Research Related to Transportation of Juvenile Salmonids on the Columbia and Snake Rivers, 1992

by
Jerrel R. Harmon, Benjamin P. Sandford, Kenneth L. Thomas, Neil N. Paasch, Kenneth W. McIntyre, and Gene M. Matthews

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</table>
In 1992, National Marine Fisheries Service (NMFS) research addressed two areas related to smolt transportation. The first was completion of a 3-year marking program to evaluate barge transport of smolts from Lower Granite and McNary Dams to a release site below Bonneville Dam; the second was an estuarine release-site study on barged steelhead (Oncorhynchus mykiss) smolts.

Barge Transportation Studies

Drought conditions in the Snake River Basin again precluded marking of spring/summer chinook salmon (O. tshawytscha) and steelhead smolts for the final year of a 3-year reevaluation of transportation from Lower Granite Dam. A similar 3-year study marking juvenile fall and spring/summer chinook salmon at McNary Dam was completed in 1988.

Adult recoveries continued for these studies and for a group of spring/summer chinook salmon smolts marked for transport at Lower Granite Dam during the 1990 drought year. Adult recoveries from transport and control groups of spring/summer chinook salmon smolts marked at Lower Granite Dam in 1989 are complete, but are much lower than expected. Nevertheless, significantly more transports than controls were recovered, with a transport to control ratio (T/C) of 2.4 and a 95% confidence interval (CI) of 1.4 to 4.3. Adult recoveries of spring/summer chinook salmon smolts marked for barge transport in 1990 are incomplete. So
far, this group is returning at a higher rate than any group we have marked since 1983. Adult recoveries of steelhead smolts, marked as transports and controls and released in 1989, are also incomplete but, like adult returns of spring/summer chinook salmon marked in that year, are much lower than expected. The preliminary T/C is 2.1 at Lower Granite Dam.

We continued to observe high abrasion levels from marine mammal teeth and claws on adult spring/summer chinook salmon. Prevalence of abrasions in 1992 was 15%, with open wounds occurring on about one-third of the fish with abrasions.

For the McNary Dam studies, adult returns from transport and control groups of spring/summer chinook salmon smolts marked in 1988 are complete. The T/C was 1.6 with a 95% CI for combined recoveries between 1.0 and 2.6. For fall chinook salmon, adult returns for juveniles marked as transports and controls in 1986 are complete. Significantly more fall chinook salmon transports than controls were recovered from all locations, with a T/C of 3.0 in the ocean fisheries. Adult returns for the 1987 and 1988 study years are incomplete; however, recoveries from all areas continue to strongly favor the transported groups.

Steelhead Release-Site Study

In 1992, we began a 3-year marking study to compare adult returns of barged steelhead smolts, released in the upper Columbia River estuary at Tongue Point (River kilometer [Rkm] 29.3), with those released at the traditional site just
downstream from Bonneville Dam near Skamania Light (Rkm 224.0). Between 1 and 20 May, we marked seven release lots of approximately 9,000 steelhead each for the Tongue Point releases, and seven lots of 10,000 steelhead each for the Skamania Light releases. Overall post-marking delayed mortality and tag loss were low, averaging 0.7 and 0.5%, respectively.
TRANSPORTATION STUDIES: LOWER GRANITE AND MCNARY DAMS

Introduction

The U.S. Army Corps of Engineers (COE) has conducted the barge transportation program annually since 1981. To index its relative success, the National Marine Fisheries Service (NMFS) marked spring/summer chinook salmon (Oncorhynchus tshawytscha) smolts at Lower Granite Dam in 1983, 1984, and 1985, and steelhead (O. mykiss) smolts in 1984 and 1985. No paired control groups of either species were marked during any of the above years. The 1985 smolt-marking operations were conducted by the Fish Passage Center (formerly the Water Budget Center). Therefore, data on these releases were not included in any of the NMFS annual reports. Final adult returns for the 1983 and 1984 release groups were reported by Harmon et al. (1989), and final adult returns for the 1985 releases were reported by Matthews et al. (1990).

By 1985, preliminary adult returns from these marking efforts indicated that survival of marked, transported smolts had improved considerably compared to returns from the 1976-80 study years (Park et al. 1986). We believe a combination of factors was responsible for the observed increase in smolt-to-adult survival. These factors included, but were not necessarily limited to, the following: major improvements in transport and collection facilities, improved fish quality, and greatly improved fish handling/marketing techniques.
In 1986, a new 3-year transportation study was initiated on spring/summer chinook salmon and steelhead at Lower Granite Dam and spring/summer and fall chinook salmon at McNary Dam. The primary goal of the study was to reevaluate transportation of smolts around dams, utilizing state-of-the-art collection/transport and handling/marketing techniques. At McNary Dam, we marked transport and control groups of spring/summer and fall chinook salmon for three consecutive years (1986-88). At Lower Granite Dam, we marked transport and control groups of spring/summer chinook salmon and steelhead in 1986. However, drought conditions caused low river flows and no inriver control releases were marked in 1987, 1988, 1990, 1991, and 1992. We marked transport and control groups of both species in 1986 and 1989. In 1987 and 1990, we marked barge transport groups for indexing of both species. No marking was done in 1988, 1991, and 1992 due to the prolonged drought.

While recovery of adults for some of these marking efforts is complete, other recovery efforts are ongoing. Completed studies previously reported for Lower Granite Dam include results from both spring/summer chinook salmon and steelhead released in 1986 (Matthews et al. 1992), and spring/summer chinook salmon released in 1987 (Achord et al. 1992). For McNary Dam studies, complete returns include those for spring/summer chinook salmon released in 1986 (Matthews et al. 1992) and 1987 (Achord et al. 1992). Here we report the results from complete adult returns of fall chinook salmon marked at McNary Dam in 1986 and
spring/summer chinook salmon marked at McNary Dam in 1988 and at Lower Granite Dam in 1989.

To determine the hatchery/wild composition of the Snake River spring/summer chinook salmon population, NMFS and the Oregon Department of Fish and Wildlife began a study in 1991 to examine scales on smolts and returning adults (Achord et al. 1992). In particular, the study was intended to examine the hatchery/wild composition of each marked group of smolts for the transportation study and subsequently, to examine the scales of those returning as adults. Since drought conditions precluded marking of smolts for the 1991 and 1992 study years, we sampled scales from adults returning from previous marking efforts and from the general population. Results of the 1992 effort are reported in Appendix B of this report.

Methods

General

Smolts at both dams were marked with CWTs and freeze brands during the smolt outmigration each year, and either transported by barge for release below Bonneville Dam or released as controls below Little Goose or McNary Dams. Smolts were marked according to the procedures described by Matthews et al. (1987).

Recovery of Adults and Data Analysis

Adults were recovered from 3 to 6 years (depending upon species and study site) after their release as juveniles. Traps in fish ladders at Lower Granite and Priest Rapids Dams (for
McNary Dam releases) were the primary recovery sites for
spring/summer chinook salmon and steelhead. Ocean and river
commercial fisheries were primary recovery sites for fall chinook
salmon marked at McNary Dam. If recoveries were sufficient,
trapping efficiencies were estimated for individual release lots
by comparing the number of marked trap recoveries to the total
number of marked fish returning to the hatcheries and, when
available, to tributary sport fisheries and natal spawning areas.

Evaluation of transportation was based upon recovery rates
of adults and associated transport/control ratios (T/C) from fish
marked as juveniles. A 95% confidence interval (CI) was used to
test the null hypothesis: That the true transport to control
ratio was equal to one (1). If the 95% CI did not include a
ratio equal to one (1), then the null hypothesis was rejected.
Beginning at Lower Granite Dam in 1989, the study design was
adjusted to test a T/C of 1.5 with a coefficient of variation of
10% for spring/summer chinook salmon and 7.5% for steelhead.

To normalize the distribution, the ratios were log
transformed prior to CI construction. The endpoints of the CI
were then back transformed to provide a nonsymmetric CI on the
original scale. For analysis of total recoveries, the CI was
calculated using both theoretical and empirical estimates of
variance. The CI employing the empirical variance estimate was
preferred.
The 95% CI using transformed data based on theoretical variance was derived by the following term:

\[ \ln(T/C) \pm 1.96 \sqrt{\frac{1}{n_t} + \frac{1}{n_c} - \frac{1}{N_t} - \frac{1}{N_c}} \]

The 95% CI was back-transformed to its original scale using the following term:

\[ \left( e^{\ln(T/C) - 1.96 \sqrt{\frac{1}{n_t} + \frac{1}{n_c} - \frac{1}{N_t} - \frac{1}{N_c}}} , e^{\ln(T/C) + 1.96 \sqrt{\frac{1}{n_t} + \frac{1}{n_c} - \frac{1}{N_t} - \frac{1}{N_c}}} \right) \]

The 95% CI using transformed data based on empirical variance was derived by the following term:

\[ \ln(T/C) \pm t_{0.05} S.E.(\ln(T/C)) \]

The 95% CI back transformed to the original scale was derived by the following term:

\[ \left( e^{\ln(T/C) - t_{0.05} S.E.(\ln(T/C))} , e^{\ln(T/C) + t_{0.05} S.E.(\ln(T/C))} \right) \]

where,

\[ T/C = \text{overall transport recovery percentage divided by overall control recovery percentage} \]

\[ S.E. = \text{standard deviation of the } r \text{ replicate } \ln(T/C) \text{'s divided by } r^{1/2} \]

\[ n_t = \text{total of transport recoveries} \]

\[ n_c = \text{total of control recoveries} \]

\[ N_t = \text{total of transport releases} \]

\[ N_c = \text{total of control releases} \]
Results and Discussion

Adult Recoveries for Lower Granite Dam Studies

*Spring/summer chinook salmon*—Adult recoveries from transport and control groups of naturally migrating smolts marked at Lower Granite Dam in 1989 are complete (Appendix Tables 1.0 through 2.12 and Table 1). Lower Granite Dam was used as the principal evaluation point for adult recoveries because the entire adult migration can be systematically sampled as it passes over the dam. In addition, we were only capable of marking the numbers of juveniles required for a precise evaluation of adult returns back to this point. Sites further upstream also were sampled for recoveries; however, these sites were not relied upon for precise results due to the extremely large numbers of marked juveniles that would have been required to provide credible results. In addition, we did not compute a T/C for total adult returns because this sample included hatchery recoveries that we strongly suspect were not obtained systematically.

At Lower Granite Dam, we recovered 46 transports (0.06% of the release) and 28 controls (0.02% of the release). Using empirical standard errors, we calculated the T/C at 2.4, with a 95% CI between 1.4 and 4.3. The 95% CI was wider than desired because adult returns of study fish in both test groups were about three times lower than expected, as were the adult returns.

\[ t = \text{the } t \text{ probability for a two-sided significance level } \alpha = 0.05 \text{ and } n-1 \text{ degrees of freedom} \]

\[ 1.96 = \text{the normal probability for a two-sided } \alpha = 0.05 \]
Table 1.--Summary of recovered adult spring/summer chinook salmon marked at Lower Granite Dam in 1989 (recoveries through February 1993). Numbers in parentheses represent fish that were jaw tagged at the dams and subsequently recovered upstream.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number released</th>
<th>Ocean age</th>
<th>Transport</th>
<th>Control</th>
<th>Transport</th>
<th>Control</th>
<th>Transport</th>
<th>Control</th>
<th>Transport</th>
<th>Control</th>
<th>Transport</th>
<th>Control</th>
<th>Transport</th>
<th>Control</th>
<th>Transport</th>
<th>Control</th>
<th>Transport</th>
<th>Control</th>
<th>Transport</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Observation Adult</td>
<td>Returns</td>
<td></td>
<td>Observation Adult</td>
<td>Returns</td>
<td>Observation Adult</td>
<td>Returns</td>
<td>Observation Adult</td>
<td>Returns</td>
<td>Observation Adult</td>
<td>Returns</td>
<td>Observation Adult</td>
<td>Returns</td>
<td>Observation Adult</td>
<td>Returns</td>
<td>Observation Adult</td>
<td>Returns</td>
<td>Observation Adult</td>
<td>Returns</td>
</tr>
<tr>
<td>Transport</td>
<td>75,295</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0.01</td>
<td>37</td>
<td>0.05</td>
<td>1</td>
<td>23</td>
<td>0.03</td>
<td>64</td>
</tr>
<tr>
<td>Control</td>
<td>107,176</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>15</td>
<td>3</td>
<td>15</td>
<td>2</td>
<td>13</td>
<td>0</td>
<td>13</td>
<td>13</td>
<td>0.01</td>
<td>23</td>
<td>0.02</td>
<td>1</td>
<td>13</td>
<td>0.01</td>
<td>38</td>
</tr>
</tbody>
</table>

* Fish captured more than once were only counted once in totals.
of the general population from the 1989 smolt outmigration. The same pattern is noted below for adult steelhead returns from the 1989 smolt outmigration.

During spring 1990, we marked a barge index group of spring/summer chinook salmon smolts at Lower Granite Dam. Observed recoveries of age-1-ocean and age-2-ocean adults at Lower Granite Dam totaled 79 or 0.18% of the release (Appendix Tables 3.0 through 3.7 and Table 2). Returns of these age-classes to all other recovery sites are incomplete. We will continue to monitor adult recoveries from this group. When complete, we expect adult returns of this marked group to be the highest since returns from the transport group marked in 1975.

We continued monitoring the prevalence of marine mammal tooth and claw abrasions on adult spring/summer chinook salmon during 1992 (Table 3). Overall, prevalence averaged 15.0%, with open wounds noted on approximately one-third of the fish with abrasions. As in past years, the prevalence of abrasions was generally higher during the earliest portion of the run (Matthews et al. 1992). Average abrasion prevalence for 1992 was similar to that of 1991 (Achord et al. 1992) and slightly lower than for 1990 (Matthews et al. 1992). Our concern about the potential negative effects of marine mammals on the depressed runs of wild Snake River spring/summer chinook salmon continues.

**Steelhead**—Adult recoveries of steelhead smolts marked in 1989 are ongoing and are much lower than expected. Age-2-ocean adults returned during fall 1991 and spring 1992 (Appendix Tables
Table 2.—Preliminary summary of recovered adult spring/summer chinook salmon marked at Lower Granite Dam in 1990 (recoveries through February 1993). Numbers in parentheses represent fish that were jaw-tagged at the dams and subsequently recovered upstream.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number released</th>
<th>Number</th>
<th>Ocean-</th>
<th>Observed adult returns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>age</td>
<td>Ocean fishery</td>
</tr>
<tr>
<td>Transport</td>
<td>44,708</td>
<td>1</td>
<td>age</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>44,708</td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

* Fish captured more than once were only counted once in totals.
Table 3.--Weekly prevalence (9 April to 26 June) of marine mammal tooth and claw abrasions on adult spring/summer chinook salmon at Lower Granite Dam in 1992.

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample size</th>
<th>Incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-11 Apr</td>
<td>5</td>
<td>0.0</td>
</tr>
<tr>
<td>12-18 Apr</td>
<td>63</td>
<td>21.0</td>
</tr>
<tr>
<td>19-25 Apr</td>
<td>333</td>
<td>14.0</td>
</tr>
<tr>
<td>26 Apr-2 May</td>
<td>498</td>
<td>19.0</td>
</tr>
<tr>
<td>3-9 May</td>
<td>405</td>
<td>19.0</td>
</tr>
<tr>
<td>10-16 May</td>
<td>438</td>
<td>19.0</td>
</tr>
<tr>
<td>17-23 May</td>
<td>428</td>
<td>15.0</td>
</tr>
<tr>
<td>24-30 May</td>
<td>209</td>
<td>15.0</td>
</tr>
<tr>
<td>31 May-6 June</td>
<td>323</td>
<td>13.0</td>
</tr>
<tr>
<td>7-13 June</td>
<td>228</td>
<td>4.0</td>
</tr>
<tr>
<td>14-20 June</td>
<td>237</td>
<td>6.0</td>
</tr>
<tr>
<td>21-26 June</td>
<td>88</td>
<td>3.0</td>
</tr>
<tr>
<td>Total and average</td>
<td>3,255</td>
<td>15.0*</td>
</tr>
</tbody>
</table>

* Open wounds were associated with 36.4% of the abrasions.
4.0 through 5.6 and Table 4), and few age-3-ocean adult returns are expected in 1992-93. Total adult recoveries to Lower Granite Dam for transport and control groups were 163 (0.5% of the release) and 108 (0.3% of the release), respectively, for a preliminary T/C of 2.1. Adult returns to all recovery sites combined were 194 transports (0.54% of the release) and 123 controls (0.26% of the release). So far, return rates of marked adult steelhead in both test groups have been about one-third of the rate expected, as were the adult returns in general for steelhead smolts that outmigrated in spring 1989. As previously noted, the same pattern was apparent for the 1989 smolt outmigration of spring/summer chinook salmon. Achord et al. (1992) suggested that poor estuary/ocean survival of smolts likely accounted for the low adult returns from the 1989 outmigration.

Adult Recoveries for McNary Dam Studies

**Spring chinook salmon**—Adult recoveries of spring chinook salmon marked as smolts at McNary Dam in 1986-88 are complete. Final returns for study years 1986 and 1987 were reported previously (Achord et al. 1992, Matthews et al. 1992). Adult recoveries of 1986 releases were insufficient for analysis. While results of the 1987 study suggested a survival benefit from transportation of spring chinook salmon smolts at McNary Dam, T/Cs varied greatly among recovery sites, and theoretical 95% CIs overlapped one (1) in most cases.

Adult recoveries from the 1988 study year are presented in
Table 4.—Preliminary summary of recovered adult steelhead marked at Lower Granite Dam in 1989 (recoveries through February 1993). Numbers in parentheses represent fish that were jaw tagged at the dam and subsequently recovered upstream.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number released</th>
<th>Ocean- age</th>
<th>Bonneville Dam</th>
<th>Indian fishery</th>
<th>River fishery</th>
<th>Lower Granite Dam</th>
<th>Hatcheries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>30,116</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>33 (8)</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>0</td>
<td>16</td>
<td>38</td>
<td>129 (44)</td>
<td>13</td>
<td>152</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1 (1)</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>30,116</td>
<td>3</td>
<td>19</td>
<td>44</td>
<td>163 (53)</td>
<td></td>
<td>21</td>
<td>194*</td>
</tr>
<tr>
<td>Control</td>
<td>42,259</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>33 (14)</td>
<td>5</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>22</td>
<td>71 (23)</td>
<td>7</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>42,259</td>
<td>3</td>
<td>8</td>
<td>31</td>
<td>108 (37)</td>
<td></td>
<td>12</td>
<td>123*</td>
</tr>
</tbody>
</table>

* Fish captured more than once were only counted once in totals.
Appendix Tables 6.0 through 7.10 and Table 5. An empirical CI was constructed for total combined recoveries. The combined 1.6 T/C, with an empirical 95% CI between 1.0 and 2.6, suggests a benefit from transporting smolts from McNary Dam in 1988.

In summary, although 95% CI values were wide and overlapped one and the number of recoveries from a variety of locations was small, the T/C estimates for the 1987 and 1988 study years suggested a survival benefit from transportation of spring chinook salmon smolts from McNary Dam. Further testing will be required if finer statistical resolution is desired. Future testing should include greatly increased numbers of marked smolts and establish a systematic adult recovery plan.

**Fall chinook salmon**—Adult returns of fall chinook salmon released as juvenile transport and control groups from McNary Dam in 1986 are complete (Appendix Tables 8.0 through 9.12 and Table 6). A total of 444 transports and 165 controls were recovered from all sites combined. We constructed 95% CIs using empirical standard errors (Table 7). The data showed significant transport benefits and very similar T/Cs at all recovery sites except the combined hatcheries. However, the combined CWT hatchery recoveries were predominated by recoveries from Priest Rapids Hatchery. The overall recoveries from this hatchery were further predominated by recoveries from the first five replicates of juveniles marked from 11 June to 15 July at McNary Dam. The T/Cs in the ocean fisheries were low and similar to the T/Cs at Priest Rapids Hatchery for these early replicates. We also examined the
### Table 5: Summary of recovered adult spring/summer chinook salmon marked at McNary Dam in 1988 (recoveries through February 1993)
Numbers in parentheses represent fish that were jaw-tagged at the dams and subsequently recovered upstream.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number released</th>
<th>Ocean-age</th>
<th>Observed adult returns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ocean fishery</td>
<td>Bonneville Dam fishery</td>
</tr>
<tr>
<td>Transport</td>
<td>50,028</td>
<td>1</td>
<td>2 (3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>1 17</td>
</tr>
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<td>2 22 (4)</td>
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<td>75,036</td>
<td>1</td>
<td>0 1 (2)*</td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>0 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>0 29 (5)</td>
</tr>
</tbody>
</table>

* Fish captured more than once were only counted once in totals.
Table 6.—Summary of recovered adult fall chinook salmon marked at McNary Dam in 1986 (recoveries through February 1993). Numbers in parentheses represent fish that were jaw-tagged at the dam and subsequently recovered upstream.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number released</th>
<th>Ocean age</th>
<th>Observed adult returns</th>
<th>Stream surveys</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ocean fishery</td>
<td>Bonneville Dam fishery</td>
<td>Indian Dam fishery</td>
<td>Priest R. Dam</td>
</tr>
<tr>
<td>Transport</td>
<td>114,653</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>28</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>42</td>
<td>0</td>
<td>17</td>
</tr>
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<td></td>
<td>4</td>
<td>84</td>
<td>56</td>
<td>(16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>9</td>
<td>4</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>165</td>
<td>64</td>
<td>(18)</td>
<td>53</td>
</tr>
<tr>
<td>Control</td>
<td>115,991</td>
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<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>11</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>24</td>
<td>0</td>
<td>9</td>
</tr>
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<td>19</td>
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<td></td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>55</td>
<td>17</td>
<td>(4)</td>
<td>16</td>
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</tbody>
</table>

* Fish captured more than once were only counted once in totals.
Table 7.—Summary of T/Cs and 95% CIs for adult recoveries of fall chinook salmon marked as smolts at McNary Dam in 1986.

<table>
<thead>
<tr>
<th>Recovery site</th>
<th>T/C</th>
<th>Empirical 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean fishery</td>
<td>3.0</td>
<td>(1.7, 5.4)</td>
</tr>
<tr>
<td>River fishery</td>
<td>3.4</td>
<td>(1.8, 6.2)</td>
</tr>
<tr>
<td>Bonneville Dam</td>
<td>3.8</td>
<td>(1.3, 11.1)</td>
</tr>
<tr>
<td>Indian fishery</td>
<td>3.1</td>
<td>(1.2, 7.8)</td>
</tr>
<tr>
<td>Hatcheries</td>
<td>1.5</td>
<td>(0.4, 8.9)</td>
</tr>
<tr>
<td>Spawning grounds</td>
<td>3.3</td>
<td>(---, ---)*</td>
</tr>
<tr>
<td>Combined</td>
<td>2.8</td>
<td>(1.4, 5.6)</td>
</tr>
</tbody>
</table>

* Insufficient adult recoveries to estimate.
1986 study results using expanded catch data provided by the Pacific States Marine Fisheries Commission. The effect of expansion on data symmetry was trivial. This is not surprising since both test groups represented the same population, and considering the nature of subyearling salmon migrations, their time of ocean entry was likely similar.

Adult recoveries of fall chinook salmon released in 1987 total 371 transports (0.5% of the release) and 101 controls (0.2% of the release) (Appendix Tables 10.0 through 11.7 and Table 8). These preliminary data indicate a substantial survival benefit for transported fish. When recoveries of age-5-ocean adults and other late-arriving data are processed, we will provide a statistical analysis of the results.

There are only a few returns from the 1988 study year, with 52 transport and 12 control fish recaptured (Appendix Tables 12.0 through 13.6 and Table 8). We expect to receive many more CWT recoveries from this study within the next 2 to 3 years.

STEELHEAD RELEASE-SITE STUDY

Introduction

There is a growing body of evidence suggesting that survival of juvenile salmonids can be enhanced by releasing them into upper areas of estuaries rather than farther upstream in freshwater areas. In Scandanavian countries, releases of hatchery-reared Atlantic salmon (Salmo salar) smolts directly into estuarine waters have resulted in increased survival
Table 8.--Preliminary summary of recovered adult fall chinook salmon marked at McNary Dam in 1987 and 1988 (recoveries through February 1993). Numbers in parentheses represent fish that were jaw-tagged at the dam and subsequently recovered upstream.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number released</th>
<th>Ocean-age</th>
<th>Ocean - Bonneville Dam</th>
<th>River - Indian Rapids Dam</th>
<th>Indian Dam fishery</th>
<th>Priest Dam fishery</th>
<th>Hatcheries</th>
<th>Stream surveys</th>
<th>Total N</th>
<th>%</th>
</tr>
</thead>
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<tr>
<td>1987</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
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<td>2</td>
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<td>6</td>
<td>7</td>
<td>0</td>
<td>8</td>
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<td>38 (12)</td>
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<td></td>
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<td>46</td>
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<td>31</td>
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<td>4</td>
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<td>26</td>
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</tr>
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</tr>
<tr>
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<td>8</td>
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<td>4</td>
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<td>1</td>
<td>1</td>
<td>12*</td>
<td>0.02</td>
<td></td>
</tr>
</tbody>
</table>

* Fish captured more than once were only counted once in totals.
compared to similar releases in fresh water (Gunnerod et al. 1988). Macdonald et al. (1988) and Levings et al. (1989) speculated that increased survival of salmonid juveniles released into estuarine areas was related to decreased predation and stress, increased food availability, and ease of osmoregulation in the estuary. In a 5-year study, Solazzi et al. (1991) released hatchery-reared coho salmon (*O. kisutch*) immediately below Bonneville Dam (control), at Tongue Point (upper intrusion of salt water in the estuary), and at several locations farther into the Columbia River plume. They reported a survival rate 1.6 times higher for fish released at Tongue Point than for the control group.

After release at the site immediately below Bonneville Dam, smolts transported from the Snake River must migrate approximately 150 km through the lower Columbia River before arriving at the estuary. Although the river is free-flowing in this reach, the area is known to harbor large numbers of predators, primarily northern squawfish (*Ptychocheilus oregonensis*) and various avian species. The studies mentioned above suggest that mortality from predation alone may be of sufficient magnitude to warrant the additional transport distance.

In spring 1992, we began a study to determine if steelhead smolts transported by barge and released in the upper estuary at Tongue Point will return as adults to Lower Granite Dam in significantly greater numbers than those transported by barge and
released at the traditional site near Skamania Light just downstream from Bonneville Dam. Spring/summer chinook salmon were not included in the present study because excessively large numbers of marked smolts are required to detect small differences in survival for this species. Depending upon the results of the study for steelhead, spring/summer chinook salmon may be tested in the future. Results of the first year of marking and release are reported here.

Methods

All sampling and marking was conducted using a new fish-handling system that we designed and installed adjacent to the upstream (new) raceways at Lower Granite Dam. The system included a preanesthesia handling method (Matthews et al. 1986). With the new facilities, the large numbers of smolts required for transportation research were sorted and marked without impacting other sampling and fish-handling activities at the collection facility. Fish used in the study were systematically sampled from the population passing from the fish and debris separator at the juvenile fish collection and handling facility. Two of the upstream raceways were used to collect and hold sampled fish prior to marking.

Much of the basic marking methodology was the same as previously described (Matthews et al. 1987). Sufficient numbers of smolts were marked to test a T/C of 1.1 with a coefficient of variation of 5.0%. For this study, the Tongue Point releases
were considered test groups and Skamania Light releases were considered control groups. Fish for each release lot were marked and transferred into a raceway during one day, and loaded onto a barge the next day. For the Tongue Point releases, additional fish were loaded onto the 2000-series barges so that hauling densities approached those on the barge used for the Skamania Light releases. Samples of marked smolts were held periodically for 24 hours to measure post-marking delayed mortality and tag loss.

Both older, 2000-series barges plus an additional tugboat were required for this study. Each of the 2000-series barges was used in tandem with a larger barge for the trip from Lower Granite Dam to Bonneville Dam. Once at Bonneville Dam, the additional tugboat moved each 2000-series barge, with the test group (Tongue Point release), downstream to the release site. The tug returned the empty barge to Bonneville Dam for reattachment to a larger barge returning to Lower Granite Dam. The 2000-series barges were used only for the Tongue Point releases because their compartments cannot be emptied independently. The Skamania Light releases were transported in and released from barges used during normal transport operations. The marking was scheduled so that 2000-series barges were at opposite ends of the transport cycle at any given time.

Adults will be recovered in each of 3 years following the juvenile releases. Lower Granite Dam will be the primary evaluation point. Statistical analysis of the results will be
the same as previously described for the other transportation studies.

Results and Discussion

Between 1 and 20 May, we marked 7 release lots of approximately 19,000 steelhead each with CWTs, freeze brands, and left ventral fin clips, for a total of 135,661 marked fish (Appendix Table 14.0). Lots consisted of approximately 10,000 steelhead smelts each for release at Skamania Light and 9,000 steelhead smelts each for release in the upper estuary near Tongue Point. Both test groups of fish marked on 3 May were released at Skamania Light in order to expedite the return of both barges to Lower Granite Dam. The barges were needed for mass transport of an unexpectedly large number of smolts that had arrived at the dam. Therefore, adult returns from the 3 May releases will not be used to calculate survival ratios. To satisfy the experimental design, an additional release lot of each group was subsequently marked and released.

Post-marking delayed mortality and tag loss were low, averaging 0.7% and 0.5%, respectively (Appendix Table 15.0). The delayed mortality value is one of the lowest we have measured for handled/ marked steelhead smolts. The new, temporary handling/ marking system at Lower Granite Dam performed exceptionally well, giving us the capability of safely handling and marking very large numbers of smolts.

To complete the study, we need to mark steelhead smolts from
at least two additional outmigrations. Assuming no delays or other complications, complete adult returns for the 3-year study would be available in spring 1998.
REFERENCES


Appendix A

Data Tables
Appendix Table 1.0.--Summary of all recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam in 1989.

Master File Date : 22 February 1993
RELEASE GROUPS INCLUDED: 8907A 8907B 8907C 8907D 8907F 8907G 8907H 8907I 8907J 8907K 8907L

1989 L. GRANITE TRANS CONTROL BELOW L. GOOSE
SPRING CHINOOK

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<td>RIVER SYSTEM TRAPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bonneville Trap</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0.002</td>
</tr>
<tr>
<td>Lower Granite Trap</td>
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<td>2</td>
<td>15</td>
<td>11</td>
<td>0</td>
<td>28</td>
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<tr>
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<td>2</td>
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<td>RIVER SPORT</td>
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<td>2</td>
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<td>3</td>
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</tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Dworska H.</td>
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<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Passingeri H.</td>
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<td>3</td>
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<td>0</td>
<td>3</td>
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<td>3</td>
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<td>1</td>
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</tr>
</tbody>
</table>

TOTALS                          | 0    | 5              | 27   | 18   | 0    | 50   | 0.047 |

PERCENT OF RECOVERY             | %    | 0.0            | 10.0 | 54.0 | 36.0 | 0.0  |
Appendix Table 1.1.--Recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam from 7 to 14 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8907A

1989 L. GRANITE TRANS CONTROL BELOW L. GOOSE SPRING CHINOOK

Brands Used: L42, J
Wire Codes Used: 232256

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Appendix Table 1.2.--Recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam from 14 to 16 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8907B

1989 L. GRANITE TRANS CONTROL BELOW L. GOOSE SPRING CHINOOK

Brands Used: LA2 2
Wire Codes Used: 232258

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NUMBER RELEASED: 10085
Appendix Table 1.3.--Recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam from 17 to 18 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8907C

1989 L. GRANITE TRANS CONTROL BELOW L. GOOSE SPRING CHINOOK

- Brads Used: LA2 2
- Wire Codes Used: 22349

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**PERCENT OF RECOVERY**

- 1989: 0.0%
- 1990: 0.0%
- 1991: 66.7%
- 1992: 33.3%
- 1993: 0.0%

NUMBER RELEASED: 19831
Appendix Table 1.4.—Recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam from 20 to 21 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8907D

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Appendix Table 1.5.—Recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam from 21 to 22 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 89078

1989 L.GRANITE TRANS CONTROL BELOW L.GOOSE SPRING CHINOOK

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Appendix Table 1.6.--Recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam on 24 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 89076

1989 L.GRANITE TRANS CONTROL BELOW L.GOOSE
SPRING CHINOOK

Brands Used: LAT3
Wire Codes Used: 232111

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PERCENT OF RECOVERY % 0.0 0.0 66.7 33.3 0.0

NUMBER RELEASED: 10123
Appendix Table 1.7.--Recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam from 25 to 26 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 89072

1989 L.GRANITE TRANS CONTROL

BILIAS GROUPS INCLUDED: 89072
1989 L.GRANITE TRANS CONTROL BELOW L.GOOSE SPRING CHINOOK

Brands Used: LART4
Wire Codes Used: 232412

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NUMBER RELEASED: 10005
Appendix Table 1.8.--Recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam from 26 to 28 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 89071

1989 L.GRANITE TRANS CONTROL BELOW L.GOOSE SPRING CHINOOK

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Appendix Table 1.9.—Recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam from 28 April to 11 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 88073

1989 L.GRANITE TRANS CONTROL BELOW L.GOOSE SPRING CHINOOK

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Appendix Table 1.10.—Recoveries of adult spring chinook salmon released as juveniles below Little Goose Dam on 27 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8607L

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Number Released: 1129
Appendix Table 2.0—Summary of all recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam in 1989.

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Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8908A 8908B 8908C 8908D 8908E 8908F 8908G 8908H 8908I 8908J 8908K 8908L

1989 L. GRANITE TRANS BARGE BELOW BONNEVILLE SPRING CHINOOK
Appendix Table 2.1.—Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam from 11 to 13 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8908A

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NUMBER RELEASED: 7083
Appendix Table 2.2.--Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam from 15 to 17 April 1989.

Master File Date: 22 February 1993.
RELEASE GROUPS INCLUDED: 69388

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NUMBER RELEASED: 7439
Appendix Table 2.3.--Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam on 18 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 6500C

1989 L.GRANITE TRANS BARGE
SPRING CHINOOK

Below Bonneville

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NUMBER RELEASED: 7057
Appendix Table 2.4.--Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam from 19 to 22 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8908D

1989 LOWER GRANITE TRANSPORTED BARGE SPRING CHINOOK

Below Bonneville Dam

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Number released: 7003
Appendix Table 2.5.--Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam on 22 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8908

1989 L.GRANITE TRANS BARGE SPRING CHINOOK

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<td>0.000</td>
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PERCENT OF RECOVERY % 0.0 0.0 60.0 40.0 0.0

NUMBER RELEASED: 7019
Appendix Table 2.6.--Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam on 23 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 88089

1989 L. GRANITE TRAN BARGE BELOW BONNEVILLE SPRING CHINOOK

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<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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NUMBER RELEASED: 7155
Appendix Table 2.7.--Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam from 24 to 25 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 69066

1989 L.GRANITE TRANS BARGE BELOW BONNEVILLE SPRING CHINOOK

Brands Used: RAG 3
Wire Codes Used: 232312

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<td>3</td>
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| PERCENT OF RECOVERY      | 0.0  | 0.0            | 66.7 | 33.3 | 0.0  |      |       |          |

NUMBER RELEASED: 7100
Appendix Table 2.8.--Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam from 25 to 26 April 1989.

Master File Date : 22 February 1993
RELEASE GROUPS INCLUDED: 88084

1989 L. GRANITE TRANS BARGE

BILIASI GROUPS IRCODID: 89084
BELOW BONNEVILLE
SPRING CHINOOK

Brands Used: RA9.4
Wire Codes Used: 232313

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NUMBER RELEASED: 7000
Appendix Table 2.9.—Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam from 26 to 27 April 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 89081

1989 L.GRANITE TRANS BARGE SPRING CHINOOK

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NUMBER RELEASED: 7095
Appendix Table 2.10.—Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam from 1 to 10 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 89883

1989 L.GRANITE TRANS BARGE BELOW BONNEVILLE SPRING CHINOOK

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Number Released: 7000
Appendix Table 2.11.—Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam from 10 to 25 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 89081

1989 L.GRANITE TRANS BARGE SPRING CHINOOK

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NUMBER RELEASED: 3435
Appendix Table 2.12.—Recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam on 30 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8908-L

1989 L.GRANITE TRANS BARGE BELOW BONNEVILLE SPRING CHINOOK

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Wire Codes Used: 232251

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PERCENT OF RECOVERY  | %    | 0.0            | 50.0 | 0.0  | 50.0 | 0.0  |        |

NUMBER RELEASED: 909
Appendix Table 3.0.—Summary of all recoveries of adult spring chinook salmon transported as juveniles from Lower Granite Dam to below Bonneville Dam in 1990.

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<td>4</td>
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Number Released: 44708
Appendix Table 3.1.—Recoveries of adult spring chinook salmon transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 13 to 18 April 1990.

**1990 L. GRANITE TRANS BARGE**

**SPRING CHINOOK**

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Appendix Table 3.2.--Recoveries of adult spring chinook salmon transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 17 to 21 April 1990.

Master File Date : 22 February 1993
RELEASE GROUPS INCLUDED: 90066

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NUMBER RELEASED: 7000
Appendix Table 3.3.--Recoveries of adult spring chinook salmon transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 21 to 25 April 1990.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 9006C

1990 L. GRANITE TRANS BARGE SPRING CHINOOK

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<th>1993</th>
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NUMBER RELEASED: 7000
Appendix Table 3.4.--Recoveries of adult spring chinook salmon transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 25 April to 2 May 1990.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: B086D

1990 L. GRANITE TRANS BARGE

SPRING CHINOOK

Brands Used: RAY 1
Wire Codes Used: 232432

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Appendix Table 3.5.—Recoveries of adult spring chinook salmon transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 2 to 14 May 1990.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 5006X

1990 L. GRANITE TRANS BARGE BELOW BONNEVILLE SPRING CHINOOK

Brands Used: DAY 2
Wire Codes Used: 22433

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<th>1993</th>
<th>TOTAL % RETURN</th>
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| PERCENT OF RECOVERY        | 0.0  | 5.6            | 94.4 | 0.0  |

NUMBER RELEASED: 7000
Appendix Table 3.6.--Recoveries of adult spring chinook salmon transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 14 to 29 May 1990.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 90066

1990 L.GRANITE TRANS BARGE BELOW BONNEVILLE SPRING CHINOOK

Brands Used: RAY 3
Wire Codes Used: 232434

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Appendix Table 3.7.--Recoveries of adult spring chinook salmon transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 29 May to 8 June 1990.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 80066

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NUMBER RELEASED: 2708
Appendix Table 4.0.—Summary of all recoveries of adult steelhead released as juveniles below Little Goose Dam in 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8909A 8909B 8909C 8909D 8909E 8909F

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Brands Used: LA3.1 LA3.2 LA3.3 LA3.4 LA2.1 LA2.2
Wire Codes Used: 232343 232345 232346 232347 232353 232028

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| TOTALS | 0 | 50 | 106 | 5 | 0 | 161 | 0.381 |
| PEERCENT OF RECOVERY | % | 0.0 | 31.1 | 65.8 | 3.1 | 0.0 |

NUMBER RELEASED: 42259
Appendix Table 4.1.—Recoveries of adult steelhead released as juveniles below Little Goose Dam from 21 April to 2 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8909A

1989 L. GRANITE TRANS CONTROL BELOW L. GOOSE STEELHEAD

Brands Used: [43]
Wire Codes Used: 232343

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NUMBER RELEASED: 7003
Appendix Table 4.2.—Recoveries of adult steelhead released as juveniles below Little Goose Dam from 4 to 6 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 89098

1989 L. GRANITE TRANS CONTROL BELOW L. GOOSE STEELHEAD

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NUMBER RELEASED: 7049
Appendix Table 4.3.--Recoveries of adult steelhead released as juveniles below Little Goose Dam from 9 to 11 May 1989.

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Appendix Table 4.4.--Recoveries of adult steelhead released as juveniles below Little Goose Dam from 13 to 16 May 1989.

**Master File Date:** 22 February 1993  
**RELEASE GROUPS INCLUDED:** 8885D  

**1989 LOWER GRANITE TRANS CONTROL BELOW L.GOOSE STEELHEAD**

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Appendix Table 4.5.--Recoveries of adult steelhead released as juveniles below Little Goose Dam from 18 to 20 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8909K

1989 L.GRANITE TRANS CONTROL BELOW L.GOOSE STEELHEAD

Brands Used: LA7.1
Wire Codes Used: 232353

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Appendix Table 5.0.—Summary of all recoveries of adult steelhead transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam in 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8910A 8910B 8910C 8910D 8910E 8910F

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Appendix Table 5.1.--Recoveries of adult steelhead transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 25 April to 3 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8910A

1989 L. GRANITE TRANS BARGE BELOW BONNEVILLE STEELHEAD

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Appendix Table 5.2.--Recoveries of adult steelhead transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 3 to 5 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8910B

BILIASI GROUPS INCLUDED: 8910

1989 L. GRANITE TRANS BARGE BELOW BONNEVILLE STEELHEAD

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Appendix Table 5.3.—Recoveries of adult steelhead transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 8 to 10 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8910C

1989 L.GRANITE TRANS BARGE BELOW BONNEVILLE STEELHEAD

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Appendix Table 5.4.--Recoveries of adult steelhead transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 12 to 15 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 89100

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PERCENT OF RECOVERY % 0.0 21.4 78.6 0.0 0.0
Appendix Table 5.5.--Recoveries of adult steelhead transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 17 to 19 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 89102

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Appendix Table 5.6.—Recoveries of adult steelhead transported as juveniles by barge from Lower Granite Dam to below Bonneville Dam from 23 to 25 May 1989.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8910P

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Appendix Table 6.0.—Summary of recoveries of all adult spring chinook salmon released as juveniles below McNary Dam in 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8802A 8802B 8802C 8802D 8802F 8802G 8802H 8802I 8802J

1988 McNary Trans Control Below McNary Spring Chinook

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Note: The data includes recoveries from 1988 through 1993, with totals and percentages calculated accordingly.
Appendix Table 6.1.--Recoveries of adult spring chinook salmon released as juveniles below McNary Dam from 8 to 16 April 1988.

Master File Date: 22 February 1993
Release Groups Included: 8802A

**1988 McNARY TRANS CONTROL BELOW McNARY**

SPRING CHINOOK

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Number Released: 7504
Appendix Table 6.2.--Recoveries of adult spring chinook salmon released as juveniles below McNary Dam from 16 April to 1 May 1988.

Master File Date: 22 February 1993
Release Groups Included: B802B

1988 McNARY TRANS CONTROL BELOW McNARY
SPRING CHINOOK

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Wire Code Used: 232227

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Appendix Table 6.3.--Recoveries of adult spring chinook salmon released as juveniles below McNary Dam from 1 to 6 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: G002C

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Appendix Table 6.4.—Recoveries of adult spring chinook salmon released as juveniles below McNary Dam from 6 to 8 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8802D

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Appendix Table 6.5.--Recoveries of adult spring chinook salmon released as juveniles below McNary Dam from 8 to 10 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8802

| Recovery Area            | 1988 | YEAR OF RETURN | | | | TOTAL | % RETURN |
|--------------------------|------|----------------|---|---|---|---|---|---|
| RIVER SYSTEM TRAPS      |      |      |      |      |      |      | | |
| BONNEVILLE TRAP         | 0    | 0    | 1    | 0    | 0    | 0    | 1 | 0.013 |
| PRIEST RAPIDS TRAP      | 0    | 0    | 1    | 0    | 0    | 0    | 1 | 0.013 |
| OCEAN FISHERIES         | 0    | 0    | 0    | 0    | 0    | 0    | 0 | 0.000 |
| RIVER SPORT             |      |      |      |      |      |      | | |
| OXNATCHER R.            | 0    | 0    | 2    | 1    | 0    | 0    | 3 | 0.040 |
| RIVER COMMERCIAL        | 0    | 0    | 0    | 0    | 0    | 0    | 0 | 0.000 |
| INDIAN FISHERIES        | 0    | 0    | 0    | 0    | 0    | 0    | 0 | 0.000 |
| HATCHERIES              |      |      |      |      |      |      | | |
| LEAVENWORTH H.          | 0    | 0    | 1    | 0    | 0    | 0    | 1 | 0.013 |
| STREAM SURVEY           | 0    | 0    | 0    | 0    | 0    | 0    | 0 | 0.000 |
| **TOTALS**              | 0    | 0    | 5    | 1    | 0    | 0    | 6 | 0.080 |
| **PERCENT OF RECOVERY** | %    | 0.0  | 0.0  | 83.3 | 16.7 | 0.0  | 0.0 | |
Appendix Table 6.6.--Recoveries of adult spring chinook salmon released as juveniles below McNary Dam from 10 to 12 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 88027

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PERCENT OF RECOVERY  

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Master File Date: 22 February 1993
Release Groups Included: 8802

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Appendix Table 6.8.—Recoveries of adult spring chinook salmon released as juveniles below McNary Dam from 19 to 24 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 88021

1988 MCNARY TRANS CONTROL BELOW MCNARY

SPRING CHINOOK

| BRANDS USED: LAK 1 |
| WIRE CODES USED: 232234 |

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PERCENT OF RECOVERY % 0.0 0.0 100.0 0.0 0.0 0.0
Appendix Table 6.9.--Recoveries of adult spring chinook salmon released as juveniles below McNary Dam from 25 May to 2 June 1988.

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Appendix Table 7.0.—Summary of all recoveries of adult spring chinook salmon transported by barge from McNary Dam to below Bonneville Dam in 1988.

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Appendix Table 7.1.—Recoveries of adult spring chinook salmon transported as juvenile by barge from McNary Dam to below Bonneville Dam from 8 to 16 April 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8601A

1988 MCNARY TRANSPORTED AS JUVENILE BY BARGE FROM McNARY DAM TO BELOW BONNEVILLE DAM FROM 8 TO 16 APRIL 1988.

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Appendix Table 7.2.—Recoveries of adult spring chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 16 April to 1 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8801B

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Appendix Table 7.3.--Recoveries of adult spring chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 1 to 6 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8801C

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NUMBER RELEASED: 5002
Appendix Table 7.4.—Recoveries of adult spring chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 6 to 8 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8801D

1988 MCNARY TRANS BARGE BELOW BONNEVILLE SPRING CHINOOK

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NUMBER RELEASED: 5011
Appendix Table 7.5.--Recoveries of adult spring chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 8 to 10 May 1988.

Master File Date: 22 February 1993
Release Groups Included: 88018

1988 McNary Trans Barge Below Bonneville

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Percent of Recovery: 0.0 20.0 40.0 40.0 0.0 0.0
Appendix Table 7.6.--Recoveries of adult spring chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 10 to 12 May 1988.

Master File Date : 22 February 1993
RELEASE GROUPS INCLUDED: 6661F

1988 MCNARY TRANS BARGE BELOW BONNEVILLE
SPRING CHINOOK

| Brand Used: RAY 2 | Wire Codes Used: 232211 |

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| PERCENT OF RECOVERY         | %    | 0.0  | 0.0  | 100.0| 0.0  | 0.0  | 0.0   |          |
Appendix Table 7.7.—Recoveries of adult spring chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 12 to 15 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 88016

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NUMBER RELEASED: 5001
Appendix Table 7.8.--Recoveries of adult spring chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 15 to 19 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 88016

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Number Released: 5003
Appendix Table 7.9.—Recoveries of adult spring chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 19 to 25 May 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 88011

1988 MCNARY TRAN BARGE BELOW BONNEVILLE SPRING CHINOOK

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Wire Codes Used: 222244

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Appendix Table 7.10.--Recoveries of adult spring chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville dam from 25 May to 2 June 1988.

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Master File Date : 22 February 1993
RELEASE GROUPS INCLUDED: 08015

1988 MCNARY TRANS BARGE BELOW BONNEVILLE
SPRING CHINOOK

Number Released: 5002
Appendix Table 8.0.--Summary of all recoveries of adult fall chinook salmon released as juveniles below McNary Dam in 1986.

Master File Date : 22 February 1989.
RELEASE GROUPS INCLUDED: 8615A 8615B 8615C 8615D 8615E 8615F 8615G 8615H 8615I 8615J 8615K 8615L

1986 McNary Trans Control Below McNary Fall Chinook

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Appendix Table 8.1.—Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 11 to 18 June 1986.

Master File Date: 22 February 1993
Release groups included: 8615A

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Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8615C

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NUMBER RELEASED: 9972
Appendix Table 8.4.--Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 27 June to 8 July 1986.

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RELEASE GROUPS INCLUDED: 8615-A

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Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 6615f

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RELEASE GROUPS INCLUDED: 86156

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Appendix Table 8.8.--Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 21 to 22 July 1986.

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RELEASE GROUPS INCLUDED: 8615A

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NUMBER RELEASED: 9850
Appendix Table 8.9.--Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 22 to 23 July 1986.

| BRANDS USED: LA101 | WIRE CODES USED: 231937 |

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Master File Date : 22 February 1993
RELEASE GROUPS INCLUDED: 8615J

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**Release Groups Included:** 0615L

**Beginning File Date:** 22 February 1993

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**Number Released:** 5798
Appendix Table 9.0.--Summary of all recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam in 1986.

Master File Date: 22 February 1993
Release Groups Included: 8616A 8616B 8616C 8616D 8616E 8616F 8616G 8616H 8616I 8616J 8616K 8616L

1986 MCNARY TRANS BARGE BELOW BONNEVILLE FALL CHINOOK

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Appendix Table 9.1.--Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 11 to 18 June 1986.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8616A

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FALL CHINOOK

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Appendix Table 9.3.--Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 21 to 27 June 1986.

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Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8616C

Brands Used: 8A3J1
Wire Codes Used: 231926

Number Released: 9971
### Appendix Table 9.4.

Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 27 June to 8 July 1986.

**Master File Date: 22 February 1993**

**RELEASE GROUPS INCLUDED: 8616D**

**1986 MCNARY TRANS BARGE BELOW BONNEVILLE FALL CHINOOK**

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% Recovered: 0.0% 7.7% 9.6% 40.4% 38.5% 3.8%
Appendix Table 9.6.--Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 15 to 19 July 1986.

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Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8616F

NUMBER RELEASED: 9972

1986 MCNARY      TRANS BARGE      BELOW BONNEVILLE

FALL CHINOOK
Appendix Table 9.7.--Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 19 to 21 July 1986.

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Release Groups Included: 8616G

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Percent of Recovery: 0.0% 3.3% 6.7% 26.7% 60.0% 3.3%
Appendix Table 9.8.—Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 21 to 22 July 1986.

**Master File Date:** 22 February 1993  
**RELEASE GROUPS INCLUDED:** 86166

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Appendix Table 9.9.--Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 22 to 23 July 1986.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 66161

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PERCENT OF RECOVERY % | 0.0 | 0.0 | 4.5 | 20.5 | 63.6 | 11.4 |
Appendix Table 9.10.—Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 23 to 28 July 1986.

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RELEASE GROUPS INCLUDED: 86163

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Appendix Table 9.11.--Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 29 July to 1 August 1986.

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RELEASE GROUPS INCLUDED: 86564

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Appendix Table 9.12.--Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 1 to 7 August 1986.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8616L

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NUMBER RELEASED: 4527
Appendix Table 10.0.--Summary of all recoveries of adult fall chinook salmon released as juveniles below McNary Dam in 1987.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8708A 8708B 8708C 8708D 8708E 8708F 8708G

1987 McNary Trans Control Below McNary Fall Chinook

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Appendix Table 10.1.—Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 18 to 23 June 1987.

Master File Date: 22 February 1993
Release Groups Included: 8708A

1987 McNary | Trans Control | Below McNary
---|---|---
**FALL CHINOOK**

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Appendix Table 10.2.--Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 23 to 25 June 1987.

Master File Date: 22 February 1993
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Appendix Table 10.3.—Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 25 June to 1 July 1987.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8708C

FALL CHINOOK

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**Date:** 22 February 1993  
**Release Groups Included:** 8708D

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**Number Released:** 10000
Appendix Table 10.5.--Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 8 to 14 July 1987.

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Release Groups Included: 8708K

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Appendix Table 10.6.--Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 15 to 30 July 1987.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 6766F

1987 MCNARY TRANS CONTROL BELOW MCNARY
FALL CHINOOK

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Number Released: 9392
Appendix Table 10.7.--Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 30 July to 13 August 1987.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 87086

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PERCENT OF RECOVERY % 0.0  31.8  0.0  36.4  31.8  0.0
Appendix Table 11.0.—Summary of all recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam in 1987.

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Appendix Table 11.1.--Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 18 to 23 June 1987.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8706A

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Appendix Table 11.2.--Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 23 to 25 June 1987.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 87098

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Appendix Table 11.3.—Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 25 June to 1 July 1987.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8703C

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Appendix Table 11.4.—Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 1 to 8 July 1987.

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Appendix Table 11.5.—Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 8 to 14 July 1987.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 87088

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Appendix Table 11.7.—Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 30 July to 14 August 1987.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 87096

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Appendix Table 12.0.—Summary of all recoveries of adult fall chinook salmon released as juveniles below McNary Dam in 1988.

Master File Date: 22 February 1993
Release groups included: 8804A 8804B 8804C 8804D 8804E 8804F 8804G

1988 McNary Trans Control Below McNary Fall Chinook

Brands Used: LA71  LA72  LA73  LA74  LA75  LA76  LA77  LA78  LA79

Wire Codes Used: 232246  232247  232248  232249  232250  232245  232244

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Number Released: 60010
Appendix Table 12.1.--Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 13 to 21 June 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8804

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Master File Date: 22 February 1993
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RELEASE GROUPS INCLUDED: 8804D

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NUMBER RELEASED: 10002
Appendix Table 12.4.—Recoveries of adult fall chinook salmon released as juveniles below McNary Dam from 5 to 13 July 1988.

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8804

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Number Released: 5008
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Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8803B

1988 MCNARY TRANS BARGE BELOW BONNEVILLE

FALL CHINOOK

Brands Used: RAUD2
Wire Codes Used: 232251

NUMBER RELEASED: 10003
Appendix Table 13.3.—Recoveries of adult fall chinook salmon transported as juveniles by barge from McNary Dam to below Bonneville Dam from 23 to 26 June 1988.

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RELEASE GROUPS INCLUDED: 8803C

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RELEASE GROUPS INCLUDED: 8803E

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<th></th>
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<td>OCEAN FISHERIES</td>
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<td>ALASKA</td>
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<tr>
<td>BRITISH COLUMBIA</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
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<td>0.030</td>
</tr>
<tr>
<td>RIVER SPORT</td>
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<td></td>
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<td>COLOMBIA R. BELOW SNAKE R.</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>0.010</td>
</tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0.010</td>
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<tr>
<td>RIVER COMMERCIAL</td>
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<td>COMMERCIAL NET</td>
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<td>1</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<td>0.020</td>
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<tr>
<td>INDIAN FISHERIES</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>FALL INDIAN NET</td>
<td>0</td>
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<td>0</td>
<td>2</td>
<td>3</td>
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</tr>
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<td>HATCHERIES</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STREAK SURVEY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
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<td>GENERAL</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<td>0.010</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
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<td>2</td>
<td>2</td>
<td>9</td>
<td>6</td>
<td>0</td>
<td>19</td>
<td>0.190</td>
</tr>
<tr>
<td><strong>PERCENT OF RECOVERY</strong></td>
<td>%</td>
<td>0.0</td>
<td>10.5</td>
<td>10.5</td>
<td>47.4</td>
<td>31.6</td>
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</tbody>
</table>

Master File Date: 22 February 1993
RELEASE GROUPS INCLUDED: 8803F
Brands Used: RA103
Wire Codes Used: 232304
NUMBER RELEASED: 10002
Appendix Table 14.0.--Summary of steelhead marked at Lower Granite Dam for release site study in 1992.

<table>
<thead>
<tr>
<th>Replicate number</th>
<th>Release site</th>
<th>Marking period</th>
<th>Release date</th>
<th>Brand position, symbol, and orientation.</th>
<th>Wire-tag code</th>
<th>Number barged</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hatchery</td>
<td>Wild</td>
<td>Total</td>
</tr>
<tr>
<td>1</td>
<td>Tongue Pt.</td>
<td>1-2 May</td>
<td>4 May</td>
<td>RAL-1</td>
<td>23-24-45</td>
<td>8,400</td>
</tr>
<tr>
<td></td>
<td>Bonneville</td>
<td>1-2 May</td>
<td>4 May</td>
<td>LAF-1</td>
<td>23-24-19</td>
<td>8,527</td>
</tr>
<tr>
<td></td>
<td>Bonneville</td>
<td>3 May</td>
<td>6 May</td>
<td>RAL-2</td>
<td>23-24-46</td>
<td>7,128</td>
</tr>
<tr>
<td></td>
<td>Bonneville</td>
<td>3 May</td>
<td>6 May</td>
<td>LAF-2</td>
<td>23-24-16</td>
<td>9,613</td>
</tr>
<tr>
<td>2</td>
<td>Tongue Pt.</td>
<td>7-8 May</td>
<td>10 May</td>
<td>RAU-1</td>
<td>23-24-47</td>
<td>8,315</td>
</tr>
<tr>
<td></td>
<td>Bonneville</td>
<td>7-8 May</td>
<td>10 May</td>
<td>LAF-3</td>
<td>23-24-14</td>
<td>9,259</td>
</tr>
<tr>
<td>3</td>
<td>Tongue Pt.</td>
<td>9 May</td>
<td>12 May</td>
<td>RAU-2</td>
<td>23-24-48</td>
<td>7,873</td>
</tr>
<tr>
<td></td>
<td>Bonneville</td>
<td>9 May</td>
<td>12 May</td>
<td>LAF-4</td>
<td>23-24-18</td>
<td>8,912</td>
</tr>
<tr>
<td>4</td>
<td>Tongue Pt.</td>
<td>13 May</td>
<td>16 May</td>
<td>RAU-3</td>
<td>23-24-49</td>
<td>8,147</td>
</tr>
<tr>
<td></td>
<td>Bonneville</td>
<td>13 May</td>
<td>16 May</td>
<td>LAV-1</td>
<td>23-24-20</td>
<td>9,084</td>
</tr>
<tr>
<td>5</td>
<td>Tongue Pt.</td>
<td>15 May</td>
<td>18 May</td>
<td>RAU-4</td>
<td>23-24-50</td>
<td>7,986</td>
</tr>
<tr>
<td></td>
<td>Bonneville</td>
<td>15 May</td>
<td>18 May</td>
<td>LAV-2</td>
<td>23-24-21</td>
<td>8,915</td>
</tr>
<tr>
<td>6</td>
<td>Tongue Pt.</td>
<td>19-20 May</td>
<td>22 May</td>
<td>RAZ-1</td>
<td>23-24-44</td>
<td>8,738</td>
</tr>
<tr>
<td></td>
<td>Bonneville</td>
<td>19-20 May</td>
<td>22 May</td>
<td>LAV-3</td>
<td>23-24-22</td>
<td>9,547</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td>120,444</td>
</tr>
</tbody>
</table>

* RA and LA (position) indicate right and left anterior sides of fish, respectively.

b Orientation refers to rotation of brand around its center point.

c Both groups were released below Bonneville Dam because of an emergent need for the barges at Lower Granite Dam. Therefore, this release lot will not be used for statistical analysis of adult returns.
Appendix Table 15.0.—Mortality and tag loss of tagged steelhead held 24 hours at Lower Granite Dam in 1992.

<table>
<thead>
<tr>
<th>Date</th>
<th>Wire-tag code</th>
<th>Number held</th>
<th>Mortality</th>
<th>Lost tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 May</td>
<td>23-24-46</td>
<td>48</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3 May</td>
<td>23-24-16</td>
<td>53</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>7 May</td>
<td>23-24-47</td>
<td>52</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>7 May</td>
<td>23-24-14</td>
<td>48</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>9 May</td>
<td>23-24-48</td>
<td>50</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>9 May</td>
<td>23-24-18</td>
<td>50</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13 May</td>
<td>23-24-49</td>
<td>52</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13 May</td>
<td>23-24-20</td>
<td>51</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15 May</td>
<td>23-24-50</td>
<td>50</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>15 May</td>
<td>23-24-21</td>
<td>49</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 May</td>
<td>23-24-44</td>
<td>50</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 May</td>
<td>23-24-22</td>
<td>51</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>604</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Mortality and tag loss (%) 0.7 0.5
Appendix B

Scale Analysis Report
ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: Life History Studies of Spring and Summer Chinook Salmon and Steelhead from the Snake River Using Scale Analysis

CONTRACT NUMBER: 40ABNF201411


Prepared by: L.A. Borgerson

Oregon Department of Fish and Wildlife
2501 S.W. First Street
P.O. Box 59
Portland, Oregon 97207

This project was funded by the National Marine Fisheries Service under contract JFT-90-XX-1 with the U.S. Army Corps of Engineers.
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SUMMARY

Objectives for FY 1992

1. Determine the hatchery:wild ratios of transported and control spring and summer chinook salmon from scales of juveniles and adults sampled at Lower Granite Dam.

2. Determine the effects of transport on age at maturity, growth, migration timing, and other life history characteristics from scales of adult spring and summer chinook salmon and steelhead at Lower Granite Dam.

Accomplishments in FY 1992

We read the scales from 1,660 juvenile chinook salmon, 471 adult spring chinook salmon, and 314 adult summer chinook salmon from the run-at-large and classified their rearing origin as hatchery or wild. We examined scales from 13 spring chinook salmon, 3 summer chinook salmon, and 203 summer steelhead marked for the transportation study and tested for differences in life history and growth characteristics between transport and control groups.

Findings in FY 1992

We estimated that 11.6% (+2.7%) of the juvenile outmigration of spring and summer chinook salmon was wild, while 11.3% (+4.8%) of the spring chinook salmon and 35.8% (+6.3%) of the summer chinook salmon returning past Lower Granite Dam were wild fish. We found no differences in life history, migration timing, or growth between transported and control groups of chinook salmon. We found that transportation or natural migration may have differing effects on hatchery and wild summer steelhead.

INTRODUCTION

Since 1975, run sizes of spring and summer chinook salmon in the Snake River have decreased to historical lows with completion of Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams. The Columbia Basin Fish and Wildlife Authority has implemented a large-scale transportation program in an effort to eliminate mortality of juvenile salmonids caused by dam passage. Although decisions have been made to implement transport at near maximum levels, definitive data on survival benefits of transporting spring chinook salmon are lacking (Matthews et al. 1990). Transportation benefits for spring chinook salmon have been difficult to evaluate because of inadequate adult returns and unexplained variability in existing return data. This variation may be caused by unknown proportions of hatchery and wild fish in the experimental transport and control samples.

In 1988, the National Marine Fisheries Service (NMFS) began a pilot study to evaluate the feasibility of using PIT tagged wild spring chinook salmon to determine transportation benefits to wild fish. However, the 10% recovery rate for marked fish at Lower Granite Dam (LGD) makes this method
impractical in a large study because of the large volume of wild fish that would have to be tagged and the high cost of PIT tags.

Discriminant analysis (DA) of fish scale patterns is an accepted method of identifying hatchery or wild origins of salmon. Between 1978 and 1987, Oregon Department of Fish and Wildlife (ODFW) used DA to correctly classify 85-95% of hatchery and wild coho salmon caught in ocean fisheries off Oregon (Borgerson 1988). Fryer and Schwartzberg (1990) used DA to correctly classify 84-91% of hatchery and wild spring chinook salmon from the Deschutes, Wenatchee, Grande Ronde, and Imnaha rivers. DA will be used as an alternative method to estimate the wild and hatchery composition of the run-at-large as well as fish in the experimental transport and control groups for the NMFS transportation study.

Benefits of transport have been evaluated in terms of smolt-to-adult survival. Transport may have effects on the life history dynamics of the populations that need to be understood to evaluate fully the benefits of transport programs. It is reasonable to expect that fish that are transported 320 miles from LGD to below Bonneville Dam in 1-3 days and control fish that migrate volitionally the same distance in 20-60 days may differ in migration timing, growth, and age at maturity. Park (1985) found that steelhead transported from Little Goose and Lower Granite dams returned to hatcheries later than non-transported fish.

In 1991 we began scale analysis on returning adults and found that wild fish made up 20.1% and 54.3% of the spring and summer chinook salmon runs past LGD (Borgerson 1992), respectively. We also measured scale growth on chinook salmon and steelhead used in the 1989 transport experiment, but found no outstanding differences between control and transport groups. Comparing the wild fish component of the outmigrating juveniles to that of the returning adults from the same brood year will be of particular interest in future scale analyses.

METHODS

Scale Preparation and Reading

Scale collection involved three agencies and two tribes. Personnel from NMFS collected the mixed-stock groups of chinook salmon and steelhead from LGD. Personnel from Idaho Department of Fish and Game, ODFW, and the Nez Perce and Umatilla tribes collected the known origin scales used to develop the discriminant functions. We provided diagrams showing location of the key scale area (Nicholas and Van Dyke 1982) and sample procedures so all collections were sampled by the same methods.

Mixed-stock spring and summer chinook salmon from LGD were collected proportionally throughout the run-at-large. We selected sample sizes for all groups so that the analysis would yield a 95% confidence interval that was +25% of the point estimate (Worlund and Fredin 1962). Because the percentage of wild fish in the sample affects the size of the confidence interval, we started our study by assuming that wild fish would comprise 5-10% of the juvenile population and 20% of the adult population. Based on these criteria, we set the sample size requirements at 1,750 per group of juveniles and 550
per group of adults. All summer steelhead marked for the transportation study were sampled for scales.

We mounted the scales from LGD on gummed cards and made acetate impressions. Scales collected at other locations were mounted and pressed by the collecting agency. All collectors provided location, length, date, presence or absence of mark, and sex data for each sample.

We used an Apple IIc microcomputer, Altec digitizing board, and Scale Reader Program software (Mullen 1984) to measure and record scale measurements. The scale image was enlarged to 88x magnification using a microfiche reader. Measurements were made along a radius 200 to the anterior-posterior axis on the ventral side of the scale. We made two groups of measurements; one group consisted of extensive measurements in the freshwater zone on all chinook salmon scales used for the hatchery or wild DA (Figure 1). A second set of measurements was made on the portion of the scale that represented juvenile migration and early ocean residence of all chinook salmon and summer steelhead that were marked for the transportation study (Figure 2). After reading the scales, measurement data were transferred from the Apple IIc computer to an IBM-compatible computer for computation of additional variables (Table 1) and final analysis.

Hatchery or Wild Classification of Chinook Salmon

We used discriminant analysis to classify spring and summer chinook salmon by hatchery or wild origin. For discriminant analysis to provide meaningful results, the training populations of known origin samples used to develop the function must be representative of the groups within the unknown sample. We used samples scales from various streams based on the estimated contribution of fish from that stream to the overall population. For example, the wild spring chinook salmon training population was weighted so that 1/4 of the samples were from Oregon tributaries and 3/4 were from Idaho tributaries. The hatchery training populations were composed of scale samples in proportion to the release numbers from each hatchery and the approximate survival of the hatchery group. Appendix Table A contains a list of specific locations where scales used in training populations were collected.

Ideally, the samples making up the training populations would be from the same brood years as the samples in the unknown groups. Since field personnel were unable to collect sufficient known samples from any one year, we used as many known samples from the current brood years as were available and augmented the training populations with fish from previous brood years that were reared most similarly to current production strategies. With each new year of analysis, we add current year scales to the training populations and remove scales that are from the oldest brood years.

We developed three linear discriminant functions using BMDP Statistical Software 88 Release (Dixon et al. 1988). One function classified combined spring and summer chinook salmon juveniles. A second function classified adult spring chinook salmon, while the third was developed for adult summer chinook salmon. All three functions classified the fish according to hatchery or wild origin. Variables were added to or removed from the function in a step-wise method based on their F values. The juvenile chinook salmon
Figure 1. Measurements of scale growth used to discriminate between hatchery and wild chinook salmon. The scale is from a wild spring chinook salmon sampled in Capehorn Creek, tributary to North Fork of the Salmon River. Measurement labels are defined in Table 1.
Figure 2. Measurements of scale growth that occurred during juvenile migration and early ocean residence. The scale is from a hatchery reared summer steelhead marked as part of the control group for the transport study. Measurement labels are defined in Table 1.
Table 1. Definition of scale variables read or calculated.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Read:</strong></td>
<td></td>
</tr>
<tr>
<td>FWCC</td>
<td>Number of circuli in the freshwater zone.</td>
</tr>
<tr>
<td>NR</td>
<td>Radial measurement of the nucleus, also considered circulus 1.</td>
</tr>
<tr>
<td>FWANN</td>
<td>Radial measurement to the winter annulus of the freshwater zone.</td>
</tr>
<tr>
<td>FWRAD, OE</td>
<td>Radial measurement to the last circulus in the freshwater zone.</td>
</tr>
<tr>
<td>CC4-CC28</td>
<td>Radial measurements in 3 circuli increments between the fourth and 28th circuli of the freshwater zone.</td>
</tr>
<tr>
<td>SUMCC</td>
<td>Number of circuli between OE and the first annulus formed in the ocean.</td>
</tr>
<tr>
<td>OCANN</td>
<td>Radial measurement to the first annulus formed in the ocean.</td>
</tr>
<tr>
<td>OC4-OC25</td>
<td>Radial measurements in 3 circuli increments between the fourth and 25th circuli of the ocean zone.</td>
</tr>
<tr>
<td>B4</td>
<td>Radial measurement to the fourth circulus counted back into the freshwater zone from OE, inclusive.</td>
</tr>
<tr>
<td>B7</td>
<td>Radial measurement to the seventh circulus counted back into the freshwater zone from OE, inclusive.</td>
</tr>
<tr>
<td><strong>Calculated:</strong></td>
<td></td>
</tr>
<tr>
<td>BW1</td>
<td>Width of first band of 3 circuli, CC4-NR.</td>
</tr>
<tr>
<td>BW2</td>
<td>Width of second band of 3 circuli, CC7 - CC4.</td>
</tr>
<tr>
<td>BW123</td>
<td>Bandwidths 1, 2, and 3, CC10 - NR.</td>
</tr>
<tr>
<td>BW56</td>
<td>Bandwidths 5 and 6, CC19 - CC13.</td>
</tr>
<tr>
<td>FWANN2</td>
<td>FWANN - NR.</td>
</tr>
<tr>
<td>FWAVSP</td>
<td>Average circuli spacing in the freshwater zone, (FWRAD-NR)/(FWCC-1).</td>
</tr>
<tr>
<td>RID6</td>
<td>Ratio of bandwidths 1 and 6, (CC4-NR)/(CC19-CC16).</td>
</tr>
<tr>
<td>JM1</td>
<td>OE - B4.</td>
</tr>
<tr>
<td>JM2</td>
<td>B4 - B7.</td>
</tr>
<tr>
<td>OR1</td>
<td>OC4 - OE.</td>
</tr>
<tr>
<td>OR2</td>
<td>OC7 - OC4.</td>
</tr>
<tr>
<td>OR3</td>
<td>OC10 - OC7.</td>
</tr>
<tr>
<td>OR4</td>
<td>OC13 - OC10.</td>
</tr>
<tr>
<td>OR5</td>
<td>OC16 - OC13.</td>
</tr>
<tr>
<td>OR6</td>
<td>OC19 - OC16.</td>
</tr>
<tr>
<td>OR7</td>
<td>OC22 - OC19.</td>
</tr>
<tr>
<td>OR8</td>
<td>OC25 - OC22.</td>
</tr>
<tr>
<td>OET</td>
<td>OCANN-OE.</td>
</tr>
</tbody>
</table>
function contained four variables (FWANN2, FWAVSP, CC13, and BW123), the adult spring chinook function contained six variables (FWANN, FWAVSP, CC13, CC22, CC25, and BW2), and the summer chinook function contained five variables (FWANN, R12D67, BW1, CC13, and FWAVSP). For all functions, the variable FWANN, representing fish size at the end of the winter in fresh water, was the first variable selected and was the most powerful for discriminating between hatchery and wild fish.

Ideally, we would have tested the classification ability of our functions with additional sets of known origin samples, but that was not possible. Instead, we estimated correct classification using the cross validation method (Table 2). In 1991, we estimated the correct classification of our spring chinook salmon function using the jackknife method, provided by BMDP Statistical Software (Efron 1982), as well as the cross-validation and bootstrap methods (Efron and Tibshirani 1991) and found that cross validation provided the most conservative results.

After the run-at-large samples were classified, we corrected the results for misclassification and calculated confidence intervals using the methods of Worlund and Fredin (1962). A few fish that had been marked for the transportation study were within the run-at-large samples. We noted the percentage of wild fish within the marked transport and control groups, but we did not correct the estimate or calculate confidence intervals for these small subsamples.

Table 2. Two-way classification matrixes for the known hatchery and wild groups of spring and summer chinook salmon used to develop discriminant function in 1992.

<table>
<thead>
<tr>
<th>Stock</th>
<th>Wild</th>
<th>Hatchery</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Juvenile spring and summer chinook salmon</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Correct Classification</td>
<td>88.4</td>
<td>86.5</td>
<td>87.5</td>
</tr>
<tr>
<td>Sample size</td>
<td>216</td>
<td>215</td>
<td>431</td>
</tr>
<tr>
<td><strong>Adult spring chinook salmon</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Correct Classification</td>
<td>86.9</td>
<td>88.6</td>
<td>87.8</td>
</tr>
<tr>
<td>Sample size</td>
<td>160</td>
<td>175</td>
<td>335</td>
</tr>
<tr>
<td><strong>Adult summer chinook salmon</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Correct Classification</td>
<td>91.2</td>
<td>93.3</td>
<td>92.2</td>
</tr>
<tr>
<td>Sample size</td>
<td>125</td>
<td>119</td>
<td>244</td>
</tr>
</tbody>
</table>
Differences in Age Composition, Ocean Growth Rate, and Migration Timing Between Hatchery and Wild Fish Belonging to Experimental Transport and Control Groups

We determined the age of each fish by counting winter annuli. We used a contingency table to compare the age compositions of transport and control groups of chinook salmon and summer steelhead.

We used two-way analysis of variance on scale measurements representing ocean entrance timing and growth during juvenile migration and early ocean residence to test for significant differences ($p < .05$) between hatchery and wild fish that were transported or used as controls in the transportation study. Chinook salmon were included in either the hatchery or wild group based on the results of the discriminant analysis. For this analysis, spring and summer run fish were pooled together. Steelhead were identified as hatchery fish by having clipped fins. All steelhead released from hatcheries in the Snake River system are fin clipped; steelhead with no clipped fins were assumed to be wild. Chinook salmon and summer steelhead were identified as belonging to experimental transport and control groups by various freeze brands (Matthews et al. 1991). For this analysis we used all fish that were branded in 1989, including those that were sampled and analyzed in 1991 (Borgerson 1992).

To represent growth that occurred during early ocean residence, we used measurements of five-circuli bands beyond the ocean entrance check. To represent growth that occurred in the Snake and Columbia rivers during migration, we measured two bands of three circuli that immediately preceded the ocean entrance check (Figure 2). Depending on how quickly a fish migrated, these river bands may include growth from freshwater residence as well as migration.

We used the distance between the first winter annulus formed in the ocean and the ocean entrance check to index the time of ocean entrance. We assumed that the winter annulus was formed at the same time of the year for all fish so if the distance between the ocean entrance check and the annulus was large the fish had entered the ocean "early." A small distance would indicate "late" ocean entrance.

RESULTS AND DISCUSSION

Wild or Hatchery Classification of Chinook Salmon

Results from our hatchery or wild discriminant analysis are in Table 3. Juvenile scales were analyzed for the first time in 1992, while adult scales were analyzed in 1991 and 1992. In 1991 we found 20.1% and 54.6% wild fish in the spring and summer runs of adult chinook salmon, respectively. In contrast to the 1991 runs, we found lower percentages of wild fish in both the spring and summer runs of 1992, however, in both years the summer run contained a higher percentage of wild fish than the spring run.

Our estimate in 1992 for wild spring chinook salmon was lower than expected given the estimated run size, hatchery returns, and redd counts. The
Table 3. Percentage of wild fish in the spring and summer chinook salmon populations sampled at Lower Granite Dam in 1992.

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate (+ half-width of the 95% confidence interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juvenile spring and summer chinook salmon (Brood year 1990)</td>
<td>11.6% (+ 2.7%)</td>
</tr>
<tr>
<td>Adult spring chinook salmon (Brood years 1987-89)</td>
<td>11.3% (+ 4.8%)</td>
</tr>
<tr>
<td>Adult summer chinook salmon (Brood years 1987-89)</td>
<td>35.8% (+ 6.3%)</td>
</tr>
</tbody>
</table>

majority of the 1992 return migrated to the ocean in 1990 when it was observed that some wild juveniles migrated earlier and smaller in size than wild fish in other years (personal communication on 19 February 1993 with Gene Matthews, National Marine Fisheries Service, Seattle, Washington.) Given that our discriminant function was developed using wild scale patterns from several "average" years, we acknowledged that our function may not have classified the 1990 outmigrants properly. We ran several simulations using scale patterns that might result from earlier migrating and smaller juveniles to develop alternate discriminant functions, but did not find a significant change in our estimate.

In 1992, 16 fish with readable scales that had been branded in 1989 or 1990 for the transportation study were recovered at LGD. Of these fish, two (12.5%) were classified as wild. Pooling all branded fish recovered in 1991 and 1992 results in 3 fish branded in 1988 at McNary Dam, 43 fish branded in 1989 for transport and control groups at LGD, and 18 fish branded in 1990 for the barge transport index at LGD. The percentage of wild fish in each group is given in Table 4. The number of fish classified as wild for each individual brand applied at LGD is given in Appendix Table B. Branded fish are not separated into spring and summer runs in either table.

To compare branded groups (Table 4) to the run at large, we weighted the data from the spring and summer runs by the counts of fish over LGD (personal communication on 7 December 1992 with Jerrel Harmon, National Marine Fisheries Service, Pomeroy, Washington) and calculated that the combined run contained 33.8% wild fish in 1991 and 18.9% wild fish in 1992 for a two-year weighted average of 23.8% wild fish. The combined run at large contains both barged and naturally migrating fish.
Table 4. Percentage of wild fish in groups of fish branded and coded wire tagged for the transportation study, sampled at Lower Granite Dam in 1991 and 1992.

<table>
<thead>
<tr>
<th>Dam where marked</th>
<th>Mark year</th>
<th>Group</th>
<th>Percent wild</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>McNary</td>
<td>1988</td>
<td>Control</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>McNary</td>
<td>1988</td>
<td>Barge experiment</td>
<td>50.0</td>
<td>2</td>
</tr>
<tr>
<td>Lower Granite</td>
<td>1989</td>
<td>Control</td>
<td>21.4</td>
<td>14</td>
</tr>
<tr>
<td>Lower Granite</td>
<td>1989</td>
<td>Barge experiment</td>
<td>44.8</td>
<td>29</td>
</tr>
<tr>
<td>Lower Granite</td>
<td>1990</td>
<td>Barge index</td>
<td>33.3</td>
<td>18</td>
</tr>
</tbody>
</table>

Differences in Age Composition, Ocean Growth Rate, and Migration Timing Between Hatchery and Wild Fish Belonging to Experimental Transport and Control Groups

We found no significant differences between the age compositions of transport and control groups of chinook salmon ($X^2 = 0.904, p = 0.6363$) or summer steelhead ($X^2 = 7.720, p = 0.4553$). Age compositions for fish used in transportation studies at LGD are given in Table 5. For chinook salmon, 3-year-old fish were recovered one year before scale sampling began so the number given in Table 5 for age 3 is taken from Appendix Tables 2.0 and 3.0 by Matthews et al. (1991).

We found no differences ($p < .05$) in any scale parameter between groups of barged and control chinook salmon. Also, there were no differences in scale variables representing early ocean growth and migration timing between hatchery and wild chinook salmon. Means of variables analyzed are in Table 6.

We found significant differences in three variables between groups of barged and control of steelhead (Table 7). The variable OR1 represents growth occurring immediately after ocean entrance and soon after migration or transport. The other two significant variables, OR4 and OR5, occur later in time, probably near the middle of the summer. The two variables, OR2 and OR3, which represent growth during the time between OR1 and OR4, were not significant and cast some doubt as to how transporting could truly influence OR4 and OR5 when it did not influence these two variables. We found significant differences in most variables between hatchery and wild fish. Wild steelhead appeared to enter the ocean earlier than hatchery fish and once in the ocean had better growth rates than hatchery fish.
Table 5. Age composition of spring and summer chinook salmon and summer steelhead marked for the transportation study in 1989 and recovered through November 1992 at Lower Granite Dam.

<table>
<thead>
<tr>
<th>Total age</th>
<th>Life historya (Freshwater/Ocean)</th>
<th>Transport Number</th>
<th>Transport Percent</th>
<th>Control Number</th>
<th>Control Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring and summer chinook salmon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1/1</td>
<td>3</td>
<td>9.4</td>
<td>2</td>
<td>11.1</td>
</tr>
<tr>
<td>4</td>
<td>1/2</td>
<td>24</td>
<td>75.0</td>
<td>15</td>
<td>83.3</td>
</tr>
<tr>
<td>5</td>
<td>1/3</td>
<td>5</td>
<td>15.6</td>
<td>1</td>
<td>5.6</td>
</tr>
<tr>
<td>Summer steelhead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1/1</td>
<td>25</td>
<td>17.2</td>
<td>21</td>
<td>24.1</td>
</tr>
<tr>
<td>4</td>
<td>2/1</td>
<td>5</td>
<td>3.4</td>
<td>5</td>
<td>5.7</td>
</tr>
<tr>
<td>5</td>
<td>3/1</td>
<td>2</td>
<td>1.4</td>
<td>2</td>
<td>2.3</td>
</tr>
<tr>
<td>4</td>
<td>1/2</td>
<td>91</td>
<td>62.8</td>
<td>50</td>
<td>57.5</td>
</tr>
<tr>
<td>5</td>
<td>2/2</td>
<td>20</td>
<td>13.8</td>
<td>7</td>
<td>8.0</td>
</tr>
<tr>
<td>6</td>
<td>3/2</td>
<td>2</td>
<td>1.4</td>
<td>1</td>
<td>1.2</td>
</tr>
<tr>
<td>5</td>
<td>1/3</td>
<td>0</td>
<td>--</td>
<td>1</td>
<td>1.2</td>
</tr>
</tbody>
</table>

a Number of freshwater annuli/number of ocean annuli.

Table 6. Two-way analysis of variance and group means for scale variables representing growth during juvenile migration (JM) and early ocean residence (OR), and ocean entrance timing (OET) for adult spring and summer chinook salmon from the transportation study sampled at Lower Granite Dam in 1991.

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Wild Transport</th>
<th>Wild Control</th>
<th>Means</th>
<th>Hatchery Transport</th>
<th>Hatchery Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>JM1</td>
<td>61.7</td>
<td>59.3</td>
<td></td>
<td>60.2</td>
<td>56.0</td>
</tr>
<tr>
<td>JM2</td>
<td>57.1</td>
<td>55.7</td>
<td></td>
<td>55.2</td>
<td>47.8</td>
</tr>
<tr>
<td>OR1</td>
<td>84.1</td>
<td>97.0</td>
<td></td>
<td>93.5</td>
<td>99.3</td>
</tr>
<tr>
<td>OR2</td>
<td>108.1</td>
<td>106.7</td>
<td></td>
<td>118.6</td>
<td>110.9</td>
</tr>
<tr>
<td>OR3</td>
<td>106.3</td>
<td>104.0</td>
<td></td>
<td>112.1</td>
<td>105.7</td>
</tr>
<tr>
<td>OR4</td>
<td>104.1</td>
<td>116.7</td>
<td></td>
<td>99.6</td>
<td>107.9</td>
</tr>
<tr>
<td>OR5</td>
<td>108.9</td>
<td>118.0</td>
<td></td>
<td>114.0</td>
<td>106.5</td>
</tr>
<tr>
<td>OR6</td>
<td>110.7</td>
<td>100.0</td>
<td></td>
<td>109.5</td>
<td>107.8</td>
</tr>
<tr>
<td>OET</td>
<td>789.8</td>
<td>763.0</td>
<td></td>
<td>724.9</td>
<td>759.0</td>
</tr>
<tr>
<td>Sample size</td>
<td>13</td>
<td>3</td>
<td></td>
<td>16</td>
<td>11</td>
</tr>
</tbody>
</table>
Table 7. Two-way analysis of variance and group means for scale variables representing growth during juvenile migration (JM) and early ocean residence (OR), and ocean entrance timing (OET) for adult summer steelhead from the transportation study sampled at Lower Granite Dam in 1991.

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Means</th>
<th>Significant differences (p &lt; .05)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wild Transport</td>
<td>Control</td>
</tr>
<tr>
<td>JM1</td>
<td>58.4</td>
<td>60.7</td>
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<tr>
<td>JM2</td>
<td>53.8</td>
<td>58.1</td>
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<tr>
<td>OR1</td>
<td>83.0</td>
<td>94.0</td>
</tr>
<tr>
<td>OR2</td>
<td>100.1</td>
<td>99.9</td>
</tr>
<tr>
<td>OR3</td>
<td>104.7</td>
<td>112.6</td>
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<td>OR4</td>
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<td>109.7</td>
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<tr>
<td>OR5</td>
<td>101.1</td>
<td>111.0</td>
</tr>
<tr>
<td>OR6</td>
<td>108.3</td>
<td>118.2</td>
</tr>
<tr>
<td>OR7</td>
<td>112.6</td>
<td>110.7</td>
</tr>
<tr>
<td>OR8</td>
<td>113.7</td>
<td>113.3</td>
</tr>
<tr>
<td>OET</td>
<td>747.3</td>
<td>804.9</td>
</tr>
</tbody>
</table>

Sample size 28 14 112 72

PLANS FOR 1993

We will repeat all work accomplished in 1992 with the exception that the hatchery-wild discrimination work on chinook salmon juveniles will be reduced. All chinook salmon juveniles released from hatcheries during the spring of 1993 will be fin clipped. It will not be necessary to use scales to identify hatchery or wild origin. However, we plan to analyze scales from 800 juveniles to test our technique and maintain a continuous data set.
REFERENCES


APPENDIX TABLE A

Stock composition of training populations used to develop discriminant functions for classifying spring and summer chinook salmon of unknown origin.
Appendix Table A. Stock composition of training populations used to develop discriminant functions for classifying spring and summer chinook salmon of unknown origin.

<table>
<thead>
<tr>
<th>Training population location</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Juvenile Spring and Summer Chinook Salmon</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hatchery:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearwater</td>
<td>3</td>
<td>1.4</td>
</tr>
<tr>
<td>Dworshak</td>
<td>50</td>
<td>23.3</td>
</tr>
<tr>
<td>Lookingglass (Imnaha)</td>
<td>11</td>
<td>5.1</td>
</tr>
<tr>
<td>Lookingglass (Grande Ronde)</td>
<td>19</td>
<td>8.8</td>
</tr>
<tr>
<td>McCall</td>
<td>15</td>
<td>7.0</td>
</tr>
<tr>
<td>Pahsimeroi</td>
<td>14</td>
<td>6.5</td>
</tr>
<tr>
<td>Powell</td>
<td>6</td>
<td>2.8</td>
</tr>
<tr>
<td>Rapid River</td>
<td>42</td>
<td>19.5</td>
</tr>
<tr>
<td>Red River</td>
<td>7</td>
<td>3.3</td>
</tr>
<tr>
<td>Sawtooth</td>
<td>48</td>
<td>22.3</td>
</tr>
<tr>
<td></td>
<td>215</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Wild:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearwater</td>
<td>4</td>
<td>1.9</td>
</tr>
<tr>
<td>Grande Ronde</td>
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<td>22.7</td>
</tr>
<tr>
<td>Imnaha</td>
<td>15</td>
<td>6.9</td>
</tr>
<tr>
<td>Middle Fork Salmon</td>
<td>73</td>
<td>33.8</td>
</tr>
<tr>
<td>Salmon</td>
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<td>15.7</td>
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<tr>
<td>South Fork Salmon</td>
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</tr>
<tr>
<td></td>
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<td>100.0</td>
</tr>
<tr>
<td><strong>Adult Spring Chinook Salmon</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hatchery:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearwater</td>
<td>3</td>
<td>1.7</td>
</tr>
<tr>
<td>Rapid River</td>
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<td>24.0</td>
</tr>
<tr>
<td>Red River</td>
<td>7</td>
<td>4.0</td>
</tr>
<tr>
<td>Powell</td>
<td>6</td>
<td>3.4</td>
</tr>
<tr>
<td>Sawtooth</td>
<td>48</td>
<td>27.4</td>
</tr>
<tr>
<td>Dworshak</td>
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<td>28.6</td>
</tr>
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<td>Lookingglass</td>
<td>19</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td>175</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Wild:</strong></td>
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<td></td>
</tr>
<tr>
<td>Middle Fork Salmon</td>
<td>73</td>
<td>45.6</td>
</tr>
<tr>
<td>Clearwater</td>
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<td>2.5</td>
</tr>
<tr>
<td>Salmon</td>
<td>34</td>
<td>21.3</td>
</tr>
<tr>
<td>Grande Ronde</td>
<td>49</td>
<td>30.6</td>
</tr>
<tr>
<td></td>
<td>160</td>
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</tr>
<tr>
<td>Training population location</td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Hatchery:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McCall</td>
<td>54</td>
<td>45.4</td>
</tr>
<tr>
<td>Pahsimeroi</td>
<td>37</td>
<td>31.1</td>
</tr>
<tr>
<td>Lookingglass</td>
<td>28</td>
<td>23.5</td>
</tr>
<tr>
<td></td>
<td>119</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Wild:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Fork Salmon</td>
<td>85</td>
<td>66.7</td>
</tr>
<tr>
<td>Imnaha</td>
<td>40</td>
<td>33.3</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Adult Summer Chinook Salmon
APPENDIX TABLE B

Hatchery or wild classification based on scale analysis of spring and summer chinook salmon marked for the transportation study at Lower Granite Dam in 1989 and recovered at the same dam in 1991 and 1992.
Appendix Table B. Hatchery or wild classification based on scale analysis of spring and summer chinook salmon marked for the transportation study at Lower Granite Dam in 1989 and recovered at the same dam in 1991 and 1992.

<table>
<thead>
<tr>
<th>Mark Brand</th>
<th>CWT code</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Number hatchery</td>
</tr>
<tr>
<td>LA2-1</td>
<td>232256</td>
<td>2</td>
</tr>
<tr>
<td>LA2-2</td>
<td>232258</td>
<td>0</td>
</tr>
<tr>
<td>LA2-3</td>
<td>232349</td>
<td>1</td>
</tr>
<tr>
<td>LA2-4</td>
<td>232350</td>
<td>6</td>
</tr>
<tr>
<td>LART-1</td>
<td>232351</td>
<td>1</td>
</tr>
<tr>
<td>LART-2</td>
<td>232352</td>
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</tr>
<tr>
<td>LART-3</td>
<td>232411</td>
<td>0</td>
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<td>Total</td>
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<table>
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<th>Classification</th>
</tr>
</thead>
<tbody>
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<td></td>
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