/DEAD RECOVERY)

	estim.	std. err.	
S1 =	0.9839	(0.0113)	Control group without maladies
Pa = Pd	1.0	N/A	Recovery probability*
S2 =	0.9352	(0.0237)	shallow release without maladies
S3 =	0.8000	(0.0539)	deep release without maladies

* -- Because of constraints in the data set, this probability is assumed equal to 1.0; not estimated.

log-likelihood : -63.6818

Tau = 0.9505 (0.0264) shallow release/Control ratio
Tau = 0.8131 (0.0556) deep release/Control ratio

Z statistic for the equality between release depths without maladies: 2.2313

Compare with quantiles of the normal distribution:

	1-tailed	2-tailed
For significance level 0.10:	1.2816	1.6449
For significance level 0.05:	1.6449	1.9600
For significance level 0.01:	2.3263	2.5758

Variance-Covariance matrix for estimated probabilities:

0.00012797	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00000000	0.00000000
0.00000000	0.00000000	0.00056124	0.00000000
0.00000000	0.00000000	0.00000000	0.00290909

Confidence intervals:

	Shallow release Tau	Deep release Tau
90 percent:	(0.9070, 0.9940)	(0.7216, 0.9046)
95 percent:	(0.8987, 1.0023)	(0.7041, 0.9221)
99 percent:	(0.8824, 1.0186)	(0.6699, 0.9563)

===

Likelihood ratio statistic for equality of recovery probabilities: -0.0001

Compare with quantiles of the chi-squared distribution with 1 d.f.:
For significance level 0.10: 2.706
For significance level 0.05: 3.841
For significance level 0.01: 6.635

APPENDIX D

DAILY FISH DISPOSITION DATA

APPENDIX TABLE D-1

Short-term turbine passage survival data on individual chinook salmon released at Spillbay 5 at the Ice Harbor Dam, April-May 2003. Fish were tagged with Normandeau's HI-Z Turb-N tags. Description of condition codes and details on injured fish are presented in Table 2-7.

Fish No.	Time: Re-leased	Time: Re-covered	Time: At Large (min.)	No. of Turb-N Tags Recovered	Fish Data: Alive/ Dead	Fish Data: Condition Codes	Fish Data: Total Length (mm)	Fish Data: Comments
23 April 2003 - Testlot 1 : 50%, shallow - Water temp=50.5 F								
UF0	17:06	17:11	5	2	ALIVE	A	144	
UF1	17:06	17:12	6	2	ALIVE	A	127	
UF2	17:07	17:13	6	2	ALIVE	A	138	
UF3	17:06	17:16	10	2	ALIVE	W	156	
UF4	17:08	17:13	5	2	ALIVE	A	130	
UF5	16:47	16:52	5	2	ALIVE	A	143	
UF6	16:44	16:56	12	2	ALIVE	A	134	
UF7	16:44	16:49	5	2	ALIVE	A	134	
UF8	16:47	16:51	4	2	ALIVE	A	140	
UF9	16:46	16:50	4	2	ALIVE	A	134	
UH0	18:12	18:25	13	2	ALIVE	A	148	
UH1	18:13	18:19	6	2	ALIVE	G	151	
UH2	18:13	18:20	7	2	ALIVE	A	124	
UH3	18:10	18:17	7	2	ALIVE	GH	142	
UH4	18:11	18:16	5	2	ALIVE	A	139	
UH5	18:15	18:22	7	2	ALIVE	A	139	
UH6	18:14	18:27	13	2	ALIVE	A	136	
UH7	18:16	18:25	9	2	ALIVE	A	135	
UH8	18:14	18:21	7	2	ALIVE	A	124	
UH9	18:15	18:27	12	2	ALIVE	A	135	
UJ0	18:35	18:41	6	2	ALIVE	A	139	
UJ1	18:35	18:43	8	2	ALIVE	A	140	
UJ2	18:36	18:51	15	2	ALIVE	A	137	
UJ3	18:34	18:39	5	2	ALIVE	G	134	
UJ4	18:36	18:40	4	2	ALIVE	A	141	
UJ5	18:38	18:45	7	2	ALIVE	A	137	
UJ6	18:38	18:44	6	2	ALIVE	A	137	
UJ7	18:39	18:44	5	2	ALIVE	A	136	
UJ8	18:37	18:48	11	2	ALIVE	A	140	
UJ9	18:39	18:45	6	2	ALIVE	A	139	
UK0	19:03	19:11	8	2	ALIVE	A	136	
UK1	19:04	19:13	9	2	ALIVE	A	143	
UK2	19:02	19:08	6	2	ALIVE	A	142	
UK3	19:04	19:10	6	2	ALIVE	A	138	
UK5	19:06	19:11	5	2	ALIVE	A	131	
UK6	19:07	19:13	6	2	ALIVE	A	134	
UK7	20:00	20:07	7	2	ALIVE	C	136	
UK8	19:05	19:12	7	2	ALIVE	A	131	
UK9	19:05	19:12	7	2	ALIVE	A	127	
UL0	19:33	19:40	7	2	ALIVE	A	166	
UL1	19:31	19:37	6	2	ALIVE	A	148	
UL2	19:31	19:37	6	2	ALIVE		135	
UL3	19:32	19:39	7	2	ALIVE	A	135	
UL4	19:32	19:38	6	2	ALIVE	A	143	
UL5	19:34	19:43	9	2	ALIVE	A	144	
UL6	19:36	19:46	10	2	ALIVE	A	134	
UL7	19:33	19:39	6	2	ALIVE	A	131	
UL8	19:35	19:43	8	2	ALIVE	A	132	
UL9	19:34	19:42	8	2	ALIVE	GC	133	
WM0	19:58	20:04	6	2	ALIVE	A	139	
WM1	19:56	20:03	7	2	ALIVE	A	138	
WM2	19:57	20:04	7	2	ALIVE	A	139	
WM3	19:59	20:06	7	2	ALIVE	A	149	
WM4	19:57	20:04	7	2	ALIVE	A	139	
WM5	20:01	20:09	8	2	ALIVE	A	136	
WM7	20:02	20:10	8	1	ALIVE	A	144	
WM8	20:02	20:12	10	2	ALIVE	A	143	
WM9	20:00	20:09	9	2	ALIVE	A	138	
24 April 2003 - Testlot 2 : 100%, deep - Water temp=50.0 F								
EM0	19:21	19:44	23	2	ALIVE	A	137	
EM1	19:22	19:29	7	2	ALIVE	A	143	
EM2	19:20	19:27	7	2	ALIVE	A	132	
EM3	19:22	19:27	5	2	ALIVE	A	137	

APPENDIX TABLE D-1

Continued.

Fish No.	Time			No. of Turb-N Tags Recovered	Fish Data			
	Re-leased	Re-covered	At Large (min.)		Alive/ Dead	Condition Codes	Total Length (mm)	Comments
EM5	19:24	19:36	12	2	ALIVE	A	146	
EM7	19:23	19:31	8	2	ALIVE	H	142	
EM8	19:25	19:35	10	2	ALIVE	A	134	
EM9	19:25	19:33	8	2	ALIVE	A	142	
EN0	19:55	20:00	5	2	ALIVE	A	148	
EN1	19:54	20:01	7	2	ALIVE	A	137	
EN2	19:56	20:03	7	2	ALIVE	A	132	
EN3	19:55	20:02	7	2	ALIVE	GD	140	
EN4	19:53	19:59	6	2	ALIVE	A	128	
EN5	19:56	20:12	16	2	ALIVE	A	141	
EN6	19:58	20:05	7	2	ALIVE	A	124	
EN7	19:57	20:04	7	2	ALIVE	A	150	
EN8	19:57	20:04	7	2	ALIVE	A	145	
EN9	19:59	20:05	6	2	ALIVE	A	132	
EP0	20:18	20:47	29	2	ALIVE	A	130	
EP1	20:16	20:27	11	2	ALIVE	H	135	
EP2	20:19	20:20	1	2	ALIVE	GEW	138	
EP3	20:16	20:39	23	2	ALIVE	GW	160	
EP4	20:17	20:23	6	2	ALIVE	A	161	
EP5	20:21	20:32	11	2	ALIVE	A	141	
EP6	20:22	20:38	16	2	ALIVE	A	142	
EP7	20:19	20:30	11	1	ALIVE	A	130	
EP8	20:22	20:29	7	2	ALIVE	A	137	
EP9	20:20	20:37	17	2	ALIVE	A	151	
HE3	17:12	17:23	11	2	ALIVE	A	140	
HE4	19:26	19:34	8	2	ALIVE	A	139	
WN0	15:49	15:58	9	2	ALIVE	A	129	
WN1	15:49	15:58	9	2	ALIVE	A	143	
WN2	15:48	15:56	8	2	ALIVE	A	137	
WN3	15:50	15:57	7	2	ALIVE	A	144	
WN4	15:46	15:55	9	2	ALIVE	A	132	
WN5	15:53	16:03	10	2	ALIVE	A	139	
WN6	15:55	16:02	7	2	ALIVE	A	146	
WN7	15:53	16:02	9	2	ALIVE	A	131	
WN8	15:52	16:04	12	2	ALIVE	A	169	
WN9	15:54	16:04	10	2	ALIVE	A	133	
WP0	16:25	16:32	7	2	ALIVE	A	145	
WP1	16:24	16:36	12	2	ALIVE	A	144	
WP2	16:25	16:37	12	2	ALIVE	A	135	
WP3	16:23	16:32	9	2	ALIVE	A	167	
WP4	16:22	16:33	11	2	ALIVE	A	130	
WP5	16:27	16:35	8	2	ALIVE	A	124	
WP6	16:28	16:38	10	2	ALIVE	A	144	
WP7	16:27	16:34	7	2	ALIVE	A	136	
WP8	16:28	16:40	12	2	ALIVE	A	143	
WP9	16:26	16:38	12	2	ALIVE	A	126	
WR0	17:15	17:27	12	2	ALIVE	A	126	
WR1	17:16	17:23	7	2	ALIVE	A	137	
WR2	17:16	17:25	9	2	ALIVE	A	135	
WR3	17:17	17:28	11	2	ALIVE	A	141	
WR4	17:15	17:22	7	2	ALIVE	A	138	
WR5	17:14	17:23	9	2	ALIVE	A	135	
WR6	17:13	17:19	6	2	ALIVE	A	138	
WR7	17:14	17:23	9	2	ALIVE	A	137	
WR9	17:13	17:23	10	2	ALIVE	A	135	
WS0	18:19	18:25	6	2	ALIVE	A	140	
WS1	18:21	18:33	12	2	ALIVE	A	142	
WS2	18:20	18:27	7	2	ALIVE	A	163	
WS3	18:26	18:32	6	2	ALIVE	A	145	
WS4	18:21	18:29	8	2	ALIVE	A	135	
WS5	18:24	18:31	7	2	ALIVE	A	156	
WS6	18:24	18:29	5	2	ALIVE	A	138	
WS7	18:22	18:29	7	2	ALIVE	A	135	
WS8	18:23	18:35	12	2	ALIVE	A	144	
WS9	18:23	18:28	5	2	ALIVE	A	133	
WT0	18:41	18:47	6	2	ALIVE	A	145	
WT1	18:41	18:46	5	2	ALIVE	A	128	
WT2	18:44	18:49	5	2	ALIVE	A	147	
WT4	18:42	18:48	6	2	ALIVE	A	135	
WT5	18:45	18:57	12	2	ALIVE	A	138	

APPENDIX TABLE D-1

Continued.

Fish No.	Time Re-leased	Re-covered	At Large (min.)	No. of Turb-N Tags Recovered	Fish Data Alive/Dead	Condition Codes	Total Length (mm)	Comments
WT6	18:44	18:52	8	2	ALIVE	A	140	
WT7	18:46	18:52	6	2	ALIVE	A	135	
WT8	18:46	18:53	7	2	ALIVE	A	140	
WT9	18:47	18:55	8	2	ALIVE	A	126	
25 April 2003 - Testlot 3 : Control - Water temp=51.8 F								
ER0	15:44	15:53	9	2	ALIVE	A	130	
ER1	15:47	15:54	7	2	ALIVE	A	148	
ER2	15:45	15:53	8	2	ALIVE	A	142	
ER3	15:46	15:56	10	2	ALIVE	A	138	
ER4	15:46	16:00	14	2	ALIVE	A	140	
ER5	15:48	15:56	8	2	ALIVE	A	130	
ER6	15:48	15:57	9	2	ALIVE	A	137	
ER7	15:47	15:57	10	2	ALIVE	A	168	
ER8	15:49	15:58	9	2	ALIVE	A	132	
ER9	15:49	15:56	7	2	ALIVE	A	143	
ES0	16:12	16:18	6	2	ALIVE	A	146	
ES1	16:13	16:17	4	2	ALIVE	A	144	
ES2	16:11	16:18	7	2	ALIVE	A	140	
ES3	16:12	16:18	6	2	ALIVE	A	149	
ES4	16:13	16:20	7	2	ALIVE	A	150	
ES5	16:14	16:19	5	2	ALIVE	A	140	
ES6	16:16	16:22	6	2	ALIVE	A	142	
ES7	16:15	16:22	7	2	ALIVE	A	130	
ES8	16:14	16:22	8	2	ALIVE	A	129	
ES9	16:16	16:19	3	2	ALIVE	A	133	
ET0	16:43	16:51	8	2	ALIVE	A	133	
ET1	16:45	16:58	13	2	ALIVE	A	127	
ET2	16:43	16:59	16	2	ALIVE	A	144	
ET3	16:44	16:59	15	2	ALIVE	A	153	
ET4	16:44	17:00	16	2	ALIVE	A	136	
ET5	16:47	16:52	5	2	ALIVE	A	133	
ET6	16:45	17:00	15	2	ALIVE	A	142	
ET7	16:47	16:56	9	2	ALIVE	A	147	
ET8	16:46	16:51	5	2	ALIVE	A	137	
ET9	16:46	16:51	5	2	ALIVE	A	138	
EU0	17:14	17:22	8	2	ALIVE	A	155	
EU1	17:13	17:18	5	2	ALIVE	A	129	
EU2	17:12	17:18	6	2	ALIVE	A	143	
EU3	17:11	17:17	6	2	ALIVE	A	144	
EU4	17:12	17:17	5	2	ALIVE	A	135	
EU5	17:15	17:19	4	2	ALIVE	A	137	
EU6	17:16	17:23	7	2	ALIVE	A	134	
EU7	17:15	17:21	6	2	ALIVE	A	155	
EU8	17:16	17:25	9	2	ALIVE	A	153	
EU9	17:14	17:20	6	2	ALIVE	A	130	
EV0	18:17	18:24	7	2	ALIVE	A	155	
EV1	18:16	18:21	5	2	ALIVE	A	146	
EV2	18:16	18:24	8	2	ALIVE	A	128	
EV3	18:15	18:32	17	2	ALIVE	A	134	
EV4	18:15	18:22	7	2	ALIVE	H	135	
EV5	18:19	18:25	6	2	ALIVE	A	141	
EV6	18:18	18:25	7	2	ALIVE	A	146	
EV7	18:17	18:22	5	2	ALIVE	A	132	
EV8	18:18	18:23	5	2	ALIVE	A	138	
EV9	18:19	18:27	8	2	ALIVE	A	137	
EW0	18:37	18:43	6	2	ALIVE	A	143	
EW1	18:38	18:43	5	2	ALIVE	A	161	
EW2	18:37	18:41	4	2	ALIVE	A	137	
EW3	18:37	18:46	9	2	ALIVE	A	143	
EW4	18:36	18:41	5	2	ALIVE	A	159	
EW5	18:39	18:44	5	2	ALIVE	GC	146	
EW6	18:41	18:49	8	2	ALIVE	A	146	
EW7	18:38	18:44	6	2	ALIVE	A	140	
EW8	18:39	18:47	8	2	ALIVE	A	137	
EW9	18:40	18:45	5	2	ALIVE	A	138	
EX0	18:52	19:06	14	2	ALIVE	A	133	
EX1	18:54	19:00	6	2	ALIVE	A	141	

APPENDIX TABLE D-1

Continued.

Fish No.	Time Re-leased	Re-covered	At Large (min.)	No. of Turb-N Tags Recovered	Fish Data Alive/Dead	Condition Codes	Total Length (mm)	Comments
EX2	18:53	19:03	10	2	ALIVE	A	140	
EX3	18:53	18:59	6	2	ALIVE	A	146	
EX4	18:54	19:00	6	2	ALIVE	A	155	
EX5	18:57	19:03	6	2	ALIVE	A	136	
EX6	18:55	19:02	7	2	ALIVE	A	135	
EX7	18:55	19:11	16	2	ALIVE	A	134	
EX8	18:56	19:04	8	2	ALIVE	A	127	
EX9	18:56	19:02	6	2	ALIVE	A	142	
EY0	19:14	19:21	7	2	ALIVE	A	138	
EY1	19:14	19:21	7	2	ALIVE	A	144	
EY2	19:12	19:18	6	2	ALIVE	A	140	
EY3	19:13	19:18	5	2	ALIVE	A	140	
EY4	19:14	19:22	8	2	ALIVE	A	147	
EY5	19:15	19:21	6	2	ALIVE	A	123	
EY6	19:17	19:28	11	2	ALIVE	A	133	
EY7	19:16	19:21	5	2	ALIVE	A	136	
EY8	19:14	19:23	9	2	ALIVE	A	137	
EY9	19:16	19:22	6	2	ALIVE	A	136	
EZ0	19:29	19:36	7	2	ALIVE	A	143	
EZ1	19:30	19:35	5	2	ALIVE	A	135	
EZ2	19:28	19:34	6	2	ALIVE	A	146	
EZ3	19:30	19:36	6	2	ALIVE	A	147	
EZ4	19:29	19:41	12	2	ALIVE	A	135	
EZ5	19:32	19:44	12	2	DEAD	JH	133	
EZ6	19:32	19:38	6	2	ALIVE	A	135	
EZ7	19:31	19:37	6	2	ALIVE	A	143	
EZ8	19:31	19:38	7	2	ALIVE	A	142	
EZ9	19:33	19:39	6	2	ALIVE	A	125	
26 April 2003 - Testlot 4 : 50%, deep - Water temp=50.0 F								
FM0	13:38	13:42	4	2	ALIVE	A	151	
FM1	13:40	13:49	9	2	ALIVE	A	144	
FM2	13:38	13:43	5	2	ALIVE	A	137	
FM3	13:40	13:51	11	2	ALIVE	A	143	
FM4	13:37	13:48	11	2	ALIVE	N	133	
FM5	13:41	13:47	6	2	ALIVE	A	126	
FM6	13:41	13:45	4	2	ALIVE	A	145	
FM7	13:41	13:48	7	2	ALIVE	A	141	
FM8	13:42	13:46	4	2	ALIVE	A	137	
FM9	13:42	13:48	6	2	ALIVE	E	148	
FN0	14:15	14:21	6	2	ALIVE	A	140	
FN1	14:17	14:25	8	2	ALIVE	A	140	
FN2	14:15	14:19	4	2	ALIVE	GH	143	
FN3	14:16	14:23	7	2	ALIVE	A	147	
FN4	14:15	14:23	8	2	ALIVE	A	160	
FN5	14:19	14:25	6	2	ALIVE	A	136	
FN6	14:19	14:28	9	2	ALIVE	A	132	
FN7	14:19	14:24	5	2	ALIVE	E	131	
FN8	14:17	.	.	0	TAG & PIN		132	
FN9	14:18	14:26	8	2	ALIVE	A	138	
FP0	14:40	14:44	4	2	ALIVE	A	142	
FP1	14:41	14:47	6	2	ALIVE	A	147	
FP2	14:41	14:48	7	2	ALIVE	A	138	
FP3	14:42	14:47	5	2	ALIVE	A	172	
FP4	14:40	14:45	5	2	ALIVE	A	143	
FP5	14:42	14:47	5	2	ALIVE	G	138	
FP6	14:44	14:50	6	2	ALIVE	A	147	
FP7	14:45	14:52	7	2	ALIVE	G	139	
FP8	14:43	14:51	8	1	ALIVE	A	151	
FP9	14:45	14:51	6	2	ALIVE	G	181	
FR0	15:10	15:26	16	2	ALIVE	C	137	
FR1	15:13	15:19	6	2	ALIVE	A	128	
FR2	15:12	15:18	6	2	ALIVE	A	137	
FR3	15:14	15:18	4	2	ALIVE	A	144	
FR4	15:11	15:15	4	2	ALIVE	A	142	
FR5	15:09	15:16	7	2	ALIVE	A	152	
FR6	15:08	15:13	5	2	ALIVE	A	136	
FR7	15:08	15:12	4	2	ALIVE	A	134	

APPENDIX TABLE D-1

Continued.

Fish No.	Time Re-leased	Re-covered	At Large (min.)	No. of Turb-N Tags Recovered	Fish Data Alive/ Dead	Condition Codes	Total Length (mm)	Comments
FR8	15:09	15:13	4	2	ALIVE	A	148	
FR9	15:10	15:16	6	2	ALIVE	A	148	
HE5	8:48	8:54	6	2	ALIVE	GH	127	
HE6	10:41	10:48	7	2	ALIVE	A	139	
HF0	11:02	11:09	7	2	ALIVE	A	147	
HF1	11:03	11:10	7	2	ALIVE	A	141	
HF2	11:02	11:07	5	2	ALIVE	A	133	
HF3	11:03	11:09	6	2	ALIVE	A	137	
HF4	11:04	11:11	7	2	ALIVE	A	150	
HF5	11:06	.	.	0	DEAD	Z	133	
HF6	11:05	11:13	8	2	ALIVE	A	136	
HF7	11:06	11:15	9	2	ALIVE	A	139	
HF8	11:07	11:16	9	2	ALIVE	A	140	
HF9	11:05	11:11	6	2	ALIVE	A	132	
HH0	11:38	11:46	8	2	ALIVE	A	148	
HH1	11:37	11:43	6	2	ALIVE	A	134	
HH2	11:37	11:46	9	2	ALIVE	A	140	
HH3	11:36	11:43	7	2	ALIVE	A	155	
HH4	11:36	11:43	7	2	ALIVE	A	137	
HH5	11:40	11:47	7	2	ALIVE	A	137	
HH6	11:39	11:45	6	2	ALIVE	A	138	
HH7	11:40	11:47	7	2	ALIVE	A	135	
HH8	11:41	11:48	7	2	ALIVE	A	140	
HH9	11:39	11:48	9	2	ALIVE	A	151	
HJ0	12:17	12:34	17	2	ALIVE	A	134	
HJ1	12:17	12:24	7	2	ALIVE	A	151	
HJ2	12:18	12:25	7	2	ALIVE	A	144	
HJ3	12:16	12:22	6	2	ALIVE	A	121	
HJ4	12:16	12:22	6	2	ALIVE	A	132	
HJ5	12:19	12:25	6	2	ALIVE	A	150	
HJ6	12:19	12:29	10	2	ALIVE	A	126	
HJ7	12:20	12:27	7	2	ALIVE	A	130	
HJ8	12:18	12:25	7	2	ALIVE	A	131	
HJ9	12:21	12:26	5	2	ALIVE	A	133	
HK0	12:44	12:56	12	2	ALIVE	A	136	
HK1	12:45	12:50	5	2	ALIVE	A	146	
HK2	12:43	12:49	6	2	ALIVE	A	143	
HK3	12:43	12:46	3	2	ALIVE	A	162	
HK4	12:44	12:47	3	2	ALIVE	A	157	
HK5	12:46	12:50	4	2	ALIVE	A	135	
HK6	12:48	12:56	8	2	ALIVE	A	153	
HK7	12:47	12:55	8	2	ALIVE	A	132	
HK8	12:46	12:51	5	2	ALIVE	A	147	
HK9	12:45	12:49	4	2	ALIVE	A	149	
HL0	13:15	13:20	5	2	ALIVE	A	143	
HL1	13:17	13:21	4	2	DEAD	JH	128	
HL2	13:16	13:32	16	2	ALIVE	A	131	
HL3	13:16	13:20	4	2	ALIVE	C	147	
HL4	13:17	13:28	11	2	ALIVE	A	137	
HL5	13:38	13:42	4	2	ALIVE	A	146	
HL6	13:20	13:27	7	2	ALIVE	A	142	
HL7	13:19	13:22	3	2	ALIVE	A	168	
HL8	13:21	13:24	3	2	ALIVE	A	149	
HL9	13:20	13:24	4	2	ALIVE	A	140	
WU0	8:45	8:52	7	2	ALIVE	EH	146	
WU1	8:44	8:50	6	2	ALIVE	A	151	
WU2	8:44	8:50	6	2	ALIVE	A	152	
WU4	8:46	8:52	6	2	ALIVE	G	124	
WU5	8:45	8:54	9	2	ALIVE	A	130	
WU6	8:46	8:59	13	2	ALIVE	GW	137	
WU7	8:47	8:52	5	2	ALIVE	A	140	
WU8	8:46	8:57	11	2	ALIVE	A	138	
WU9	8:48	8:56	8	2	ALIVE	A	156	
WV0	9:04	9:24	20	2	ALIVE	A	151	
WV1	9:05	9:13	8	2	ALIVE	A	140	
WV2	9:05	9:10	5	2	ALIVE	A	135	
WV3	9:03	9:19	16	2	ALIVE	A	139	
WV4	9:04	9:09	5	2	ALIVE	A	135	
WV5	9:06	9:11	5	2	ALIVE	A	125	
WV6	9:07	9:13	6	2	ALIVE	A	141	

Continued.

Fish No.	Time: Re-leased	Time: Re-covered	Time: At Large (min.)	No. of Turb-N Tags Recovered	Fish Data: Alive/ Dead	Condition Codes	Total Length (mm)	Comments
WV7	9:08	9:12	4	2	ALIVE	H	142	
WV8	9:08	9:13	5	2	ALIVE	A	135	
WV9	9:07	9:18	11	2	ALIVE	A	145	
WW0	9:30	9:33	3	2	ALIVE	A	146	
WW1	9:29	9:34	5	2	ALIVE	A	135	
WW2	9:29	9:34	5	2	ALIVE	A	137	
WW3	9:30	9:37	7	2	ALIVE	G	163	
WW4	9:31	9:36	5	2	DEAD	JNH	133	
WW5	9:31	9:39	8	2	ALIVE	A	133	
WW6	9:33	9:41	8	2	ALIVE	A	138	
WW7	9:33	9:40	7	2	ALIVE	C	141	
WW8	9:32	9:37	5	2	ALIVE	A	136	
WW9	10:09	10:19	10	2	ALIVE	A	132	
WX0	9:49	9:56	7	2	ALIVE	A	134	
WX1	9:48	10:00	12	2	ALIVE	A	127	
WX2	9:47	9:52	5	2	ALIVE	A	149	
WX3	9:48	9:54	6	2	ALIVE	A	156	
WX4	9:46	9:59	13	2	ALIVE	A	135	
WX5	9:50	9:58	8	2	ALIVE	A	143	
WX6	9:50	9:54	4	2	ALIVE	A	145	
WX7	9:49	9:58	9	2	ALIVE	A	136	
WX8	9:51	9:55	4	2	ALIVE	GD	126	
WX9	10:11	10:17	6	2	ALIVE	GH	141	
WY0	10:07	10:12	5	2	ALIVE	A	142	
WY1	10:06	10:13	7	2	ALIVE	A	140	
WY2	10:06	10:14	8	2	ALIVE	A	140	
WY3	10:06	10:11	5	2	ALIVE	A	136	
WY4	10:08	10:13	5	2	ALIVE	A	133	
WY5	9:31	9:37	6	2	ALIVE	A	136	
WY6	10:10	10:14	4	2	ALIVE	A	134	
WY7	10:08	10:14	6	2	ALIVE	A	135	
WY8	10:10	10:17	7	2	ALIVE	A	136	
WY9	10:09	10:18	9	2	ALIVE	A	146	
WZ0	10:39	10:46	7	2	ALIVE	A	138	
WZ1	10:39	10:45	6	2	ALIVE	A	152	
WZ2	10:38	10:46	8	2	ALIVE	A	142	
WZ3	10:37	10:44	7	2	ALIVE	A	138	
WZ4	10:38	10:40	2	2	ALIVE	A	144	
WZ5	10:42	10:47	5	2	ALIVE	A	132	
WZ7	10:42	10:51	9	2	ALIVE	A	145	
WZ8	10:39	10:46	7	2	ALIVE	A	134	
WZ9	10:41	10:48	7	2	ALIVE	A	137	
28 April 2003 - Testlot 5 : Control - Water temp=50.9 F								
FS0	16:05	16:15	10	2	ALIVE	A	141	
FS1	16:05	16:16	11	2	ALIVE	A	137	
FS2	16:04	16:09	5	2	ALIVE	A	125	
FS3	16:04	16:10	6	2	ALIVE	A	147	
FS4	16:04	16:14	10	2	ALIVE	A	145	
FS5	16:07	16:11	4	2	ALIVE	A	120	
FS6	16:06	16:14	8	2	ALIVE	A	133	
FS7	16:07	16:12	5	2	ALIVE	A	150	
FS8	16:08	16:15	7	2	ALIVE	A	152	
FS9	16:08	16:18	10	2	ALIVE	A	138	
FT0	16:21	16:29	8	2	ALIVE	A	134	
FT1	16:19	16:24	5	2	ALIVE	A	140	
FT2	16:19	16:33	14	2	ALIVE	A	138	
FT3	16:20	16:28	8	2	ALIVE	A	135	
FT4	16:20	16:25	5	2	ALIVE	A	144	
FT5	16:21	16:27	6	2	ALIVE	A	152	
FT6	16:22	16:25	3	2	ALIVE	A	133	
FT7	16:23	.	.	0	UNKNOWN	X	132	
FT8	16:22	16:36	14	2	ALIVE	A	138	
FT9	16:23	16:28	5	2	ALIVE	A	145	
FU0	17:11	17:19	8	2	ALIVE	A	140	
FU1	17:13	17:21	8	2	ALIVE	A	142	
FU2	17:10	17:18	8	2	ALIVE	A	126	
FU3	17:11	17:17	6	2	ALIVE	A	130	

APPENDIX TABLE D-1

Continued.

Fish No.	Time Re-leased	Re-covered	At Large (min.)	No. of Turb-N Tags Recovered	Fish Data Alive/Dead	Condition Codes	Total Length (mm)	Comments
FU4	17:12	17:18	6	2	ALIVE	A	137	
FU5	17:13	17:23	10	2	ALIVE	A	133	
FU6	17:14	17:21	7	2	ALIVE	A	152	
FU7	17:14	17:23	9	2	ALIVE	A	139	
FU8	17:15	17:23	8	2	ALIVE	A	145	
FU9	17:16	17:23	7	2	ALIVE	A	172	
FV0	19:00	19:03	3	2	ALIVE	A	133	
FV1	18:59	19:10	11	2	ALIVE	A	140	
FV2	18:58	19:01	3	2	ALIVE	A	146	
FV3	18:59	19:02	3	2	ALIVE	A	134	
FV4	19:00	19:05	5	2	ALIVE	A	145	
FV5	19:02	19:08	6	2	ALIVE	A	145	
FV6	19:00	19:05	5	2	ALIVE	A	142	
FV7	19:01	19:06	5	2	ALIVE	A	129	
FV8	19:01	19:07	6	2	ALIVE	A	143	
FV9	19:02	19:07	5	2	ALIVE	A	146	
FW0	19:16	19:21	5	2	ALIVE	A	143	
FW1	19:18	19:22	4	2	ALIVE	A	140	
FW2	19:18	19:26	8	2	ALIVE	A	135	
FW3	19:17	19:21	4	2	ALIVE	A	140	
FW4	19:19	19:23	4	2	ALIVE	A	140	
FW5	19:21	19:26	5	2	ALIVE	A	139	
FW6	19:20	19:26	6	2	ALIVE	A	135	
FW7	19:20	19:23	3	2	ALIVE	A	145	
FW8	19:22	19:30	8	2	ALIVE	A	155	
FW9	19:19	19:24	5	2	ALIVE	A	140	
29 April 2003 - Testlot 6 : Control - Water temp=50.9 F								
FX0	14:56	15:06	10	2	ALIVE	A	147	
FX1	14:56	15:04	8	2	ALIVE	A	149	
FX2	14:47	15:04	17	2	ALIVE	A	134	
FX3	14:58	15:04	6	2	ALIVE	A	147	
FX4	14:59	15:06	7	2	ALIVE	A	153	
FX5	14:59	15:04	5	2	ALIVE	A	142	
FX6	14:58	15:07	9	2	ALIVE	A	147	
FX7	15:00	15:07	7	2	ALIVE	A	130	
FX8	14:59	15:04	5	2	ALIVE	A	144	
FX9	15:00	15:06	6	2	ALIVE	A	142	
FY0	15:10	15:18	8	2	ALIVE	A	143	
FY1	15:09	15:16	7	2	ALIVE	A	137	
FY2	15:11	15:20	9	2	ALIVE	A	134	
FY3	15:10	15:16	6	2	ALIVE	A	132	
FY4	15:09	15:17	8	2	ALIVE	A	137	
FY5	15:11	15:19	8	2	ALIVE	A	129	
FY6	15:12	15:19	7	2	ALIVE	A	133	
FY7	15:12	15:19	7	2	ALIVE	A	135	
FY8	15:13	15:19	6	2	ALIVE	A	141	
FY9	15:13	15:19	6	2	ALIVE	A	142	
FZ0	15:46	15:53	7	2	ALIVE	A	150	
FZ1	15:44	16:03	19	2	ALIVE	A	144	
FZ2	15:45	15:52	7	2	ALIVE	A	140	
FZ3	15:44	15:51	7	2	ALIVE	A	150	
FZ4	15:45	15:52	7	2	ALIVE	A	137	
FZ5	15:48	15:54	6	2	ALIVE	A	133	
FZ6	15:47	16:01	14	2	ALIVE	A	140	
FZ7	15:46	15:56	10	2	ALIVE	A	142	
FZ8	15:49	15:54	5	2	ALIVE	A	147	
HE7	15:47	15:51	4	2	ALIVE	A	149	
HM0	16:14	16:21	7	2	ALIVE	A	127	
HM1	16:13	16:19	6	2	ALIVE	A	157	
HM2	16:15	16:21	6	2	ALIVE	A	147	
HM3	16:15	16:20	5	2	ALIVE	A	152	
HM4	16:14	16:20	6	2	ALIVE	A	133	
HM5	16:16	16:21	5	2	ALIVE	A	151	
HM6	16:17	16:23	6	2	ALIVE	A	128	
HM7	16:17	16:21	4	2	ALIVE	A	139	
HM8	16:16	16:21	5	2	ALIVE	A	146	
HM9	16:18	16:23	5	2	ALIVE	A	137	

APPENDIX TABLE D-1

Continued.

Fish No.	Time			No. of Turb-N Tags Recovered	Fish Data			
	Re-leased	Re-covered	At Large (min.)		Alive/ Dead	Condition Codes	Total Length (mm)	Comments
HN0	18:11	18:17	6	2	ALIVE	A	142	
HN1	18:11	18:17	6	1	ALIVE	B	156	
HN2	18:12	18:26	14	2	ALIVE	A	137	
HN3	18:12	18:19	7	2	ALIVE	A	147	
HN4	18:12	18:18	6	2	ALIVE	A	142	
HN5	18:14	18:20	6	2	ALIVE	A	142	
HN6	18:14	18:21	7	2	ALIVE	A	136	
HN7	18:15	18:31	16	2	ALIVE	A	140	
HN8	18:13	18:26	13	2	ALIVE	A	142	
HN9	18:13	18:22	9	2	ALIVE	A	134	
HP0	18:18	18:22	4	2	ALIVE	A	138	
HP1	18:16	18:25	9	2	ALIVE	A	147	
HP2	18:17	18:24	7	2	ALIVE	GH	154	
HP3	18:18	18:22	4	2	ALIVE	A	134	
HP4	18:17	18:22	5	2	ALIVE	A	151	
HP5	18:20	18:25	5	2	ALIVE	A	141	
HP6	18:19	18:23	4	2	ALIVE	A	147	
HP7	18:19	18:27	8	2	ALIVE	A	135	
HP8	18:19	18:29	10	2	ALIVE	A	138	
HP9	18:20	.	.	0	UNKNOWN	X	155	
HR0	18:42	18:47	5	2	ALIVE	A	139	
HR1	18:42	18:49	7	2	ALIVE	A	127	
HR2	18:43	18:48	5	2	ALIVE	A	144	
HR3	18:43	18:47	4	2	ALIVE	A	164	
HR4	18:43	18:54	11	2	ALIVE	A	147	
HR5	18:44	18:59	15	2	ALIVE	A	140	
HR6	18:45	18:50	5	2	ALIVE	A	138	
HR7	18:45	19:16	31	2	ALIVE	TA	157	
HR8	18:44	18:49	5	2	ALIVE	A	142	
HR9	18:45	18:50	5	2	ALIVE	C	148	
HS0	19:04	19:20	16	2	ALIVE	A	141	
HS1	19:05	19:10	5	2	ALIVE	A	156	
HS2	19:04	19:10	6	2	ALIVE	A	134	
HS3	19:03	19:09	6	2	ALIVE	A	170	
HS4	19:04	19:19	15	2	ALIVE	A	146	
HS5	19:06	19:17	11	2	ALIVE	A	140	
HS6	19:05	19:10	5	2	ALIVE	A	147	
HS7	19:06	19:13	7	2	ALIVE	A	140	
HS8	19:06	19:12	6	2	ALIVE	A	154	
HS9	19:07	19:11	4	2	ALIVE	A	129	
HT0	19:28	19:33	5	2	ALIVE	A	132	
HT1	19:29	19:33	4	2	ALIVE	A	143	
HT2	19:27	19:31	4	2	ALIVE	A	138	
HT3	19:28	19:33	5	2	ALIVE	A	162	
HT4	19:29	19:40	11	2	ALIVE	A	124	
HT5	19:30	19:36	6	2	ALIVE	A	147	
HT7	19:30	19:36	6	2	ALIVE	A	138	
HT8	19:29	19:35	6	2	ALIVE	A	143	
HT9	19:31	19:35	4	2	ALIVE	A	137	
HU0	19:42	19:45	3	2	ALIVE	A	134	
HU1	19:40	19:52	12	2	ALIVE	A	137	
HU2	19:41	19:54	13	2	ALIVE	A	144	
HU3	19:40	19:47	7	2	ALIVE	A	134	
HU4	19:41	19:45	4	2	ALIVE	A	150	
HU5	19:42	19:49	7	2	ALIVE	GH	148	
HU6	19:43	19:52	9	2	ALIVE	A	151	
HU7	19:43	19:48	5	2	ALIVE	A	143	
HU8	19:42	19:47	5	2	ALIVE	A	152	
HU9	19:43	19:47	4	2	ALIVE	A	133	
30 April 2003 - Testlot 7 : 50%, deep - Water temp=50.9 F								
HV0	8:20	8:28	8	2	ALIVE	GH	153	
HV1	8:18	8:23	5	2	ALIVE	A	144	
HV2	8:19	8:27	8	2	ALIVE	A	134	
HV3	8:19	8:24	5	2	ALIVE	G	141	
HV4	8:19	8:26	7	2	ALIVE	A	147	
HV5	8:21	8:30	9	2	ALIVE	A	133	
HV6	8:22	8:27	5	2	ALIVE	A	142	

Continued.

Fish No.	Time			No. of Turb-N Tags Recovered	Fish Data			
	Re-leased	Re-covered	At Large (min.)		Alive/ Dead	Condition Codes	Total Length (mm)	Comments
HV7	8:22	8:35	13	2	ALIVE	A	148	
HV8	8:21	8:30	9	2	ALIVE	A	154	
HV9	8:22	8:29	7	2	ALIVE	A	146	
HW0	8:49	8:55	6	2	ALIVE	A	133	
HW1	8:50	8:57	7	2	ALIVE	A	133	
HW2	8:48	8:54	6	2	ALIVE	A	137	
HW3	8:49	8:56	7	2	ALIVE	A	127	
HW4	8:50	8:56	6	2	ALIVE	E	128	
HW5	8:51	9:01	10	2	ALIVE	A	156	
HW6	8:51	8:57	6	2	ALIVE	A	140	
HW7	8:42	9:03	21	2	ALIVE	A	123	
HW8	8:52	9:00	8	2	ALIVE	A	141	
HW9	8:52	8:58	6	2	ALIVE	A	149	
HX0	9:09	9:14	5	2	ALIVE	A	125	
HX1	9:09	9:22	13	2	ALIVE	W	152	
HX2	9:08	9:15	7	2	ALIVE	H	133	
HX3	9:07	9:12	5	2	ALIVE	A	143	
HX4	9:08	9:16	8	2	ALIVE	A	164	
HX5	9:11	9:16	5	2	ALIVE	A	135	
HX6	9:12	9:17	5	2	ALIVE	G	142	
HX7	9:10	9:15	5	2	ALIVE	A	151	
HX8	9:10	9:20	10	2	ALIVE	E	136	
HX9	9:11	9:17	6	2	ALIVE	A	137	
HY0	9:27	9:31	4	2	ALIVE	A	142	
HY1	9:28	9:33	5	2	ALIVE	A	143	
HY2	9:28	9:34	6	2	ALIVE	A	140	
HY3	9:29	9:36	7	2	ALIVE	A	129	
HY4	9:28	9:36	8	2	ALIVE	A	144	
HY5	9:30	9:39	9	2	ALIVE	A	134	
HY6	9:29	9:35	6	2	ALIVE	A	150	
HY7	9:30	9:37	7	2	ALIVE	A	138	
HY8	9:31	9:39	8	1	ALIVE	A	141	
HY9	9:30	9:35	5	2	ALIVE	A	155	
HZ0	9:44	9:50	6	2	ALIVE	A	155	
HZ1	9:45	9:54	9	2	ALIVE	A	153	
HZ2	9:46	9:52	6	2	ALIVE	A	140	
HZ3	9:45	9:51	6	2	ALIVE	WN	131	
HZ4	9:44	9:49	5	2	ALIVE	GH	139	
HZ5	9:47	9:54	7	2	ALIVE	A	157	
HZ6	9:48	9:56	8	2	ALIVE	A	137	
HZ7	9:46	9:52	6	2	ALIVE	A	146	
HZ8	9:47	9:54	7	2	ALIVE	E	144	
HZ9	9:48	9:55	7	2	ALIVE	A	143	
JM0	10:11	10:26	15	2	ALIVE	A	154	
JM1	10:11	10:16	5	2	ALIVE	A	132	
JM2	10:12	10:19	7	2	ALIVE	A	137	
JM3	10:12	10:20	8	2	ALIVE	A	132	
JM4	10:12	10:41	29	1	ALIVE	B	134	
JM5	10:13	10:20	7	2	ALIVE	A	133	
JM6	10:14	10:22	8	2	ALIVE	A	147	
JM7	10:15	10:20	5	2	ALIVE	A	153	
JM8	10:14	10:18	4	2	ALIVE	A	150	
JM9	10:15	10:22	7	2	ALIVE	A	129	
JN0	10:44	10:51	7	2	ALIVE	A	140	
JN1	10:43	10:50	7	2	ALIVE	A	136	
JN2	10:44	10:53	9	2	ALIVE	A	144	
JN3	10:44	10:50	6	2	ALIVE	A	134	
JN4	10:43	10:48	5	2	ALIVE	A	135	
JN5	10:45	10:52	7	2	ALIVE	G	144	
JN6	10:45	10:52	7	2	ALIVE	A	130	
JN7	10:47	10:58	11	2	ALIVE	A	141	
JN8	10:47	10:55	8	2	ALIVE	A	134	
JN9	10:46	10:52	6	2	ALIVE	A	152	
JP0	11:01	11:06	5	2	ALIVE	A	139	
JP1	11:02	11:09	7	2	ALIVE	A	138	
JP2	11:02	11:07	5	2	ALIVE	EG	131	
JP3	11:03	11:10	7	2	ALIVE	A	141	
JP4	11:03	11:08	5	2	ALIVE	G	128	
JP5	11:05	11:14	9	2	ALIVE	G	140	
JP6	11:05	11:11	6	2	ALIVE	A	134	

APPENDIX TABLE D-1

Continued.

Fish No.	Time			No. of Turb-N Tags Recovered	Fish Data			
	Re-leased	Re-covered	At Large (min.)		Alive/ Dead	Condition Codes	Total Length (mm)	Comments
JP7	11:04	11:10	6	2	ALIVE	A	134	
JP8	11:04	11:11	7	2	ALIVE	GWH	155	
JP9	11:06	11:13	7	2	ALIVE	A	147	
JR0	11:19	11:33	14	2	ALIVE	A	133	
JR1	11:18	11:24	6	2	ALIVE	A	143	
JR2	11:20	11:25	5	2	ALIVE	G	145	
JR3	11:19	11:29	10	2	ALIVE	A	141	
JR4	11:18	11:22	4	2	ALIVE	A	137	
JR5	11:20	11:29	9	2	ALIVE	A	136	
JR6	11:20	11:29	9	2	ALIVE	A	130	
JR7	11:21	11:28	7	2	ALIVE	A	134	
JR8	11:21	11:34	13	2	ALIVE	A	147	
JR9	11:22	11:27	5	2	ALIVE	A	134	
JS0	11:39	11:50	11	2	ALIVE	A	137	
JS1	11:38	11:45	7	2	ALIVE	G	149	
JS2	11:37	11:48	11	2	ALIVE	A	146	
JS3	11:38	11:44	6	2	ALIVE	A	139	
JS4	11:37	11:44	7	2	ALIVE	A	137	
JS5	11:41	11:54	13	2	ALIVE	GH	146	
JS6	11:41	11:47	6	2	ALIVE	G	144	
JS7	11:40	11:48	8	2	ALIVE	A	139	
JS8	11:39	11:45	6	2	ALIVE	A	137	
JS9	11:40	11:46	6	2	ALIVE	A	134	
JT0	12:28	12:55	27	2	ALIVE	A	133	
JT1	12:26	12:47	21	2	ALIVE	A	153	
JT2	12:27	12:49	22	2	ALIVE	A	142	
JT3	12:25	12:48	23	2	ALIVE	A	163	
JT4	12:27	12:58	31	2	ALIVE	A	130	
JT5	12:30	12:53	23	2	ALIVE	A	140	
JT6	12:29	12:52	23	2	ALIVE	A	136	
JT7	12:29	12:41	12	2	ALIVE	A	144	
JT8	12:29	12:45	16	2	ALIVE	A	147	
JT9	12:30	12:46	16	2	ALIVE	A	136	
JU0	13:00	13:17	17	2	ALIVE	A	150	
JU1	13:00	13:13	13	2	ALIVE	A	137	
JU2	13:01	13:12	11	2	ALIVE	A	138	
JU3	13:02	13:24	22	2	ALIVE	A	135	
JU4	13:01	13:17	16	2	ALIVE	A	143	
JU5	13:03	13:18	15	2	ALIVE	A	142	
JU6	13:04	13:29	25	2	ALIVE	A	136	
JU7	13:03	13:23	20	2	ALIVE	A	151	
JU8	13:04	13:21	17	2	ALIVE	A	153	
JU9	13:03	13:23	20	2	ALIVE	A	137	
JV0	13:31	13:47	16	2	ALIVE	A	130	
JV1	13:31	13:46	15	2	ALIVE	A	151	
JV2	13:30	13:43	13	2	ALIVE	A	152	
JV3	13:29	13:43	14	2	ALIVE	A	130	
JV4	13:30	13:44	14	2	ALIVE	A	143	
JV5	13:32	13:45	13	2	ALIVE	A	144	
JV6	13:32	13:45	13	2	ALIVE	A	137	
JV7	13:33	13:52	19	2	ALIVE	A	139	
JV8	13:33	13:50	17	2	ALIVE	A	136	
JV9	13:24	13:47	23	2	ALIVE	A	134	
JW0	14:12	14:30	18	2	ALIVE	A	140	
JW1	14:14	14:18	4	2	ALIVE	A	140	
JW2	14:13	14:28	15	2	ALIVE	A	133	
JW3	14:13	14:37	24	2	ALIVE	A	153	
JW4	14:14	14:24	10	2	ALIVE	A	136	
JW5	14:16	14:23	7	2	ALIVE	A	149	
JW6	14:14	14:31	17	2	ALIVE	A	140	
JW7	14:16	14:32	16	2	ALIVE	A	154	
JW8	14:16	14:28	12	2	ALIVE	A	152	
JW9	14:15	14:33	18	2	ALIVE	QA	127	
JX0	14:41	14:50	9	2	ALIVE	A	137	
JX1	14:42	14:49	7	2	ALIVE	A	143	
JX2	14:42	15:02	20	2	ALIVE	A	140	
JX3	14:41	14:55	14	2	ALIVE	A	133	
JX4	14:11	14:53	42	2	ALIVE	A	147	
JX5	14:45	14:57	12	2	ALIVE	A	141	
JX6	14:43	14:53	10	2	ALIVE	A	144	

APPENDIX TABLE D-1

Continued.

Fish No.	Time Re-leased	Re-covered	At Large (min.)	No. of Turb-N Tags Recovered	Fish Data Alive/ Dead	Condition Codes	Total Length (mm)	Comments
JX7	14:44	14:59	15	2	ALIVE	A	147	
JX8	14:44	15:00	16	2	ALIVE	A	133	
JX9	14:43	14:58	15	2	ALIVE	A	138	
	1 May 2003 - Testlot 8 : Control - Water temp=51.8 F							
JY0	9:05	9:10	5	2	ALIVE	A	143	
JY1	9:04	9:10	6	2	ALIVE	A	137	
JY2	9:03	9:08	5	2	ALIVE	A	137	
JY3	9:03	9:14	11	2	ALIVE		137	
JY4	9:05	9:15	10	2	ALIVE	A	134	
JY5	9:06	9:12	6	2	ALIVE	A	149	
JY6	9:05	9:13	8	2	ALIVE	A	143	
JY7	9:07	9:14	7	2	ALIVE	A	146	
JY8	9:06	9:15	9	2	ALIVE	A	141	
JY9	9:07	9:14	7	2	ALIVE	A	148	
JZ0	9:24	9:32	8	2	ALIVE	A	140	
JZ1	9:22	9:30	8	2	ALIVE	A	142	
JZ2	9:24	9:34	10	2	ALIVE	A	137	
JZ3	9:23	9:29	6	2	ALIVE	A	157	
JZ4	9:23	9:29	6	2	ALIVE	A	147	
JZ5	9:19	9:30	11	2	ALIVE	A	135	
JZ6	9:20	9:25	5	2	ALIVE	A	149	
JZ7	9:21	9:28	7	2	ALIVE	A	135	
JZ8	9:20	9:27	7	2	ALIVE	A	139	
JZ9	9:21	9:27	6	2	ALIVE	A	155	
KR7	11:53	11:57	4	2	ALIVE	G	137	
LM0	9:49	9:55	6	2	ALIVE	A	145	
LM1	9:48	9:54	6	2	ALIVE	A	153	
LM2	9:48	9:53	5	2	ALIVE	A	148	
LM3	9:47	9:53	6	2	ALIVE	A	138	
LM4	9:48	9:53	5	2	ALIVE	A	138	
LM5	9:51	9:57	6	2	ALIVE	A	134	
LM6	9:50	9:55	5	2	ALIVE	A	157	
LM7	9:51	9:58	7	2	ALIVE	A	156	
LM8	9:50	9:56	6	2	ALIVE	A	150	
LM9	9:52	9:58	6	2	ALIVE	A	153	
LN0	10:37	10:44	7	2	ALIVE	A	130	
LN1	10:37	10:50	13	2	ALIVE	A	141	
LN2	10:36	10:48	12	2	ALIVE	A	167	
LN3	10:35	10:51	16	2	ALIVE	A	144	
LN4	10:35	10:42	7	2	ALIVE	A	143	
LN5	10:40	10:51	11	2	ALIVE	A	132	
LN6	10:39	10:48	9	2	ALIVE	A	140	
LN7	10:39	10:53	14	2	ALIVE	A	148	
LN8	10:40	10:47	7	2	ALIVE	A	146	
LN9	10:38	10:48	10	2	ALIVE	A	132	
LP0	10:59	11:10	11	2	ALIVE	A	134	
LP1	11:00	11:10	10	2	ALIVE	A	130	
LP2	11:00	11:10	10	2	ALIVE	A	150	
LP3	11:01	11:10	9	2	ALIVE	A	147	
LP4	11:01	11:10	9	2	ALIVE	A	145	
LP5	10:57	11:05	8	2	ALIVE	A	139	
LP6	10:57	11:10	13	2	ALIVE	A	142	
LP7	10:58	11:06	8	2	ALIVE	A	148	
LP8	10:56	11:06	10	2	ALIVE	A	148	
LP9	10:56	11:06	10	2	ALIVE	A	144	
LR0	11:33	11:38	5	2	ALIVE	GH	135	
LR1	11:32	11:38	6	2	ALIVE	GC	132	
LR2	11:33	11:39	6	2	ALIVE	A	153	
LR3	11:32	11:39	7	2	ALIVE	A	132	
LR4	11:34	11:41	7	2	ALIVE	A	134	
LR5	11:36	11:42	6	2	ALIVE	A	137	
LR6	11:36	11:44	8	2	ALIVE	EH	147	
LR7	11:35	11:46	11	2	ALIVE	GEH	142	
LR8	11:37	11:44	7	2	ALIVE	A	153	
LR9	11:35	11:43	8	2	ALIVE	A	138	
LS0	11:51	12:00	9	2	ALIVE	A	142	
LS1	11:51	12:06	15	2	ALIVE	A	152	

APPENDIX TABLE D-1

Continued.

Fish No.	Time			No. of Turb-N Tags Recovered	Fish Data			
	Re-leased	Re-covered	At Large (min.)		Alive/ Dead	Condition Codes	Total Length (mm)	Comments
LS2	11:52	11:58	6	2	ALIVE	G	140	
LS3	11:50	12:04	14	2	ALIVE	GH	128	
LS4	11:50	11:56	6	2	ALIVE	A	139	
LS6	11:54	11:58	4	2	DEAD	NHJ	124	
LS7	11:53	12:01	8	2	ALIVE	A	148	
LS8	11:54	11:59	5	2	ALIVE	E	139	
LS9	11:52	12:01	9	2	ALIVE	A	143	
LT0	12:11	12:17	6	2	ALIVE	G	146	
LT1	12:13	12:19	6	2	ALIVE	G	135	
LT2	12:12	12:18	6	2	ALIVE	A	142	
LT3	12:12	12:23	11	2	ALIVE	A	133	
LT4	12:11	12:19	8	2	ALIVE	A	143	
LT5	12:16	12:21	5	2	ALIVE	A	124	
LT6	12:13	12:20	7	2	ALIVE	A	153	
LT7	12:14	12:20	6	2	ALIVE	A	144	
LT8	12:15	12:20	5	2	ALIVE	A	158	
LT9	12:15	12:23	8	2	ALIVE	A	142	
LU0	12:45	12:51	6	2	ALIVE	A	145	
LU1	12:45	12:53	8	2	ALIVE	A	142	
LU2	12:46	12:54	8	2	ALIVE	A	148	
LU3	12:46	12:51	5	2	ALIVE	A	150	
LU4	12:46	12:51	5	2	ALIVE	A	134	
LU5	12:49	12:54	5	2	ALIVE	A	142	
LU6	12:48	12:53	5	2	ALIVE	A	144	
LU7	12:47	12:56	9	2	ALIVE	GH	149	
LU8	12:49	12:55	6	2	ALIVE	A	132	
LU9	12:48	13:01	13	2	ALIVE	A	145	
LV0	12:30	12:32	2	2	ALIVE	A	134	
LV1	12:29	12:32	3	2	ALIVE	A	147	
LV2	12:29	12:34	5	2	ALIVE	A	143	
LV3	12:30	12:34	4	2	ALIVE	A	131	
LV4	12:29	12:37	8	2	ALIVE	A	147	
LV5	12:32	12:38	6	2	ALIVE	A	148	
LV6	12:32	12:41	9	2	ALIVE	A	142	
LV7	12:31	12:36	5	2	DEAD	JN	145	
LV8	12:33	12:40	7	2	ALIVE	A	146	
LV9	12:31	12:37	6	2	ALIVE	A	134	
LW0	13:14	13:19	5	2	ALIVE	G	134	
LW1	13:15	13:20	5	2	ALIVE	A	136	
LW2	13:13	13:18	5	1	ALIVE	B	143	
LW3	13:15	13:20	5	2	ALIVE	A	139	
LW4	13:12	13:17	5	1	ALIVE	A	125	
LW5	13:18	13:23	5	2	ALIVE	A	146	
LW6	13:17	13:22	5	2	ALIVE	A	131	
LW7	13:17	13:22	5	2	ALIVE	A	145	
LW8	13:20	13:24	4	2	ALIVE	A	137	
LW9	13:19	13:25	6	2	ALIVE	GH	146	
LX0	13:45	13:51	6	2	ALIVE	A	142	
LX1	13:43	13:58	15	2	ALIVE	A	149	
LX2	13:44	13:56	12	2	ALIVE	A	144	
LX3	13:44	13:51	7	2	ALIVE	A	136	
LX4	13:43	13:50	7	2	ALIVE	A	138	
LX5	13:47	13:57	10	2	ALIVE	A	152	
LX6	13:47	13:55	8	2	ALIVE	A	137	
LX7	13:48	13:55	7	2	ALIVE	A	134	
LX8	13:48	13:58	10	2	ALIVE	A	134	
LX9	13:46	13:57	11	2	ALIVE	A	142	
LY0	14:06	14:12	6	2	ALIVE	G	148	
LY1	14:05	14:11	6	2	ALIVE	G	142	
LY2	14:07	14:10	3	2	ALIVE	A	137	
LY3	14:05	14:11	6	2	ALIVE	A	134	
LY4	14:07	14:11	4	2	ALIVE	GH	139	
LY5	14:09	14:16	7	2	ALIVE	A	140	
LY6	14:10	14:15	5	2	ALIVE	A	137	
LY7	14:09	14:13	4	2	ALIVE	G	156	
LY8	14:08	14:12	4	2	ALIVE	A	135	
LY9	14:07	14:14	7	2	ALIVE	A	136	
LZ0	14:21	14:32	11	2	ALIVE	A	140	
LZ1	14:22	14:27	5	2	ALIVE	A	136	
LZ2	14:22	14:28	6	2	ALIVE	A	138	

APPENDIX TABLE D-1

Continued.

Fish No.	Time			No. of Turb-N Tags Recovered	Fish Data			
	Re-leased	Re-covered	At Large (min.)		Alive/ Dead	Condition Codes	Total Length (mm)	Comments
LZ3	14:21	14:37	16	2	ALIVE	A	152	
LZ4	14:20	14:25	5	2	ALIVE	A	140	
LZ5	14:23	14:29	6	2	ALIVE	A	143	
LZ6	14:24	14:30	6	2	ALIVE	A	135	
LZ7	14:25	14:30	5	2	ALIVE	GH	153	
LZ8	14:24	14:29	5	2	ALIVE	A	144	
LZ9	14:25	14:34	9	2	ALIVE	A	145	
YM0	14:43	14:50	7	2	ALIVE	A	133	
YM1	14:44	14:56	12	2	ALIVE	A	138	
YM2	14:42	14:47	5	2	ALIVE	A	136	
YM3	14:44	14:53	9	2	ALIVE	G	140	
YM4	14:43	14:49	6	2	ALIVE	G	146	
YM5	14:47	14:54	7	2	ALIVE	A	142	
YM6	14:46	14:51	5	2	ALIVE	A	145	
YM7	14:46	14:51	5	2	ALIVE	A	148	
YM8	14:47	14:55	8	2	ALIVE	A	137	
YM9	14:45	14:50	5	2	ALIVE	A	143	
	2 May 2003 - Testlot 9 : 50%, deep - Water temp=52.7 F							
TM0	17:17	17:27	10	2	ALIVE	A	148	
TM1	17:18	17:31	13	2	ALIVE	A	134	
TM2	17:17	17:31	14	2	ALIVE	A	126	
TM3	17:18	17:34	16	2	ALIVE	A	134	
TM4	17:17	17:25	8	2	ALIVE	A	160	
TM5	17:20	17:45	25	2	ALIVE	A	142	
TM6	17:19	17:38	19	2	ALIVE	A	139	
TM7	17:20	17:40	20	2	ALIVE	G	137	
TM8	17:19	17:29	10	2	ALIVE	A	145	
TM9	17:21	17:35	14	2	ALIVE	A	141	
YN0	13:54	13:58	4	2	ALIVE	A	139	
YN1	13:56	13:59	3	2	ALIVE	A	141	
YN2	13:54	13:58	4	2	ALIVE	A	140	
YN3	13:55	14:01	6	2	ALIVE	A	125	
YN4	13:55	13:58	3	2	ALIVE	A	140	
YN5	13:58	14:04	6	2	ALIVE	A	134	
YN6	13:58	14:01	3	2	ALIVE	A	134	
YN7	13:56	14:02	6	2	ALIVE	A	156	
YN8	13:57	14:01	4	2	ALIVE	A	142	
YN9	13:57	14:03	6	2	ALIVE	A	143	
YP0	14:13	14:16	3	2	ALIVE	A	133	
YP1	14:12	14:15	3	2	ALIVE	A	132	
YP2	14:14	14:21	7	2	ALIVE	A	138	
YP3	14:13	14:18	5	2	ALIVE	A	137	
YP4	14:14	14:25	11	2	ALIVE	A	138	
YP5	14:15	14:20	5	2	ALIVE	A	142	
YP6	14:16	14:20	4	2	ALIVE	A	135	
YP7	14:15	14:19	4	2	ALIVE	A	139	
YP8	14:16	14:23	7	2	ALIVE	A	147	
YP9	14:16	14:21	5	2	ALIVE	A	141	
YR0	14:29	14:34	5	2	ALIVE	A	136	
YR1	14:27	14:29	2	2	ALIVE	A	145	
YR2	14:29	14:33	4	2	ALIVE	A	133	
YR3	14:28	14:31	3	2	ALIVE	A	150	
YR4	14:28	14:30	2	2	ALIVE	A	148	
YR5	14:31	14:39	8	2	ALIVE	H	165	
YR6	14:32	14:36	4	2	ALIVE	A	155	
YR7	14:30	14:39	9	2	ALIVE	A	140	
YR8	14:31	14:34	3	2	ALIVE	A	136	
YR9	14:30	14:34	4	2	ALIVE	A	136	
YS0	14:42	14:47	5	2	ALIVE	A	135	
YS1	14:41	14:47	6	2	ALIVE	A	138	
YS2	14:42	14:47	5	2	ALIVE	A	131	
YS3	14:41	14:59	18	2	ALIVE	GH	133	
YS4	14:40	14:44	4	2	ALIVE	A	146	
YS5	14:43	14:47	4	2	ALIVE	A	143	
YS6	14:45	14:51	6	2	ALIVE	A	137	
YS7	14:44	14:48	4	2	ALIVE	A	137	
YS8	14:44	14:49	5	2	ALIVE	A	141	

APPENDIX TABLE D-1

Continued.

Fish No.	Time Re-leased	Re-covered	At Large (min.)	No. of Turb-N Tags Recovered	Fish Data Alive/Dead	Condition Codes	Total Length (mm)	Comments
YS9	14:45	14:56	11	2	ALIVE	G	139	
YT0	15:07	15:17	10	2	ALIVE	A	144	
YT1	15:07	15:12	5	2	ALIVE	A	162	
YT2	15:06	15:11	5	2	ALIVE	A	150	
YT3	15:05	15:10	5	2	ALIVE	NG	136	
YT4	15:06	15:12	6	2	ALIVE	A	142	
YT5	15:09	15:15	6	2	ALIVE	A	140	
YT6	15:10	15:13	3	2	ALIVE	A	136	
YT7	15:07	15:20	13	2	ALIVE	A	149	
YT8	15:09	15:13	4	2	ALIVE	A	143	
YT9	15:08	15:16	8	2	ALIVE	A	135	
YU0	15:27	15:32	5	2	ALIVE	A	127	
YU1	15:28	15:33	5	2	ALIVE	A	128	
YU2	15:26	15:31	5	2	ALIVE	A	150	
YU3	15:27	15:31	4	2	ALIVE	A	142	
YU4	15:26	15:29	3	2	ALIVE	A	132	
YU5	15:30	15:36	6	2	ALIVE	A	138	
YU6	15:29	15:33	4	2	ALIVE	A	149	
YU7	15:29	15:36	7	2	ALIVE	A	137	
YU8	15:28	15:33	5	2	ALIVE	A	149	
YU9	15:30	15:35	5	2	ALIVE	A	154	
YV0	15:45	15:50	5	2	ALIVE	A	132	
YV1	15:46	15:57	11	2	ALIVE	GH	128	
YV2	15:45	15:50	5	2	ALIVE	A	136	
YV3	15:45	15:49	4	2	ALIVE	A	157	
YV4	15:46	15:51	5	2	ALIVE	A	147	
YV5	15:47	15:51	4	2	ALIVE	GH	138	
YV6	15:47	15:54	7	2	ALIVE	A	138	
YV7	15:48	15:55	7	2	ALIVE	A	139	
YV8	15:48	15:54	6	2	ALIVE	A	135	
YV9	15:48	15:55	7	2	ALIVE	A	139	
YW0	16:04	16:09	5	2	ALIVE	A	140	
YW1	16:03	16:08	5	2	ALIVE	A	148	
YW2	16:04	16:09	5	2	ALIVE	N	132	
YW3	16:03	16:09	6	2	ALIVE	A	148	
YW4	16:04	16:08	4	2	ALIVE	G	142	
YW5	16:06	16:12	6	2	ALIVE	A	135	
YW6	16:07	16:11	4	2	ALIVE	GH	137	
YW7	16:08	16:14	6	2	ALIVE	A	141	
YW8	16:07	16:13	6	2	ALIVE	GH	153	
YW9	16:05	16:10	5	2	ALIVE	A	143	
YX0	16:20	16:32	12	2	ALIVE	A	142	
YX1	16:19	16:25	6	2	ALIVE	A	148	
YX2	16:21	16:30	9	1	ALIVE	B	125	
YX3	16:20	16:25	5	2	ALIVE	NW	153	
YX4	16:21	16:25	4	2	ALIVE	A	148	
YX5	16:22	16:27	5	2	DEAD	E	130	
YX6	16:22	16:30	8	2	ALIVE	A	133	
YX7	16:23	16:28	5	2	ALIVE	A	140	
YX8	16:23	16:28	5	2	ALIVE	A	141	
YX9	16:23	16:29	6	2	ALIVE	A	136	
YY0	16:37	16:42	5	2	ALIVE	A	137	
YY1	16:38	16:42	4	2	ALIVE	A	122	
YY2	16:38	16:44	6	2	ALIVE	A	150	
YY3	16:37	16:42	5	2	ALIVE	A	158	
YY4	16:38	16:43	5	2	ALIVE	A	146	
YY5	16:41	16:45	4	2	ALIVE	A	144	
YY6	16:40	16:45	5	2	ALIVE	A	143	
YY7	16:39	16:43	4	2	ALIVE	A	132	
YY8	16:39	16:44	5	2	ALIVE	A	139	
YY9	16:40	16:45	5	2	ALIVE	A	149	
YZ0	17:01	17:06	5	2	ALIVE	GH	139	
YZ1	17:00	17:03	3	2	ALIVE	A	136	
YZ2	17:01	17:04	3	2	ALIVE	A	125	
YZ3	17:00	17:03	3	2	ALIVE	A	155	
YZ4	16:59	17:02	3	2	ALIVE	H	135	
YZ5	17:04	17:13	9	2	ALIVE	A	135	
YZ6	17:04	17:14	10	2	ALIVE	A	144	
YZ7	17:03	17:14	11	2	ALIVE	A	145	
YZ8	17:03	17:12	9	2	ALIVE	A	157	
YZ9	17:05	17:09	4	2	ALIVE	A	150	