Lyons Ferry Complex Hatchery Evaluation:

Summer Steelhead Annual Report 2010 and 2011 Run Years

by

Joseph D. Bumgarner
Jerry T. Dedloff

Washington Department of Fish and Wildlife
Fish Program / Science Division
Hatchery & Wild Interactions Unit
600 Capital Way North
Olympia, Washington 98501-1091

to

U.S. Fish and Wildlife Service
Lower Snake River Compensation Plan Office
1387 Vinnell Way, Suite 343
Boise, Idaho 83709
Cooperative Agreement #'s 14110-A-J012, 14110-B-J012, and F12AC00091

May 2013

Acknowledgments

The ongoing success of the steelhead and trout program is the result of the coordinated and dedicated efforts of many Washington Department of Fish and Wildlife (WDFW) employees, as well as employees from other State and Federal Agencies. We especially thank Jon Lovrak, Doug Maxey, Derek Gloyn, Steve Jones, and the Lyons Ferry/Tucannon staff for their hard work, insight, and assistance with summer steelhead monitoring and evaluation activities conducted at Lyons Ferry Complex for the two years covered in this report. We also thank the permanent and temporary staff at the Snake River Lab for their valuable assistance during the year.

We thank Don Whitney and staff of Idaho Fish and Game for their assistance in conducting joint Snake River creel surveys and providing CWT recoveries from Idaho fisheries. We also thank Rich Carmichael's crew from Oregon Department of Fish and Wildlife, especially Mike Flesher, for their leadership in conducting the Grande Ronde River creel survey and providing angler effort and catch data, and providing CWT recoveries for expansion. Nicole Tancreto with Pacific States Marine Fisheries Commission provided valuable assistance with our PIT tag files. The accuracy and timeliness of all the data provided by the above individuals is always appreciated.

We thank additional WDFW personnel (John Sneva, Lance Campbell, Gil Lensgrave, and Lynn Anderson) for their assistance with portions of the project.

We thank Mark Schuck, Glen Mendel, and Andrew Murdoch, for their critical review of the draft report.

Finally we thank the entire staff of the Lower Snake River Compensation Plan Office for their firm support in funding these monitoring and evaluation studies.

Executive Summary

This annual report is one in a continuing series describing the Washington Department of Fish and Wildlife's (WDFW) progress toward meeting summer steelhead and rainbow trout mitigation goals established in the LSRCP.

Stocking of LSRCP-produced rainbow trout (250,943 – 2011, 243,654 - 2012) within Washington went as planned and achieved the LSRCP goals. Survival of hatchery steelhead from egg to smolt was greater than 75% for all stocks, and smolt release and marking/tagging goals for summer steelhead were met or within acceptable limits for the reporting period.

We continued smolt trapping on the Tucannon River to estimate the number of natural origin migrant steelhead. In the 2010/2011 and 2011/2012 out-migrations we estimated 27,846 and 25,505 natural origin summer steelhead migrants, respectively. Mean smolt size and peak of out-migration was similar to previous years. Average smolt-to-adult survival of wild origin summer steelhead from the Tucannon River (based on the PIT tag returns from 1999-2010 migration years) was 2.7% back to Bonneville Dam, and 2.0% to Ice Harbor Dam. Natural origin adults returning to the Tucannon River were estimated based on PIT tag detections. Average natural origin adult return based on the PIT tags for the last five run years is 146 fish; below the NOAA Fisheries recommended critical population threshold. Tucannon River (natural and hatchery endemic stock origin) steelhead continue to exhibit a disturbing adult migration pattern, with about 70% returning to, and about 50% remaining above, Lower Granite Dam. We also have observed a large percentage of Touchet and Walla Walla rivers release groups returning to the Snake River, with only a small percentage documented as returning to their release location.

As part of our ongoing annual broodstock collection and research activities, WDFW hatchery and evaluation staffs operate a series of traps in southeast Washington. We report the number of fish captured and released at all trap locations, composition of hatchery and wild origin fish, coded-wire tag recoveries (where appropriate) and age composition for each steelhead stock. In 2011 and 2012, LFH broodstock selection was altered to increase the proportion of 2-salt fish incorporated into the broodstock. In 2011 and 2012, evaluation staff conducted two survival experiments using electronarcosis for an anesthetic.

WDFW staff surveyed steelhead sport anglers during the 2010/2011 and 2011/2012 sport fishing seasons within the LSRCP area of southeast Washington to recover CWTs from tagged steelhead. Summary results of those surveys (anglers, effort, number of fish captured) are provided. All data and CWT's recovered were transferred to Olympia for inclusion into the RMIS Regional CWT database. WDFW staff also conducted joint creel surveys with ODFW on the lower Grande Ronde River; a summary of results is provided.

During the springs of 2011 and 2012, evaluation staff attempted spawning ground surveys to estimate the number of redds in index areas of the Touchet River and Asotin Creek. Stream flows in both years were high and greatly limited our ability to conduct surveys. Based on those stream surveys, information from adult traps on both streams, and using regression analysis, we estimate that 567 and 524 redds were present in the index area of Asotin Creek in 2011 and 2012, respectively. In the Touchet River index area, we estimated 408 and 260 redds in 2011 and 2012, respectively.

Coded-wire tag recoveries from fisheries, hatcheries, from traps in rivers, and PIT tag detections have provided the basic data to estimate minimum smolt-to-adult return rates on LFH, Wallowa, Touchet, and Tucannon stock summer steelhead from the hatchery program. Due to a variety of factors, smolt-to-adult survivals to the project area have generally been 2-4 times the LSRCP target rate over the years. The LFC summer steelhead program (LFH and Wallowa stock only) continues to meet and/or exceed its original mitigation goals by supplying large returns of hatchery steelhead for harvest primarily in southeast Washington. This is mainly due to the fact that harvest rates in lower Columbia River fisheries have declined substantially since the early years of the program. Survivals to adult for the endemic Tucannon stock have been high enough to warrant adoption of this program in the Tucannon River. Survivals to adult on the Touchet stock program have been less than desired. We continue to examine this program for ways to increase survival. WDFW will continue to monitor harvest recoveries and adjust programs as necessary to maintain LSRCP goals.

Table of Contents

Introduction....1

Production Goals of Rainbow Trout and Summer Steelhead Stocks....2

Summer Steelhead In-Hatchery Survival....2

Summer Steelhead Marking, Tagging, and Release....6

Tucannon River Natural Summer Steelhead Smolt Production, Adult Returns, and Survival Estimates....8

Adult Migratory Patterns Based on PIT tags....10

Summer Steelhead Broodstock Collections / Adult Returns and Evaluations....12
    LFH Trap....13
    Electronarcosis Tests....16
    Cottonwood Creek Trap....21
    TFH Trap....23
    Touchet River Adult Trap....25

Creel Surveys – Snake River and Tributaries....28
    Grande Ronde River....29

Spawning Ground Surveys....29

Smolt-to-Adult Survival Rates....33

Contributions to LSRCP Mitigation Goals....38

Conclusions and Recommendations....41

Literature Cited....43

Appendix A....44

Appendix B....47

Attachment 1....50

Attachment 2....75

List of Figures

Figure 1. Map of major rivers and streams in southeast Washington, and LFC facilities. 1

Figure 2. Percent 1-salt summer steelhead trapped and used for broodstock at Lyons Ferry hatchery from the 1986-2005 brood years. 15

Figure 3. Egg mortality over time for groups of female steelhead exposed to successively greater amounts of electro-narcosis at LFH, 2011. 19

Figure 4. Cumulative mortality of steelhead subjected to three treatements at LFH, 2011. 21

Figure 5. Estimated smolt-to-adult survival (to the LSRCP project area) of summer steelhead released from Cottonwood Acclimation Pond in the lower Grande Ronde River, 1984-2008 brood years. 34

Figure 6. Estimated smolt-to-adult survival (to the LSCRP project area) of summer steelhead released directly into the middle or lower Tucannon River. 34

Figure 7. Estimated smolt-to-adult survival of summer steelhead released directly into the Snake River at Lyons Ferry Hatchery. 35

Figure 8. Estimated smolt-to-adult survival of summer steelhead released from Dayton Acclimation Pond in the Touchet River. 35

Figure 9. Estimated smolt-to-adult return rates of summer steelhead released directly into the Walla Walla River. 36

Figure 10. Smolt-to-adult survival estimates (to Bonneville Dam) of LFH or Tucannon River endemic stock steelhead, 2001-2010 Migration Years. 37

Figure 11. Smolt-to-adult survival estimates (to Bonneville Dam) of LFH or Touchet River endemic stock steelhead, 2002-2010 Migration Years. 37

List of Tables

Table 1. Numbers of males and females spawned, eggs taken, and estimated survival by life stage of Wallowa stock summer steelhead spawned at Cottonwood Creek and transferred to LFH, 1992 to 2012 brood years. 3

Table 2. Numbers of males and females spawned, eggs taken, and survival by life state of LFH stock summer steelhead spawned at LFH, 1987 to 2012 brood years. 4

Table 3. Numbers of males and females spawned, eggs taken, and survival by life state of Tucannon River endemic stock summer steelhead spawned at LFH, 2000 to 2012 brood years. 5

Table 4. Numbers of males and females spawned, eggs taken, and survival by life state of Touchet River endemic stock summer steelhead spawned at LFH, 2000 to 2012 brood years. 5

Table 5. Summer steelhead smolt releases from Lyons Ferry Complex, 2011. 6

Table 6. Summer steelhead smolt releases from Lyons Ferry Complex, 2012. 7

Table 7. Mean fork lengths, weights, condition factor (K), co-efficient of variation (CV), fish per pound (FPP), and the percent of visually apparent precocious mature males from LFC steelhead prior to release, 2011 and 2012. 7

Table 8. Estimated smolt-to-adult survival rate of naturally produced summer steelhead smolts from the Tucannon River based on adult PIT tag detections at Bonneville and Ice Harbor dams, 1999-2011 migration years. 9

Table 9. Estimated summer steelhead returns for the 2007-2011 run years into the Tucannon River based on PIT Tag detections. 10

Table 10. Detections of PIT tagged Tucannon Endemic stock, Tucannon natural stock, and Lyons Ferry hatchery stock summer steelhead released into the Tucannon River that passed Ice Harbor Dam (IHR) and Lower Granite Dam (LGR). 11

Table 11. Detections of PIT tagged Touchet River Endemic stock summer steelhead, and Lyons Ferry stock summer steelhead (Walla Walla and Dayton AP release groups) that crossed McNary Dam, Ice Harbor Dam (IHR), and Lower Granite Dam (LGR). 12

Table 12. Summary of tagged adult summer steelhead trapped at LFH for the 2010 run year / 2011 brood year, and the 2011 run year/ 2012 brood year 14

Table 13. Age compostion of trapped and spawned summer steelhead for the Lyons Ferry stock summer steelhead, 2001 and 2012 brood years. 15

Table 14. Incidence of hemorrhaging near the spine and non-spinal for male and female steelhead spawned at LFH in 2011. 18

Table 15. Green egg to eyed egg survival rates for two study groups of fish at LFH in 2011. 18

Table 16. Summary of tagged adult summer steelhead trapped at Cottonwood Trap for 2010 run year / 2011 BY. 22

Table 17. Natural origin, hatchery LFH stock origin, hatchery Tucannon endemic stock origin summer steelhead trapped at the Tucannon Fish Hatchery from the 1997-2011 run years. 23

Table 18. Total number of fish trapped and passed upstream to spawn naturally at the Tucannon River Adult Trap, 1997-2011 run years. 24

Table 19. Summary of fresh and salt-water age composition of natural origin adult steelhead from the Tucannon River, 2000-2012 brood years. 24

Table 20. Total number of male and female summer steelhead at the Touchet River Adult Trap (1992-1994, 1998-2011 run years). 26

Table 21. Total number of fish trapped and passed upstream to spawn naturally at the Touchet River Adult Trap, 1992-1994, 1998-2011 run years. 26

Table 22. Summary of fresh and salt-water age composition of natural origin adults from the Touchet River, 1994-1995 and 1999-2012 brood years. 27

Table 23. Total number of spring Chinook, bull trout, brown trout, whitefish, northern pike minnow, and bridgelip sucker captured in the Touchet River Adult Trap (1993-1995, 1999-2012). 27

Table 24. Steelhead angler interview results for fall/winter/spring of the 2010 and 2011 run years from Washington State licensed anglers. 28

Table 25. Estimated angler effort, catch rates, and harvest for steelhead anglers on a portion of the Grande Ronde River in Washington, but near the Oregon border, run year 2009 (Mike Flesher, ODFW). 29

Table 26. Summer steelhead spawning ground survey results, 2011 and 2012. 30

Table 27. Standardized redd estimates and redds/kilometer within index reaches of Asotin Creek in southeast Washington, 1986-2012. 31

Table 28. Standardized redd estimates and redds/kilometer within index reaches of the Touchet River in southeast Washington, 1987-2012. 32

Table 29. Contribution of Lyons Ferry stock (LFH, Tucannon, Touchet, Walla Walla release groups) or Wallowa stock (Grande Ronde release group) summer steelhead back to the lower Snake River project area. 39

Table 30. Contribution of Lyons Ferry stock (LFH, Tucannon, Touchet, Walla Walla release groups) or Wallowa stock (Grande Ronde release group) summer steelhead back to the Columbia River. 40

Introduction

This annual report (Run Years 2010 and 2011) is one in a continuing series describing Washington Department of Fish and Wildlife's (WDFW) progress toward meeting summer steelhead (*Oncorhynchus mykiss)* and rainbow trout mitigation goals established in the Lower Snake River Compensation Plan (LSRCP). The reporting period covers between 1 July 2010 and 30 June 2012, unless otherwise noted.

The LSRCP program in Washington State began in 1981 with construction of Lyons Ferry Hatchery (LFH). Refurbishing of the Tucannon Fish Hatchery (TFH) followed in 1984-1985. In addition to the hatchery construction and modifications, three remote acclimation ponds (AP) were built along the Tucannon (Curl Lake AP), Touchet (Dayton AP), and Grande Ronde (Cottonwood AP) rivers to acclimate juvenile summer steelhead before release. All of these facilities make up WDFW's Lyons Ferry Complex (LFC) (Figure 1).

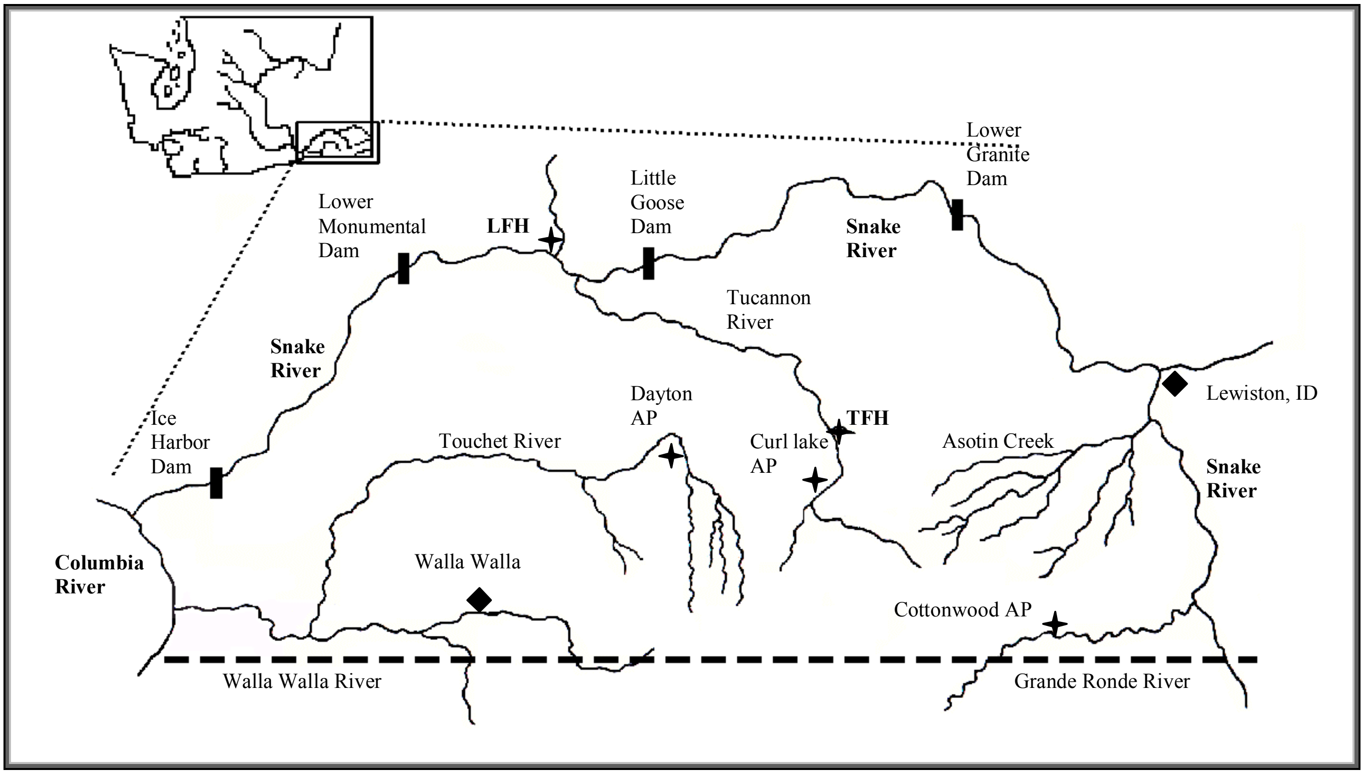


Figure 1. Map of major rivers and streams in southeast Washington, and LFC facilities.

Production Goals of Rainbow Trout and Summer Steelhead Stocks

Rainbow Trout*:* The LSRCP mitigation trout program has focused on providing recreational fishing opportunities in southeast Washington. The current LFC goal is to produce 235,000 catchable sized (3 fish/lb; generally >8in) Spokane stock trout (78,300 lbs) for release into southeast Washington area lakes (no stream plants), resulting in at least 67,500 angler days of recreation. The LFC also produces a total of 19,250 Spokane stock trout for the Nez Perce Tribe's resident fish program (1,650) and IDFG resident fall fishery program (17,600). During the report period, stocking of LSRCP produced rainbow trout within Washington (Appendix A, Tables 1 and 2), and transfers to Idaho went as planned.

Steelhead: The LFC currently uses four summer steelhead stocks to produce smolts for release into the Snake (160,000 smolts of LFH stock), Tucannon (75,000 smolts of Tucannon Endemic stock), Grande Ronde (200,000 smolts of Wallowa Stock), Walla Walla (100,000 smolts of LFH stock), and Touchet (85,000 smolts of LFH stock, 50,000 smolts of Touchet Endemic stock) rivers to enhance recreational opportunities for steelhead anglers and for ESA recovery purposes. All steelhead smolts for the program are planned for a release size of 4.5 fish/lb (100.8g/fish). Changes to the current program may occur in the near future as we continue to address ESA concerns while meeting harvest mitigation goals.

Summer Steelhead In-Hatchery Survival

Survival of steelhead at LFC remains highly variable among stocks and among years (Tables 1, 2, 3, and 4). In 2012, a LSRCP summer steelhead program review was conducted, with all relevant data collected since the program inception reviewed and compiled for that meeting. (http://www.fws.gov/lsnakecomplan/Meetings/2012SteelheadProgramReviewSymposium.html). During the process, errors or omissions were found in previous annual report data tables. All tables and figures within this report should be considered the best available data from this point forward for historical comparisons.

Fish health problems (e.g., cold water disease), presence of pathogens such as Infectious Hematopoietic Necrosis virus (IHNV), and spawning conditions at LFC and remote spawning sites have all affected in-hatchery survival rates over the years. Within hatchery survival estimates as presented in the following tables may be inaccurate because of bias in dealing with large numbers of living organisms. This bias, while not absolutely critical to program evaluations or determining program success, is likely due to one or a combination of the following: water weight, egg/fish size variability, scale error, or inconsistent methodologies among staff members.

Table 1. Numbers of males and females spawned, eggs taken, and estimated survival by life stage of Wallowa stock summer steelhead spawned at Cottonwood Creek and transferred to LFH, 1992 to 2012 brood years.

BY	Spawned		Green Eggs taken	Eyed Eggs	% Green to Eyed Egg Survival	Eggs Retained for program needs	Smolts	% retained eggs to smolt survival
	Female	Male						
1992	113	225	558,437	371,375	66.5	423,759 [a]	341,899	80.7
1993	96	96	533,995	392,595	73.5	289,198	322,508	100.0
1994	118	118	644,886	446,029	69.2	366,115	256,233	69.9
1995	99	99	511,283	412,493	80.7	335,489	263,449	78.5
1996	125	125	601,979	582,994	96.8	460,294	274,886	59.7
1997	101	101	536,723	401,270	74.8	401,270	252,211	62.9
1998	173	169	868,973	769,543	88.6	479,606	268,803 [b]	82.4
1999	129	116	625,039	418,970	67.0	389,664	274,146 [c]	82.1
2000	107	116	523,011	322,238	61.6	322,238	215,584 [d]	82.5
2001	97	108	504,182	381,427	75.7	260,000	182,722	70.3
2002	82	87	455,502	360,811	79.2	319,479	236,627	74.1
2003	65	65	327,477	315,616	96.4	242,557	137,915 [e]	85.9
2004	68	105	345,565	326,475	94.5	326,475	150,442 [f]	80.6
2005	60	70	282,675	274,586	97.1	274,586	169,390	61.7
2006	120	115	316,059	290,903	92.0	290,903	159,242 [g]	93.5
2007	106	97	340,589	310,479	91.2	242,710	175,961	72.5
2008	85	85	275,958	241,638	87.6	214,695	170,232	79.3
2009	113	125	494,638	463,442	93.7	172,367 [h]	163,197	94.7
2010	56	48	244,487	212,618	87.0	242,648	197,839	81.5
2011	106	82	522,967	411,077	78.6	193,180	176,902	91.6
2012	120	120	632,738	239,993	77.5	239,993		
Mean					82.3			79.2
SD					11.1			11.0

[a] Additional eggs were brought in from ODFW to make program needs.
[b] A total of 126,361 fry/parr/fingerlings were planted into area lakes from over production.
[c] A total of 45,824 fry/parr/fingerlings were planted into area lakes from over production.
[d] A total of 50,270 fry/parr/fingerlings were planted into area lakes from over production.
[e] A total of 70,455 fry/parr/fingerlings were planted into area lakes from overproduction.
[f] A total of 146,481 fry/parr/fingerlings were planted into area lakes from overproduction.
[g] A total of 112,751 fry/parr/fingerlings were planted into area lakes from over production.
[h] The total number of eggs retained includes 40,000 received from ODFW Wallowa Hatchery to supplement the losses from IHNV positive females spawned at Cottonwood.

Table 2. Numbers of males and females spawned, eggs taken, and survival by life state of LFH stock summer steelhead spawned at LFH, 1987 to 2012 brood years.

BY	Spawned		Green Eggs taken	Eyed Eggs	% Green to Eyed Egg Survival	Eggs Retained for program needs	Smolts	% retained eggs to smolt survival
	Female	Male						
1987	251	250	1,111,506	1,095,906	98.6	1,095,906	665,657 [a]	79.3
1988	264	279	941,765	818,148	86.9	818,148	428,040 [b]	69.1
1989	243	550	1,263,237	1,010,590	80.0	957,074	0 [c]	0.00
1990	437	955	2,570,676	NA	NA	1,483,485	635,635 [d]	58.2
1991	261	532	1,296,249	1,166,624	90.0	1,165,315	357,497 [e]	38.6
1992	240	499	1,239,055	1,117,628	90.2	905,438	371,826 [f]	84.5
1993	261	549	1,211,053	1,029,935	85.0	940,022	535,837[g]	59.5
1994	253	513	1,352,296	1,154,699	85.4	899,350	543,627[h]	62.0
1995	343	686	1,772,477	1,642,063	92.6	929,597	604,756 [i]	65.6
1996	330	660	1,614,636	1,515,188	93.8	1,151,363	596,834 [j]	70.1
1997	217	246	1,090,638	962,705	88.3	962,705	554,057 [k]	84.5
1998	279	280	1,460,967	1,242,913	85.1	934,247	567,732	60.8
1999	227	253	1,140,813	939,094	82.3	550,000	495,864	90.2
2000	183	188	871,856	693,415	79.5	693,415	382,602 [l]	61.3
2001	151	242	800,350	636,727	79.6	636,727	422,786	66.4
2002	191	231	941,223	789,637	83.9	768,832	378,917 [m]	63.0
2003	126	259	580,351	504,220	86.9	477,655	310,209	64.9
2004	129	259	494,380	435,176	88.0	408,462	355,362	87.0
2005	133	263	566,878	496,733	87.6	452,012	350,028 [n]	87.6
2006	120	241	529,379	430,667	81.4	430,667	341,424 [o]	83.4
2007	123	245	556,683	507,688	91.2	507,688	351,107 [p]	84.6
2008	116	193	563,765	507,791	90.1	507,791	366,111	72.1
2009	106	105	490,434	425,124	86.7	425,124	364,896 [q]	90.8
2010	99	99	520,127	451,318	86.8	451,318	351,777	77.9
2011	120	120	528,205	408,201	77.3	408,201	329,340	80.7
2012	103	101	603,823	415,577	68.8	415,557		
Mean					85.8			72.6
SD					6.1			13.1

[a] A total of 203,857 fry/parr/fingerlings were planted into area lakes from over production.
[b] A total of 137,021 fry/parr/fingerlings were planted into area lakes from over production.
[c] The entire production was lost due to an IHNV outbreak.
[d] A total of 227,733 fry/parr/fingerlings were planted into area lakes from over production.
[e] A total of 92,116 fry/parr/fingerlings were planted into area lakes from over production.
[f] A total of 378,257 were lost due to an IHNV outbreak, and 15,140 were retained in Curl Lake AP as residuals.
[g] A total of 23,898 were retained in Curl Lake AP as residuals.
[h] A total of 14,212 were retained in Curl Lake AP as residuals.
[i] A total of 5,244 were retained in Curl Lake AP as residuals.
[j] A total of 191,100 fry/parr/fingerlings were planted into area lakes from over production, and 19,319 were retained in Curl Lake AP as residuals.
[k] A total of 259,148 fry/parr/fingerlings were planted into area lakes from over production.
[l] A total of 42,548 fry/parr/fingerlings were planted into area lakes from over production.
[m] A total of 105,502 fry/parr/fingerlings were planted into area lakes from over production.
[n] A total of 32,336 fry/parr/fingerlings were planted into area lakes from over production.
[o] A total of 17,815 fry/parr/fingerlings were planted into area lakes from over production.
[p] A total of 78,334 fry/parr/fingerlings were planted into area lakes from over production.
[q] A total of 21,316 fry/parr/fingerlings were planted into area lakes from over production.

Table 3. Numbers of males and females spawned, eggs taken, and survival by life state of Tucannon River endemic stock summer steelhead spawned at LFH, 2000 to 2012 brood years.

BY	Spawned		Green Eggs taken	Eyed Eggs	% Green to Eyed Egg Survival	Eggs Retained for program needs	Smolts	% retained eggs to smolt survival
	Female	Male						
2000	16	21	80,850	71,971	89.0	71,971	60,020	83.4
2001	15	15	113,563	101,197	89.1	101,197	58,616	57.9
2002	13	16	74,204	66,969	90.2	66,969	43,688	65.2
2003	14	18	73,573	46,143	62.7	46,143	42,967	93.1
2004	16	15	78,109	62,460	80.0	62,460	61,238	98.0
2005	14	25	77,131	71,933	93.3	71,933	65,245	90.7
2006	13	16	72,520	67,341	92.9	67,341	62,940	93.5
2007	13	12	64,129	59,970	93.5	59,970	57,230	95.4
2008	1	1	3,054	2,537	83.1	2,400	0 [a]	0.0
2009	10	9	77,279	68,959	89.2	68,959	57,562 [b]	92.2
2010	11	11	89,791	81,100	90.3	81,100	77,683	95.8
2011	21	20	121,597	117,919	97.0	117,919	51,124 [c]	81.7
2012	17	19	93,065	72,274	77.7	72,274		
Mean					86.7			86.1
SD					9.1			13.2

[a] Production of 2,400 was considered inadequate to be of value, these were planted as fry.

[b] A total of 5,999 fry were planted into the Tucannon River as these were high titer positive progeny for IHNV.

[c] A total of 45,236 fry were planted into the Tucannon River as these were high titer positive progeny for IHNV.

Table 4. Numbers of males and females spawned, eggs taken, and survival by life state of Touchet River endemic stock summer steelhead spawned at LFH, 2000 to 2012 brood years.

BY	Spawned		Green Eggs taken	Eyed Eggs	% Green to Eyed Egg Survival	Eggs Retained for program needs	Smolts	% retained eggs to smolt survival
	Female	Male						
2000	12	7	53,139	43,572	82.0	43,572	36,487	83.7
2001	14	11	69,269	53,750	77.6	53,750	45,501	84.7
2002	14	17	70,843	66,460	93.8	66,460	31,440	47.3
2003	16	17	82,602	75,059	90.9	75,059	58,733	78.3
2004	15	10	68,511	58,451	85.3	58,451	55,706	95.3
2005	18	15	78,813	75,991	96.4	75,991	52,476 [a]	97.7
2006	18	18	88,668	85,730	96.7	85,730	58,989 [b]	85.5
2007	16	17	73,101	69,626	95.2	69,626	48,298 [c]	69.4
2008	13	11	66,520	62,279	93.6	62,279	55,255 [d]	97.4
2009	15	13	72,543	69,801	96.2	69,801	62,517 [e]	89.6
2010	15	13	75,596	65,055	86.1	65,055	62,037	95.4
2011	12	13	74,408	64,860	87.2	64,860	54,386	83.9
2012	17	13	81,555	45,418	55.7	45,418		
Mean					87.4			84.0
SD					11.3			14.3

[a] A total of 21,765 eggs/fry were planted into the Touchet River as these were high titer positive progeny for IHNV.

[b] A total of 14,276 eggs/fry were planted into the Touchet River as these were high titer positive progeny for IHNV.

[c] High fry-smolt loss was due to stress induced mortality of 20,389 fish caused by overcrowding during the PIT tagging operation.

[d] A total of 5,400 eggs were planted into the Touchet River as these were high titer positive progeny for IHNV.

[e] A total of 5,345 fry were planted into the Touchet River as these were high titer positive progeny for IHNV.

Summer Steelhead Marking, Tagging, and Release

All harvest mitigation production steelhead (LFH and Wallowa stocks) were marked with an adipose (AD) fin clip, and a portion of each release group also received a coded-wire tag (CWT) and left ventral fin clip prior to release for selective fisheries harvest management (Tables 5 and 6). Non-harvest mitigation steelhead (Tucannon and Touchet endemic stocks) were given CWTs, but were not externally marked. All groups also have some portion that receive PIT tags to estimate smolt-to-adult survival and to document straying. The CWTs obtained from sport harvest or adult trap returns provide a minimum estimated number of fish back to the project area, with generally an unknown number of fish escaping to the spawning grounds. Adult PIT tag returns, used in combination with the CWT recoveries, should allow us to account for fish that return to the spawning grounds and thus allow us to more accurately estimate total contribution of our hatchery summer steelhead to the project area for mitigation assessment.

The WDFW Snake River Lab Evaluation staff collected pre-release samples for all LFC release locations (Table 7). All release groups from all stocks were close to or above program goals (number of fish and size of fish) in 2011 and 2012. Size and release time goals on the two endemic stocks were generally met, though improvements in rearing continued to be tested.

Table 5. Summer steelhead smolt releases from Lyons Ferry Complex, 2011.

Location (Stock)	Rkm	Date	Total release	AD-only release	CWT release	CWT code	Other marks	PIT Tags	Lbs	Size #/lb	CWT % Loss
2011 Release Year											
Grande Ronde @ Cottonwood AP (Wallowa)	45.6	4/12-4/29	197,839	178,016	19,823	635567	LV	6,000	41,216	4.8	0.8905
Snake River @ LFH (LFH)	92.8	4/15-4/22	164,813	145,148	19,665	635568	LV	4,000	38,329	4.3	1.6379
Touchet River @ Dayton AP (LFH)	86.4	4/12-4/22	84,623	66,524	18,099	635570	LV	4000	18,005	4.7	2.6711
Walla Walla River (LFH)	48.0	4/15-4/19	102,341	81,551	20,790	635569	LV	4000	23,259	4.4	2.4450
Tucannon River @ Curl Intake (Tucannon)	66.5	4/08-5/05	77,683	766	76,917	635482 635571		10,000	16,184	4.8	1.2749 1.2749
Touchet River @ NF Touchet Bridge (Touchet)	91.5	4/25-4/27	62,037	791	61,246	635572		5,000	13,486	4.6	0.9860
Touchet River @ NF Touchet Bridge (Touchet)	91.5	4/26	6,439	31	6,408	635172		5,000	1,570	4.1	0.4811

Table 6. Summer steelhead smolt releases from Lyons Ferry Complex, 2012.

Location (Stock)	Rkm	Date	Total release	AD-only release	CWT release	CWT code	Other marks	PIT Tags	Lbs	Size #/lb	CWT % Loss
2012 Release Year											
Grande Ronde @ Cottonwood AP (Wallowa)	45.6	4/11-4/29	176,902	155,396	21,506	636084	LV	6,000	36,855	4.8	2.3983
Snake River @ LFH (LFH)	92.8	4/16-4/19	137,841	116,452	21,389	636081	LV	4,000	31,328	4.4	1.4839
Touchet River @ Dayton AP (LFH)	86.4	4/10-4/23	89,322	64,506	24,816	636082	LV	4,000	20,300	4.4	2.0408
Walla Walla River (LFH)	48.0	4/16-4/18	102,177	80,973	21,204	636083	LV	4,000	23,222	4.4	2.5869
Tucannon River @ Curl Intake (Tucannon)	66.5	4/17-4/20	51,124	1,203	49,921	636086		15,000	11,114	4.6	2.3529
Touchet River @ NF Touchet Bridge (Touchet)	91.5	4/23-4/25	54,386	1,317	53,069	636077		7,500	11,823	4.6	2.4229

Table 7. Mean fork lengths, weights, condition factor (K), co-efficient of variation (CV), fish per pound (FPP), and the percent of visually apparent precocious mature males from LFC steelhead prior to release, 2011 and 2012.

Location (Stock)	Sample Date	Sample size (n)	Avg LN (mm)	Avg WT (g)	K	CV	FPP	Percent precocious
2011 Release Year								
Cottonwood (Wallowa)	4/07	277	204.7	93.6	1.05	11.4	4.8	0.4
Lyons Ferry (LFH)	4/14	234	215.0	102.9	1.02	8.4	4.4	0.0
Lake #1 (LFH) [a]	4/18-20	600	223.3	105.4	0.94	7.1	4.3	0.2
Touchet (LFH)	4/12	200	206.4	95.7	1.06	8.9	4.7	0.0
Walla Walla (LFH)	4/14	211	211.2	94.9	0.99	6.7	4.8	0.9
Tucannon (Endemic)	4/4, 4/14, 5/04	606	208.9	103.5	1.07	13.2	4.5	1.2
Touchet (Endemic) [b]	4/20	468	206.3	99.1	1.07	12.9	4.6	16.2
2012 Release Year								
Cottonwood (Wallowa)	4/11	361	218.0	94.3	0.87	11.8	4.8	0.3
Lyons Ferry (LFH)	4/12	200	211.0	98.4	1.03	8.8	4.6	3.0
Lake #1 (LFH) [a]	4/16-18	600	225.4	107.5	0.93	7.1	4.2	0.0
Touchet (LFH)	4/10	202	215.5	103.7	1.02	8.3	4.4	0.5
Walla Walla (LFH)	4/12	200	213.3	97.5	0.99	8.0	4.7	2.0
Tucannon (Endemic)	4/12-19	403	198.8	98.9	1.16	16.6	4.6	0.0
Touchet (Endemic) [b]	4/19	244	200.7	98.7	1.09	19.2	4.6	2.9

[a] Fish removed from Lake#1 during April were released in the Walla Walla River or directly to the Snake River at Lyons Ferry.

[b] The high rate of precocial fish in the Touchet endemic group is due to the two-year smolt program. Estimated precocial fish in the one-year smolts was believed to be about 4%.

Tucannon River Natural Summer Steelhead Smolt Production, Adult Returns, and Survival Estimates

2010/2011 Outmigration: We operated a 1.5m rotary screw trap at rkm 3.0 on the Tucannon River between fall 2010 and spring 2011 to estimate the number of migrating natural steelhead smolts. Methods to estimate smolt production are described in Bumgarner et al. 2003. During the 2010/2011 trapping season, 3,247 natural steelhead migrants were captured, for an estimated 27,846 total migrants (95% CI: 24,254 – 32,134). Age composition of migrating smolts was 34.2% Age 1, 63.1% Age 2, and 2.7% Age 3. Mean length, weight, and K-factor for natural fish (all age groups combined) captured was 169.2 mm, 50.7 g and 1.01, respectively. Peak out-migration was 15 May with an estimated 2,394 summer steelhead migrants past the trap on that day.

2011/2012 Outmigration: We operated the trap on the Tucannon River between fall 2011 and spring 2012 to estimate the number of migrating natural steelhead smolts. During the 2011/2012 trapping season, 2,341 natural steelhead migrants were captured, for an estimated 25,505 (95% CI: 20,498 – 31,888) total migrants. Age composition of migrating smolts was 55.2% Age 1, 39.2% Age 2, 5.4% Age 3,and 0.2% Age 4. Mean length, weight, and K-factor for natural fish (all age groups combined) captured was 168.2 mm, 49.3 g and 1.01, respectively. Peak out-migration was 10 May with an estimated 1,039 summer steelhead migrants past the trap on that day.

Evaluation staff continues to PIT tag wild origin steelhead migrants from the Tucannon River smolt trap in an attempt to estimate smolt-to-adult survivals from this depressed ESA listed population (Table 8). Average smolt-to-adult survival of wild origin summer steelhead from the Tucannon River (based on the PIT tags) is 2.7% back to Bonneville Dam and 2.0% to the LSRCP project area.

Table 8. Estimated smolt-to-adult survival rate of naturally produced summer steelhead smolts from the Tucannon River based on adult PIT tag detections at Bonneville and Ice Harbor dams, 1999-2011 migration years.

Smolt Migration Year	Number of PIT Tags [a]	Bonneville or above	Percent Survival	Ice Harbor or above	Percent Survival
1999	363	6	1.7	5	1.4
2000	555	20	3.6	15	2.9
2002	1,508	39	2.6	31	2.1
2003	2150	35	1.6	28	1.3
2004	1,983	31	1.6	17	0.9
2005	1,834	27	1.5	20	1.1
2006	1,416	32	2.3	16	1.1
2007	301	8	2.7	5	1.7
2008	1,087	68	6.3	54	5.0
2009	1,193	35	2.9	26	2.2
2010	2614	81	3.1	63	2.4
2011 [b]	2942	9	0.3	7	0.2
Average (Stdev)			**2.7 (1.4)**		**2.0 (1.2)**

[a] The number of PIT tags are for fish >124mm only.

[b] The 2011 migration year is incomplete and include only 1-salt fish. Survival rates for 2011 are not included in the average calculation.

Smolt trap estimates of natural origin steelhead production, in conjunction with the adult PIT tag returns, allows for the estimation of natural origin spawners (Tucannon River Origin) in the Tucannon River Basin (Bumgarner et al, 2010). This is useful as spawning ground surveys in the Tucannon River can be severely limited by even moderate stream flows, and it is extremely difficult to determine the origin of spawners (LFH hatchery, natural, or endemic stock) from visual observation. Estimates of natural, endemic and LFH stock origin (Tucannon River releases only) returns to the Tucannon River are presented for the last five run years (Table 9). Estimates provided in the table are based on an assumed 40% conversion rate from Ice Harbor Dam. This was necessary because the PIT tag array detection efficiency in the Tucannon River is unknown and the array has sometimes not been 100% operational during high stream flows. The actual percentage of PIT tags detected in the Tucannon River based on the number of fish crossing Ice Harbor Dam is usually between 30-35%, which is why a 40% conversion rate was chosen for the estimates. In addition, based on PIT tag detections from the Tucannon River array, many other stocks and origins of steelhead are entering the Tucannon River. To date, we have not been able to compile the necessary data to expand all of these PIT Tags to determine a total escapement of steelhead into the Tucannon River. We intend to attempt this for future reports.

Based on our assumptions, the average natural origin return (Tucannon River stock) for the last five run years is 146 fish. This estimate is 139 fish below the critical minimum abundance threshold (MAT) of natural-origin adults (285 spawners) described in WDFW’s Fishery

Management Evaluation Plan (FMEP). However, other small tributaries along the Snake River and proximal to the Tucannon River are also considered part of the Tucannon population. Their abundance and the genetic data to determine if they should really be considered part of the Tucannon population is pending (Trump et al. 2013).

However, we question the accuracy of our estimates provided in Table 9, in particular the natural origin estimates. As an example, for run year 2011, the PIT tag estimate indicates 101 Tucannon River origin wild steelhead. Adult trapping at the Tucannon Fish Hatchery on the same run year captured 186 natural origin steelhead. The assumption of using a 40% conversion rate for all years and all stocks is likely not appropriate and further calculations are needed. We provide these estimates as a first glance to what population levels may be, but strongly caution the reader from using these estimates at this time.

Table 9. Estimated summer steelhead returns for the 2007-2011 run years into the Tucannon River based on PIT Tag detections.

Stock	RY 2007	RY 2008	RY 2009	RY 2010	RY 2011	Average Return
Tucannon River Wild Stock [a]	83	68	297	181	101	146
Tucannon River Hatchery Endemic Stock	213	348	675	231	111	315
Lyons Ferry Stock (Tucannon River release)	1,490	1,322	1,419	1,120	1,174	1305

a – Estimates are based on unconfirmed assumptions and should be used cautiously, and does not represent total escapement of steelhead into the Tucannon River.

Adult Migratory Patterns Based on PIT tags

PIT tag detectors in the adult ladders of mainstem Columbia and Snake River dams have been in place for a number of years. In-stream tributary detectors (PIT tag arrays) are becoming more common and will eventually provide more information on distribution. We continue to monitor the general distribution of adult hatchery and wild origin summer steelhead from the Tucannon River, which as shown in previous reports, migrate past the Tucannon River and may remain upstream of Lower Granite Dam (Table 10). Many of these have been recovered in Asotin and Alpowa creeks (both upstream of Lower Granite Dam) in Washington State (Bumgarner et al 2010). Similar to groups of fish from the Tucannon, we see steelhead that originated in the Walla Walla subbasin bypassing their intended stream as well (Table 11). WDFW will continue to monitor this "straying" behavior and assess potential impacts to other steelhead populations.

Table 10. Detections of PIT tagged Tucannon Endemic stock, Tucannon natural stock, and Lyons Ferry hatchery stock summer steelhead released into the Tucannon River that passed Ice Harbor Dam (IHR) and Lower Granite Dam (LGR).

Run Year	# Pass IHR	# Pass LGR	# that Initially Enter Tucannon	Unknown Location	# Back to Tucannon from LGR	% fallback rate to Tucannon from LGR	Total into Tucannon [a]	Percent of those that passed Ice Harbor Dam		
								% into Tucannon	% above LGR	% Unknown
Tucannon Endemic Hatchery Stock Summer Steelhead										
2005	31	23	5	3	4	17.4	9	29.0	61.3	9.7
2006	60	35	19	6	6	17.1	25	41.7	48.3	10.0
2007	79	51	13	15	14	27.5	27	34.2	46.8	19.0
2008	126	79	11	36	3	3.8	14	11.1	60.3	28.6
2009	335	214	68	52	34	15.9	103	30.7	53.7	15.6
2010	116	72	20	24	11	15.3	31	26.7	52.6	20.7
2011	39	18	20	1	7	38.9	27	69.2	28.2	2.6
Totals	**786**	**492**	**156**	**137**	**79**	**16.1**	**236**	**30.0**	**52.5**	**17.5**
Tucannon Natural Stock Summer Steelhead										
2005	23	13	4	6	3	23.1	7	30.4	43.5	26.1
2006	16	13	3	0	1	7.7	4	25.0	75.0	0.0
2007	25	11	7	7	1	9.1	8	32.0	40.0	28.0
2008	12	5	2	5	0	0.0	2	16.7	41.7	41.6
2009	38	26	6	6	4	15.4	10	26.3	57.9	15.8
2010	35	18	9	8	2	11.1	11	31.4	45.7	22.9
2011	39	23	14	2	5	21.7	19	48.7	46.2	5.1
Totals	**188**	**109**	**45**	**34**	**16**	**14.7**	**61**	**32.4**	**49.5**	**18.1**
Lyons Ferry Hatchery Stock Summer Steelhead (Released into the lower Tucannon River)										
2005	----	----	----	----	----	----	----	----	----	----
2006	----	----	----	----	----	----	----	----	----	----
2007	296	203	50	43	38	18.7	88	29.7	55.7	14.6
2008	186	98	42	46	9	9.2	51	27.4	47.8	24.8
2009	132	90	5	37	12	13.3	17	12.9	59.1	28.0
2010	93	69	7	17	12	17.4	19	20.4	61.3	18.3
2011	98	48	15	35	12	25.0	27	27.6	36.7	35.7
Totals	**805**	**508**	**119**	**178**	**83**	**16.3**	**202**	**25.1**	**52.8**	**22.2**

[a] The Tucannon River PIT tag array was taken out by high stream flow in January, 2009. Two salt returns from the 2006 migration year, and 1-salt returns from the 2007 migration year, that entered the Tucannon River after the array was destroyed could not be added to the table. Therefore, the percent of fish into the Tucannon, above Granite, or Unknown destination for the 2006 and 2007 migrations years are under or over-estimates.

Table 11. Detections of PIT tagged Touchet River Endemic stock summer steelhead, and Lyons Ferry stock summer steelhead (Walla Walla and Dayton AP release groups) that crossed McNary Dam, Ice Harbor Dam (IHR), and Lower Granite Dam (LGR).

						Percent of those that passed McNary Dam [b]			
Run Year	# Passed McNary	# Entered Walla2	# Stayed above IHR	# Stayed above LGR	# Entered Tucannon [a]	% into Walla2	% above IHR	% above LGR	% Into Tucannon [a]
Touchet Endemic Hatchery Stock Summer Steelhead									
2005	29	1	11	0	8	3.5	37.9	0.0	27.6
2006	25	9	12	1	7	36.0	48.0	4.0	28.0
2007	18	6	9	1	4	33.3	50.0	5.6	22.2
2008	57	20	23	6	1	35.1	40.4	10.5	1.8
2009	74	28	31	8	12	37.8	41.9	10.8	16.2
2010	47	11	24	8	2	23.4	51.1	17.0	4.3
2011	49	27	13	0	8	55.1	26.5	0.0	16.3
Totals	**299**	**102**	**123**	**24**	**42**	**34.1**	**41.1**	**8.0**	**14.5**
Touchet Natural Stock Summer Steelhead									
2009	12	8	2	2	0	66.7	16.7	16.7	0.0
2010	21	3	7	2	0	14.3	33.3	9.5	0.0
2011	15	7	6	0	1	46.7	40.0	0.0	6.7
Totals	**48**	**18**	**15**	**4**	**1**	**37.5**	**31.6**	**8.3**	**2.1**
Lyons Ferry Stock Summer Steelhead (Released @ Dayton Acclimation Pond)									
2008	95	8	73	24	10	8.4	76.8	25.3	10.5
2009	149	14	126	44	22	9.4	84.6	29.5	14.8
2010	80	15	50	13	2	18.8	62.5	18.8	2.5
2010	79	9	64	17	12	11.4	81.0	21.5	15.2
Totals	**403**	**46**		**98**	**46**	**11.4**	**78.4**	**24.3**	**11.4**
Lyons Ferry Stock Summer Steelhead (Released in the lower Walla Walla River)									
2008	76	1	65	24	2	1.3	85.5	31.6	2.6
2009	81	8	60	18	11	9.9	74.1	22.2	13.6
2010	62	10	48	16	3	16.1	77.4	25.8	4.8
2011	86	6	71	12	6	7.0	82.6	13.9	7.0
Totals	**305**	**25**	**244**	**70**	**22**	**8.2**	**80.0**	**22.9**	**7.2**

[a] The Tucannon River PIT tag array was taken out by high stream flow in January, 2009. Two salt returns from the 2006 migration year, and 1-salt returns from the 2007 migration year, that entered the Tucannon River after the array was destroyed could not be added to the table.

[b] Not all fish that crossed McNary Dam are shown in the table, a few were also detected at Priest Rapids Dam, Rock Island Dam, Rocky Reach Dam, and Wells Dam in the upper Columbia River.

Summer Steelhead Broodstock Collections / Adult Returns and Evaluations

As part of our annual broodstock collection and research activities, WDFW hatchery and evaluation staffs operate a series of adult steelhead traps in southeast Washington Rivers. The LFH staff operates the LFH and Cottonwood Creek adult traps. The TFH staff operates the upper Tucannon River adult trap, and evaluation staff operates the Touchet River adult trap in

Dayton. Information presented below summarizes collection and hatchery spawning activities and any additional evaluation projects for the reporting period.

LFH Trap

Run Year 2010: Adult steelhead were trapped from 16 September through 6 November 2010. A total of 1,538 adult steelhead (864 female [56.2%] and 674 male [43.8%]) were trapped. Fish to be retained for broodstock were sorted on 17 November 2010. All fish not needed for broodstock or retained to recover CWTs were returned to the Snake River to contribute to the sport fishery (1,037). Of those steelhead trapped, no wild origin (unmarked) fish were found. We recovered 271 fish with CWTs (Table 12). Sex ratio of CWT fish was similar (41.9% male, 58.1% female) to others that were trapped. Age composition of the return based on CWT recoveries was 77.4% one-ocean, 21.9% two-ocean, and 0.7% three-ocean. Mortality during trapping, holding, and spawning was 44 fish (2.9% of all fish trapped). During January and February of 2011, 88 females were spawned with 88 males, providing 520,023 total eggs and producing 401,619 eyed eggs (22.8% loss) for the LFH stock program (Table 2). An additional 32 females and 32 males were spawned as part of an experiment to test the effects of electronarcosis on egg viability. A total of 183,613 green eggs and 144,287 eyed eggs (21.4% loss) were collected from electronarcosis experimental fish. Egg mortality did not appear to be negatively affected by electronarcosis (see below). All progeny from this experiment were eventually used as forage food for the WDFW tiger musky program at Ringold Hatchery. No eggs were destroyed due to high IHN titer virus levels in 2011.

Run Year 2011: Adult steelhead were trapped from 20 September through 28 September 2011. A total of 2,114 adult steelhead (1,213 female [57.4%] and 901 male [42.6%]) were trapped. Fish to be retained for broodstock were sorted on 4 October 2011. All fish not needed for broodstock, retained to recover CWTs, or those that survived the electronarcosis long-term holding experiment (see next section) were returned to the Snake River to contribute to the sport fishery (1,231). Of those steelhead trapped, no wild origin (unmarked) fish were found. We recovered 356 fish with CWTs (Table 12). Sex ratio of CWT fish was similar (40.9% male, 59.1% female) to others that were trapped. Age composition of the return based on CWT recoveries was 84.0% one-ocean, 16.0% two-ocean, and 0.0% three-ocean. Mortality of fish that were initially trapped and held for broodstock was 87 fish (5.6% of collected). Mortality of fish that were initially trapped and held for the electronarcosis long-term holding experiment was 199 fish (36.3%); however, these fish were not treated with formalin so we knew their mortality rate would be higher. During January and February of 2012, 103 females were spawned with 101 males, collecting 603,823 total eggs and eventually producing 415,577 eyed eggs (31.2% loss) for the LFH stock program (Table 2). No eggs were destroyed due to high IHN titer virus levels in 2011.

Table 12. Summary of tagged adult summer steelhead trapped at LFH for the 2010 run year / 2011 brood year, and the 2011 run year/ 2012 brood year

Brood year	CWT code	Stock	Release site	Number of CWTs
2010 run year/ 2011 brood year				
2006	63 / 36 / 65	Lyons Ferry	Touchet River @ Dayton AP	1
2006	63 / 36 / 66	Lyons Ferry	Walla Walla River	1
2007	63 / 40 / 97	Lyons Ferry	Snake River – On Station	31
2007	63 / 40 / 98	Lyons Ferry	Touchet River @ Dayton AP	13
2007	63 / 40 / 96	Lyons Ferry	Walla Walla River	10
2007	63 / 40 / 95	Lyons Ferry	Tucannon River	5
2008	63 / 46 / 82	Wallowa	Cottonwood AP – Grande Ronde	1
2008	63 / 46 / 83	Lyons Ferry	Touchet River @ Dayton AP	44
2008	63 / 46 / 84	Lyons Ferry	Snake River – On Station	93
2008	63 / 46 / 85	Lyons Ferry	Tucannon River	19
2008	63 / 46 / 86	Lyons Ferry	Walla Walla River	53
			LV clip - No CWT	10
			Lost CWT	1
			Grand Total For Year	**282**
2011 run year/ 2012 brood year				
2008	63 / 46 / 83	Lyons Ferry	Touchet River @ Dayton AP	12
	63 / 46 / 84	Lyons Ferry	Snake River – On Station	21
	63 / 46 / 85	Lyons Ferry	Tucannon River	11
	63 / 46 / 86	Lyons Ferry	Walla Walla River	13
2009	63 / 51 / 67	Lyons Ferry	Snake River – On Station	133
	63 / 51 / 68	Lyons Ferry	Walla Walla River	70
	63 / 51 / 69	Lyons Ferry	Tucannon River	39
	63 / 51 / 70	Lyons Ferry	Touchet River @ Dayton AP	57
			LV clip - No CWT	6
			Lost CWT	1
			Grand Total For Year	**363**

In recent years, hatchery and evaluation staffs have noticed that the fish we trapped and used for broodstock seemed to be comprised of more of 1-salt fish than in earlier years of the program (Figure 2). As such, beginning with the 2011 brood, we changed the broodstock selection criteria to include only fish that were greater than 62cm in fork length. For both 2011 and 2012 broodyears, scales were taken from all fish spawned to confirm their salt water age (many of these are AD-only, and there is considerable overlap in fork length between ages). Ages from scale samples for fish used for broodstock were compiled and compared to the age composition of the overall return to the hatchery based on CWT recoveries (Table 13). Based on our size selective protocol, we effectively altered the age composition of fish contributing to the next generation. We will continue to monitor age-at-return for these broods in coming years.

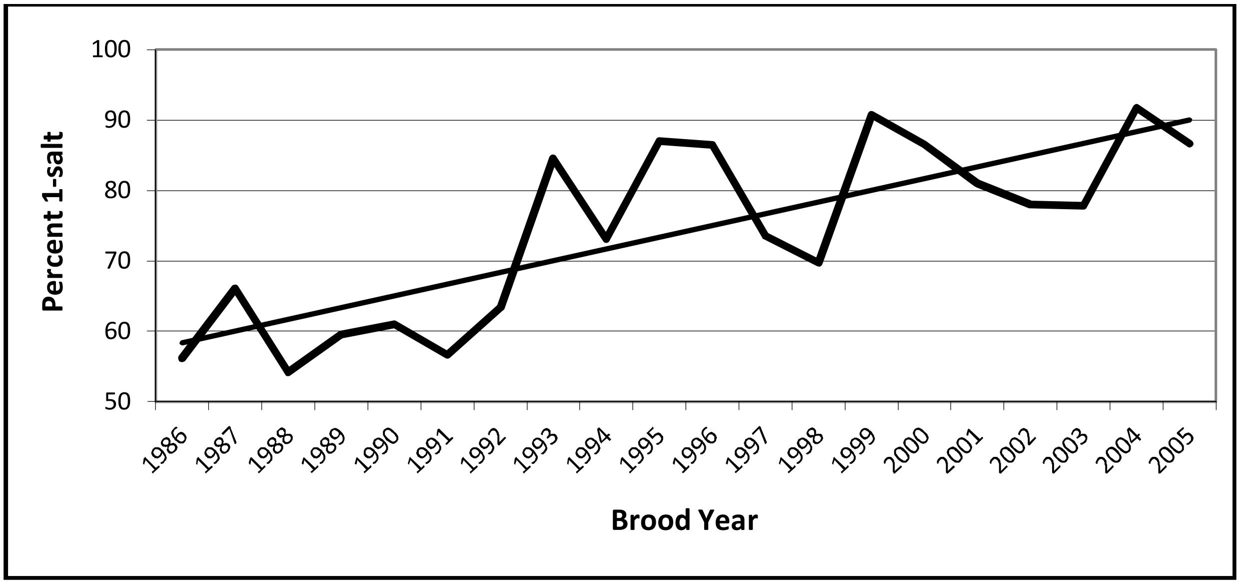


Figure 2. Percent 1-salt summer steelhead trapped and used for broodstock at Lyons Ferry hatchery from the 1986-2005 brood years.

Table 13. Age compostion of trapped and spawned summer steelhead for the Lyons Ferry stock summer steelhead, 2001 and 2012 brood years.

	Age Composition Trapped (%)			Age Composition Spawned (%)			% change in 1-salt fish used
Year	1-salt	2-salt	3-salt	1-salt	2-salt	3-salt	
2011	77.4	21.9	0.7	56.8	42.1	1.1	-20.0%
2012	84.0	16.0	0.0	41.7	58.3	0.0	-42.3%

For the 2011 brood, mean fecundities of one-ocean and two-ocean females (from both production and experimental groups) were 5,384 and 5,927, respectively. For the 2012 brood, mean fecundities of one-ocean and two-ocean females (from both production and experimental groups) were 5,439 and 6,191, respectively.

All steelhead trapped and/or retained were scanned for PIT tags. For the 2011 brood, we detected 26 unique PIT tags in the broodstock. For the 2012 brood, we detected 36 unique PIT tags. For both years, many were tagged and released at LFH, or from the Tucannon, Touchet, or Walla Walla rivers, while others were tagged at mainstem Columbia or Snake River dams as juveniles during outmigration or as adult returns. All recovered PIT tag data was uploaded to PTAGIS per sampling and reporting protocols.

Electronarcosis Tests

Fisheries professionals are in need of an approved immediate release sedative for fisheries research and management activities as a viable alternative to chemical anesthesia (MS-222 or CO^2) or the stressful practice of V-trough handling without anesthesia. Although the use of electrical sedation in fisheries research and at hatcheries is not new, recent advancements in technology have improved the safety of and reduced the negative effects from electrical-anesthetic (EA) by applying both pulse and wave form technology, and by utilizing low-voltage electronic units capable of inducing lower voltage approaches termed electro-narcosis (EN). Although no method of handling can be completely benign, results presented below from tests conducted by WDFW at Lyons Ferry Hatchery clearly show its utility as an alternative method for handling fish in an effective, time efficient, and reasonably benign manner.

In 2012, WDFW produced a formal document and operations protocol for the use of EN at WDFW operated facilities. These documents can be found in Attachment 1 and 2.

Snake River Preliminary Evaluation – 2010-2011: Evaluation staff researched current EN equipment after viewing an online video of EN use during surgical implantation of radio tags into bull trout (Hudson et al. 2011). The video showed USFWS personnel implanting radio tags quickly and efficiently into bull trout under EN with near immediate recovery to a stable swimming state following the surgery. Details of the equipment were obtained from the USFWS research staff and one test unit was purchased (< $300) for experimentation. Snake River Lab staff devised an electro-anesthetic chamber using a section of an 8" PVC pipe (cut open along the top), with EN unit leads attached to 8" round thin-plate aluminum to act as the electrodes. A few hatchery steelhead captured from the Touchet River adult trap in Dayton were introduced to the pipe via dip net at various settings ranging from 30-60 volts DC and their response observed. We found that levels of sedation were related to fish size, voltage and emersion time, although initial effects of sedation and quiescence occurred nearly immediately. Fish reached the state of EN generally at or above 50 V output. Upon removal from the electrical field, fish resumed their normal orientation and were capable of swimming nearly immediately (< 3 s). Multiple exposures of individual hatchery fish to the field did not appear to induce a cumulative sedative effect, although longer immersion times (> 60 s) generally produced a deeper narcosis; but recovery time was unaffected. Internal discussions with WDFW Fish Management Division staff identified additional concerns about long term effects (e.g. – survival, egg or sperm viability, internal skeletal/muscular injury, etc.), specifically with respect to the use of EN on ESA listed natural fish heading to their spawning ground and the potential for a population level effect if EN was used. This led to the development and completion of a more intensive study of effects on spinal/musculature injury, and egg and fry survival from spawned hatchery steelhead at the Lyons Ferry Hatchery.

Lyons Ferry Hatchery Test – 2011 Brood Spawning: Beyond the efficacy of EN, there remained much concern about the potential long term or delayed effects of using EN on salmon and steelhead. To assess those concerns we worked with LFH staff, the local fish manager and fish health specialist to devise a study using Lyons Ferry hatchery steelhead at LFH during spring 2011.

Study Design: A study group of 40 adult females and 60 adult males would be subjected to a minimum of one-minute EN exposure during the 1st week's sorting and spawning process. Output settings for the EN unit targeted 0.66 V/cm at 60 V output and did not exceed 0.15 amps. Water temperature at Lyons Ferry is a constant 11.0° C, and conductivity was measured at 220-240 µS/m. The control group was represented by broodstock spawned using standard hatchery procedures and the use of MS-222 anesthesia for sorting and spawning. Spawning crosses were restricted to each study group (EN x EN, MS-222 x MS-222). Study and control group fish were killed at spawning and carcasses were filleted and photographed using the methods described in Zydlewski et al. (2008) to document hemorrhaging and possible spinal damage (Photo 1). Eggs from study fish were fertilized, water hardened, held separate and incubated and handled in a manner consistent with the control fish. Egg mortality and survival to eye-up and to the fry stage was documented for each female in both study and control groups following standard hatchery protocols.

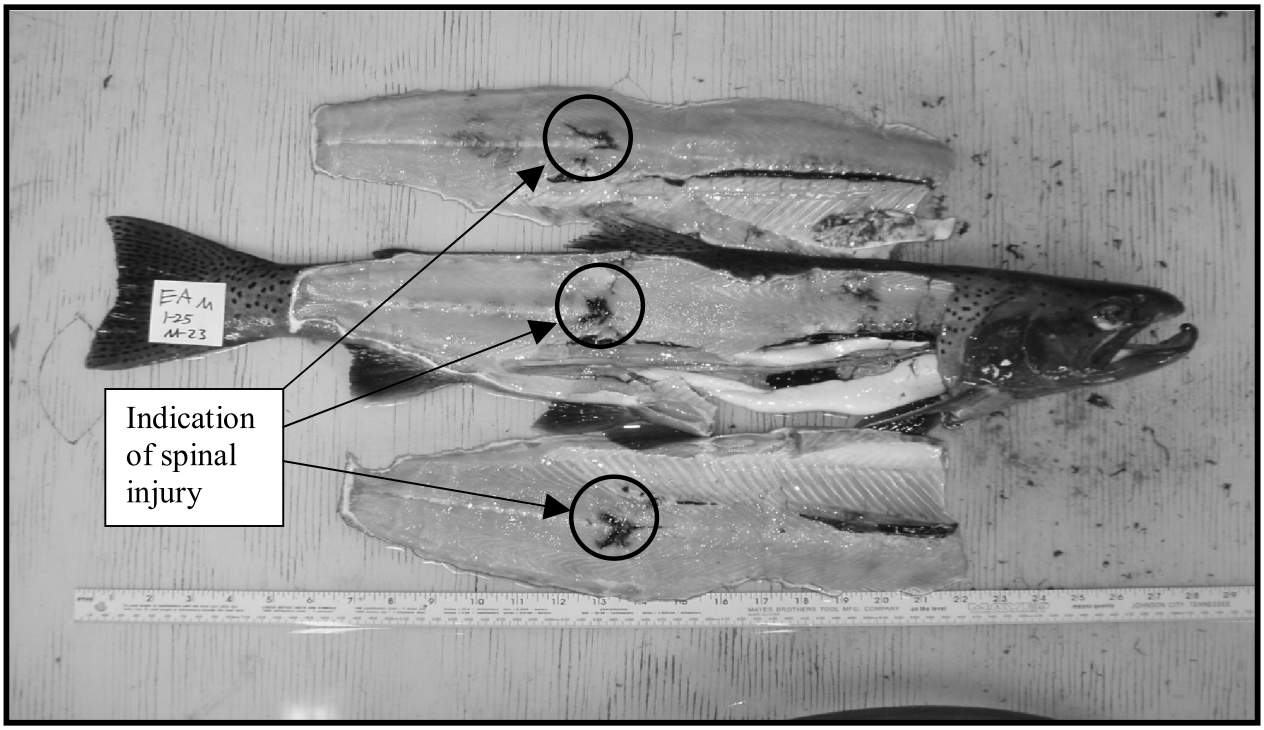


Photo 1. Filleting of study fish was completed to document hemorrhaging and whether associated with the spine or intramuscularly (a hemorrhage associated with the spine is clearly visible in this male).

Results: Incidence of spinal and intramuscular hemorrhage was similar between EN and MS-222 treated adult steelhead (Table 14), with slightly lower observed injury in the EN treated fish. This study subjected treatment male and female steelhead to one additional EN exposure weekly during the spawning season until the fish ripened and was spawned. As such some males and females were EN treated once, while others were EN treated up to six times. We examined the carcasses of fish EN treated multiple times and found no evidence of greater numbers of hemorrhages. Since the incidence of spinal/muscle hemorrhage was nearly identical in both groups, we conclude that these injuries were most likely due to trapping/handing procedures and not related to the EN treatment. Further, we saw no measurable difference in egg viability (Table 15). There was no significant difference ($P = 0.69$) in green egg to eyed egg stage survival between the groups, although the variability in egg survival was very high among females in both groups, which is typical for steelhead. Individual fish accounting was lost at eye-up when eggs were combined for hatching, but we observed nearly identical survival from eyed egg to the fry stage with MS-222 treated fish survival estimated at 97.3% and EN treated fish survival estimated at 96.9%.

Table 14. Incidence of hemorrhaging near the spine and non-spinal for male and female steelhead spawned at LFH in 2011.

	MS-222		EN	
	Males	Females	Males	Females
Number examined	40	39	43	31
Number of injuries				
Non-Spinal	4	0	2	0
Spinal	0	1	1	1
Total	4	1	3	1
Percent	6.3%		5.4%	

Table 15. Green egg to eyed egg survival rates for two study groups of fish at LFH in 2011.

	MS-222		EN	
	N	% Survival	*N*	% Survival
All fish	88	76.4	32	78.7

We examined the potential cumulative effect of multiple exposures to EN on egg viability. Over six weeks (Figure 3) there was no discernible trend toward increasing egg mortality, and though sample size was small (5-7 fish/wk) analysis with Fisher's least significant difference procedure showed the means to be homogeneous. Week 4 did not plot as sample size (n= 1) was too small.

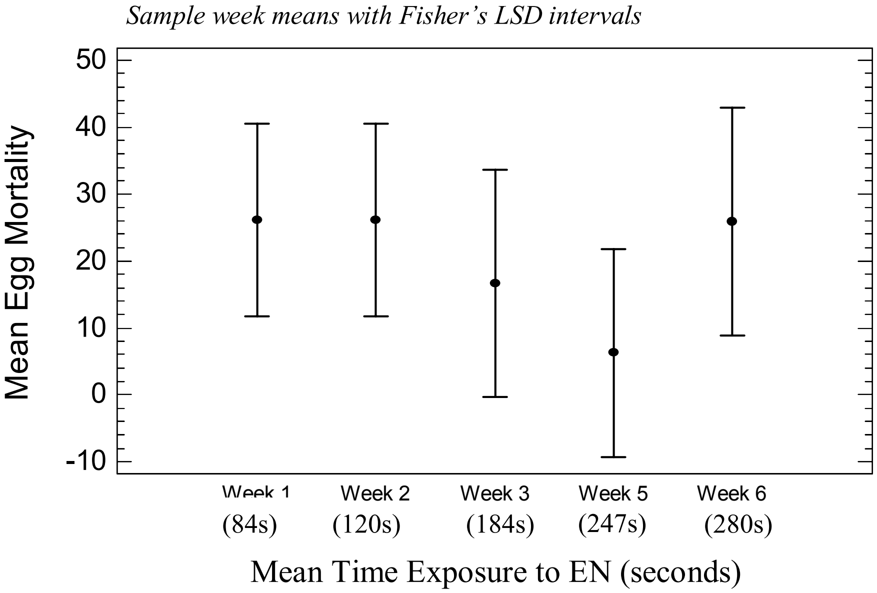


Figure 3. Egg mortality over time for groups of female steelhead exposed to successively greater amounts of electro-narcosis at LFH, 2011. (Mean cumulative exposure for groups is displayed in seconds for each week)

These results were consistent, and even slightly better than those reported in the literature for salmon, which we attributed to the use of a lower voltage DC current. Based on this test we concluded that the use of EN for handling pre-spawn steelhead is not likely to significantly increase mortality or compromise gamete viability.

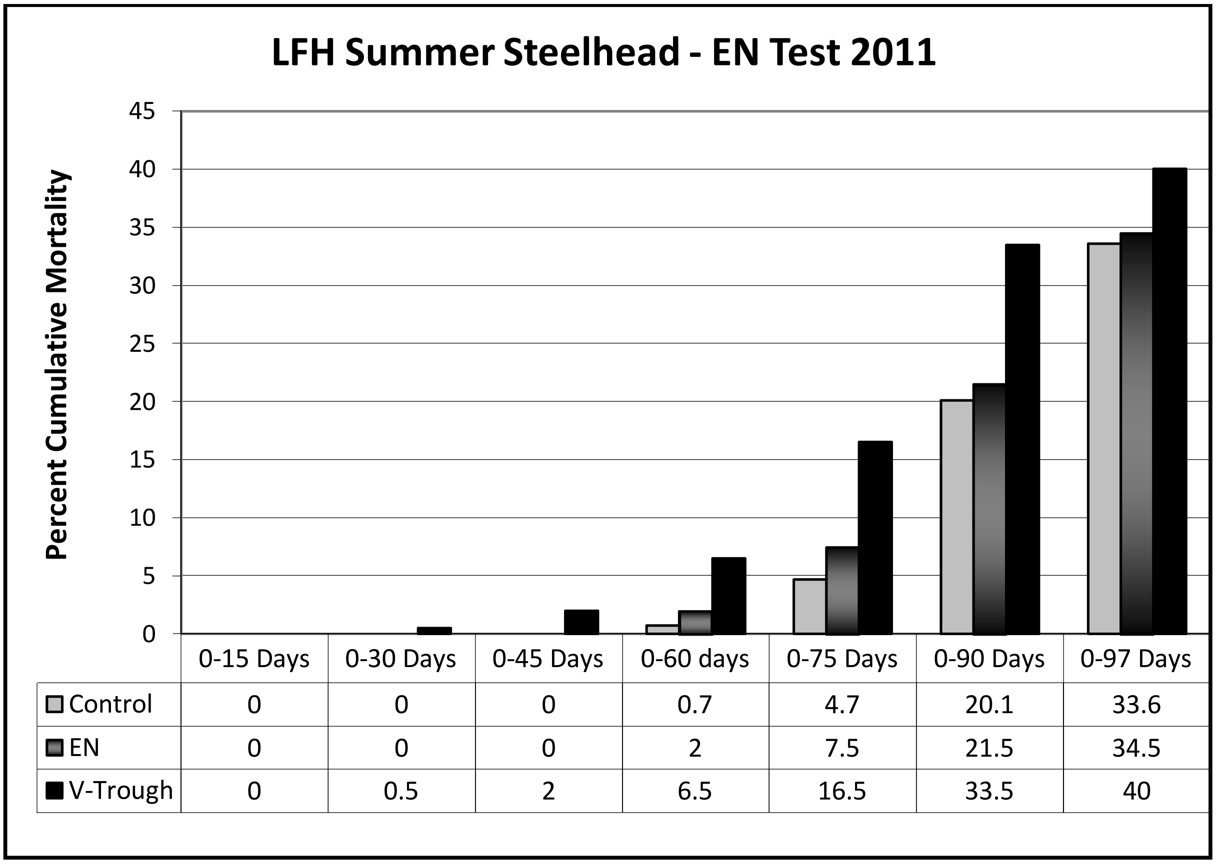
Lyons Ferry Hatchery Test – Fall 2011: A second test of the long term effects was proposed at LFH for fall 2011 to directly measure delayed mortality over a 3 month post exposure period; which is a similar time to spawning that fish may have to survive after handling at a research trap or selection for broodstock at a hatchery.

Study Design: An important distinction of this study over the previous year was the inclusion of a control group not exposed to any form of anesthesia or handling. WDFW operates steelhead trapping facilities around SE Washington, and standard handling protocol in recent years has been to use water filled V-troughs to sample and release adult steelhead without the use of anesthetic. This has been done to allow for the immediate release of hatchery fish into rivers where active sport fisheries are often underway. Although the forward 20 cm of the V-troughs is covered with black rubber and fish will often lie quiet once their head is within this dark area, capturing and inserting fish into the troughs can require tight physical restraint to prevent thrashing. Moreover, not all fish respond equally to the dark area; many will continue to fight the trough which requires a sampler to continually restrain the fish while another person samples the fish – doubling the staff required. The possibility of causing trauma to the fish is real during this type of sampling. A direct comparison of the physical effects of current handling protocol (v-trough) with EN and the inclusion of a control group (no handling of any kind during the duration of the study) seemed a logical follow up to previous studies.

Approximately 600 summer steelhead were to be trapped at LFH in 2011. On 12 October 2011, evaluation staff sampled 200 fish using EN, 200 fish with a v-trough, with an unknown number of other fish (approximately 150-200) that were not handled to be used as a control. Sampling study groups consisted of netting individual fish, determining their sex, documenting length, collection of a scale sample, and then clipping either the top/bottom distal portion of the caudle fin depending on the group (EN=top caudal, v-trough=bottom caudal). The EN group treatment was similar to the previous year, although fish were exposed to EN only as long as necessary to collect the required data. Handling of the v-trough group was identical to normal field sampling activities to provide a functional comparison of how fish might be affected by the two methods. All steelhead were held within the same adult holding raceway (10' x 80' x 6') at LFH but were **not treated** with formalin to control fungus. Because of a high density of adults in the raceway, water flow into the pond was increased. All mortalities were sampled on a daily basis by LFH hatchery staff and were sampled following standard hatchery protocols, with caudal fin clips recorded.

Results: The average time required to net, sample, and release fish in the EN group was 40 seconds when scales were collected. V-trough handling of fish required a significantly greater time ($P < 0.0005$) at 51 seconds. There was no significant difference ($P > 0.50$) in average handling time between groups when scales were not collected (mean = 33 seconds for EN: 36 seconds for v-trough). Fish handled with the v-trough had the highest mortality throughout the duration of the study (Figure 4). Mortality in all three groups was very low 45 days into the study, but rapidly increased for all groups 75-90 days into the study. This increased mortality was likely the result of rapid ripening for spawning since mortality increased concurrently within all treatment groups. At the completion of the study seven v-trough fish (bottom caudal fin clip) could not be accounted for. Based on the raw data sheets and notes of mortalities kept by hatchery staff, seven of the recorded control fish were changed to bottom caudal fish. This manipulation of the data occurred because fungus, which in many cases severely eroded the caudal fin tissue, complicated positive identification on mortalities. All EN fish (top caudal fin clip) were identified.

We conclude from this test that EN treated fish required less handling time when complex sampling occurred, and experienced fewer traumas and less overall mortality as a result of handling than fish sampled with no anesthetic using our standard handling methods (e.g., V-trough). Further, mortality within the v-trough sampled group began sooner than for EN and control groups (Figure 4).



	0-15 Days	0-30 Days	0-45 Days	0-60 days	0-75 Days	0-90 Days	0-97 Days
□ Control	0	0	0	0.7	4.7	20.1	33.6
▨ EN	0	0	0	2	7.5	21.5	34.5
■ V-Trough	0	0.5	2	6.5	16.5	33.5	40

Figure 4. Cumulative mortality of steelhead subjected to three treatements at LFH, 2011.

Cottonwood Creek Trap

Run Year 2010: At the Cottonwood Creek Trap, 512 adult steelhead (183 [35.7%] male, 389 [64.3%] female) were trapped from 7 March to 20 April. Less than 10 natural origin fish were captured during the season. A decision was made to transport the trapped adults back to Lyons Ferry, with the idea that a less stressful environment and cleaner water at Lyons Ferry would reduce the incidence of IHNV detected in spawned females. The first 560 fish trapped at Cottonwood were taken to Lyons Ferry. Age composition based on CWT recoveries of sampled hatchery origin fish was 56.0% one-ocean and 44.0% two-ocean. For the season, 106 females and 82 males were initially spawned producing about 522,967 fertilized eggs (10 females and 10 males were spawned from the ODFW program due to the high rate of IHNV detected at spawning). However, 50 females tested positive for IHNV. An estimated 217,897 eggs from those fish were destroyed at LFH, leaving 193,180 eyed eggs total for production. After the

IHNV females were removed, it was determined that only 56 females and 42 males actually contributed to the broodstock. In addition to the high incidence of IHNV, pre-spawn loss in 2011 was high (37.3%). The stress/damage caused by transport from Cottonwood to Lyons Ferry is believed to have contributed to both. It was decided post-season that this strategy would not be used in the future.

In 2011, fecundities of one-ocean and two-ocean females were 4,481 and 5,982, respectively, and similar to previous year's fecundity estimates (Bumgarner et. al. 2011). All carcasses from spawned fish, or those killed to retrieve the CWTs, were buried at Lyons Ferry. We recovered 44 fish that had, or should have had CWTs (Table 16). Sex ratio of CWT fish (50% male, 50% female) was dissimilar to those that were trapped at large. All CWTs recovered from the 2010 run year were originally released on-site at Cottonwood AP.

Run Year 2011: 1,080 adult steelhead (457 [42.3%] male, 623 [57.7%] female) were trapped from 28 February to 30 April. Ten natural origin fish were captured during the season, all were passed upstream. Age composition based on CWT recoveries of sampled hatchery origin fish was 75.3% one-ocean and 24.7% two-ocean. For the season, 120 females and 93 males were initially spawned producing about 632,738 fertilized eggs. Initial egg loss was 22.5%, leaving an estimated 563,022 eggs for production. No IHNV was detected in any of the females. Eggs in excess of program needs were destroyed (323,029), but representative eggs from each spawned female were kept to maintain the genetic diversity of the stock. Eyed eggs that were retained equaled 239,993.

Table 16. Summary of tagged adult summer steelhead trapped at Cottonwood Trap for 2010 run year / 2011 BY.

Brood year	CWT code	Stock	Release site	Number of CWTs
2010 run year / 2011 brood year				
2007	63 / 40 / 99	Wallowa	Cottonwood AP	20
2008	63 / 46 / 82	Wallowa	Cottonwood AP	44
			LV clip - No CWT	2
			Lost CWT	1
			Grand Total for Year	**47**
2010 run year / 2011 brood year				
2008	63 / 46 / 82	Wallowa	Cottonwood AP	22
2009	63 / 51 / 71	Wallowa	Cottonwood AP	67
			LV clip - No CWT	10
			RV clip – No CWT	3
			Lost CWT	0
			Grand Total for Year	**102**

In 2012, fecundities of one-ocean and two-ocean females were 4,691 and 6,252, respectively. Due to an excess of adults in 2012, and the new facility policy of not passing hatchery adults into Cottonwood Creek upstream of the adult trap/water intake, the city of Clarkston food bank was provided 381 adult steelhead from the Cottonwood Trap. All other carcasses from spawned fish, or those killed to retrieve the CWTs, were buried at Lyons Ferry. We recovered 102 fish that had, or should have had CWTs (Table 16). Sex ratio of CWT fish (56% male, 43% female) was dissimilar to those that were trapped at large. All CWTs recovered from the 2011 run year were originally released on-site at Cottonwood AP.

TFH Trap

Run Year 2010: A permanent adult steelhead and salmon trap was installed in 1998 at the TFH water intake diversion dam. Natural and Tucannon River hatchery endemic stock origin steelhead are enumerated, sampled, and passed upstream to spawn, while LFH stock fish are returned to below the trap unless they are a fish with a CWT. Fish with a CWT are removed for tag extraction. For the 2010 run year (February-May), hatchery staff trapped 202 natural origin, 130 Tucannon River endemic stock and 3 LFH stock hatchery-origin steelhead (Table 17). Twenty-six females (22 natural, 4 endemic origin) and 24 males (23 natural and one endemic origin) were collected. At the end of the season, endemic origin fish contributed to 8% of the broodstock, as one female died prior to spawning.

During March and April 2011, 21 females were spawned with 20 males at LFH. Total egg take was estimated at 121,597 (Table 3). Ten of the spawned females tested positive for IHNV. Progeny from these females were reared to the unfed fry stage at LFH, and then planted into the Tucannon River near Cummings Creek (below TFH). An estimated total of 45,236 fry were planted. Natural fish trapped from the TFH trap consisted of 28.6% one-ocean and 71.4% two-ocean age fish (Table 18). Of the females spawned, all were two-ocean females with an average fecundity of 5,678 eggs.

Table 17. Natural origin, hatchery LFH stock origin, hatchery Tucannon endemic stock origin summer steelhead trapped at the Tucannon Fish Hatchery from the 1997-2011 run years.

Run	Natural			Hatchery LFH Stock			Hatchery Endemic Stock			Totals (Percent)	
Year	Male	Female	Total	Male	Female	Total	Male	Female	Total	% Natural	% Female
1997	8	10	18	31	47	78	NA	NA	NA	18.8	59.4
1998	9	13	22	14	19	33	NA	NA	NA	40.0	58.2
1999	12	6	18	5	5	10	NA	NA	NA	64.3	39.3
2000	9	1	10	3	0	3	NA	NA	NA	76.9	7.7
2001	75	103	178	24	4	28	NA	NA	NA	86.4	51.9
2002	30	34	64	9	3	12	NA	NA	NA	84.2	48.7
2003	23	10	33	5	0	5	4	1	5	78.6	25.6
2004	36	7	43	2	0	2	11	2	13	74.1	15.5
2005	12	8	20	1	0	1	7	11	18	51.3	48.7
2006	12	2	14	3	2	5	11	3	14	42.4	21.2
2007	6	4	10	5	0	5	6	2	8	43.5	26.1
2008	38	50	88	6	2	8	121	121	242	26.0	51.2
2009	181	142	323	3	5	8	183	147	330	48.9	44.5
2010	78	124	202	1	2	3	33	97	130	60.3	66.6
2011	78	108	186	0	2	2	104	107	211	46.6	54.4

Table 18. Total number of fish trapped and passed upstream to spawn naturally at the Tucannon River Adult Trap, 1997-2011 run years.

Run	Natural Stock			Hatchery LFH Stock			Hatchery Endemic Stock		
Year	Trapped	Passed	% Passed	Trapped	Passed	% Passed	Trapped	Passed	% Passed
1997	18	18	100	78	78	100	NA	NA	NA
1998	22	22	100	33	33	100	NA	NA	NA
1999	18	18	100	10	0	0	NA	NA	NA
2000	10	10	100	3	0	0	NA	NA	NA
2001	178	178	100	28	2	7	NA	NA	NA
2002	64	64	100	12	1	8	NA	NA	NA
2003	33	33	100	5	0	0	5	5	100
2004	43	43	100	2	1	50	13	13	100
2005	20	20	100	1	0	0	18	18	100
2006	14	14	100	5	0	0	14	14	100
2007	10	8	80	5	0	0	8	8	100
2008	88	68	77	8	0	0	242	235	97
2009	323	298	92	8	0	0	330	318	96
2010	202	157	78	3	0	0	130	125	96
2011	186	139	75	2	0	0	211	211	100

Table 19. Summary of fresh and salt-water age composition of natural origin adult steelhead from the Tucannon River, 2000-2012 brood years. Note: this table does not include 3-ocean age fish, or those with freshwater age 4. Only a few of those individuals have been documented overall years (0.04%)

	Age 1.1		Age 1.2		Age 2.1		Age 2.2		Age 3.1		Age 3.2		Percent
Brood Year	N	%	N	%	N	%	N	%	N	%	N	%	repeat spawners
2000	18	25.0	6	8.3	36	50.0	7	9.7	5	6.9	0	0.0	0.0
2001	0	0	13	27.1	13	27.1	19	39.6	0	0.0	3	6.3	0.0
2002	5	8.8	10	17.5	29	50.9	10	17.5	3	5.3	0	0.0	0.0
2003	0	0	4	3.9	29	28.2	56	54.4	5	4.9	6	5.8	3.6
2004	0	0	0	0.0	42	68.9	13	21.3	5	4.9	0	0.0	1.0
2005	15	4.8	32	10.3	99	31.9	141	45.5	14	4.5	7	2.3	0.6
2006	5	4.6	7	6.5	44	40.7	44	40.7	6	5.6	1	0.9	0.9
2007	1	2.0	7	14.3	16	32.7	18	36.7	4	8.2	2	4.1	0.0
2008	1	6.3	1	6.2	8	50.0	5	31.2	1	6.3	0	0.0	0.0
2009	0	0.0	2	2.7	38	50.7	12	16.0	11	14.7	7	9.3	2.7
2010	8	5.6	10	7.0	91	63.6	22	15.4	10	7.0	2	1.4	0.0
2011	1	0.8	2	1.6	30	23.8	78	61.9	5	4.0	10	7.9	0.0
2012	0	0.0	0	0.0	12	17.4	49	71.0	5	7.2	3	4.3	0.0
Combined	**54**	**4.4**	**94**	**7.6**	**487**	**39.4**	**474**	**38.3**	**74**	**6.0**	**41**	**3.3**	**0.7**

Run Year 2011: For the 2011 run year, hatchery staff trapped 186 natural origin, 211 Tucannon River endemic stock, and 2 LFH stock hatchery-origin steelhead (Table 17). Twenty-two females and 25 males (all natural origin) were collected. During March and April 2012, 19 females were spawned with 17 males at LFH. Total egg take was estimated at 93,065 (Table 3). Four of the females tested positive for IHNV in 2012. However, the virus titers levels were low enough that it was decided to rear them. No outbreaks have occurred to date. Natural fish trapped from the TFH trap consisted of 24.6% one-ocean and 75.4% two-ocean age fish (Table

18). In 2012, fecundities of one-ocean and two-ocean females were 4,769 and 5,968, respectively,

Touchet River Adult Trap

The Touchet River adult trap, located in Dayton near rkm 86.4 has been operated continuously each spring since 1999. Dates of annual operation have varied each year due to environmental or other conditions. The main purpose of the adult trap is to capture adult summer steelhead: some were to be collected for a new hatchery broodstock for use in the Touchet River. This program (similar in nature to the Tucannon River programs; see prior section) continues, but is still considered experimental. Since 2000, nearly all LFH stock fish captured in the Touchet River adult trap have been returned downstream to either recycle through the fishery or to separate them from the upriver spawning locations. Beginning in 2009, all LFH stock fish captured were transported to the Dayton Juvenile Pond or were killed outright to obtain the CWT and provided to the Dayton food bank if possible.

Run Year 2010: For the season, staff trapped 334 (73.3%) natural, 66 (14.5%) LFH hatchery origin, and 56 (12.2%) Touchet River endemic hatchery origin steelhead (Table 19). Natural steelhead trapped for the 2010 run year consisted of 34.6% one-ocean and 65.4% two-ocean age fish (Table 20). Sex ratio of natural origin fish was 72.5% female, while hatchery steelhead was 71.3% female. We collected 34 natural origin fish (14 females and 20 males) for broodstock. There were no pre-spawning mortalities during the 2011 spawning season, and none of the females tested positive for the IHN virus. Of the fish collected for broodstock, 12 females were spawned with 13 males yielding 74,408 eggs (Table 4). All spawned females were two-ocean age with an average fecundity of 6,161 eggs.

Run Year 2011: For the season staff trapped 175 (74.8%) natural, 10 (4.3%) LFH hatchery origin and 49 (20.9%) Touchet River endemic hatchery origin steelhead (Table 19). Natural steelhead trapped for the 2011 run year consisted of 47.1% one-ocean and 52.9% two-ocean age fish (Table 20). Sex ratio of natural origin fish was 65.1% female, while hatchery steelhead was 69.5% female. We collected 32 natural origin fish (18 females and 14 males) for broodstock. There was one female pre-spawning mortality (3.1%), but no females spawned tested positive for the IHN virus. Of the fish collected for broodstock, 17 females were spawned with 13 males yielding 81,555 eggs (Table 4). For the 2011 run year, mean fecundities of natural one-ocean and two-ocean females were 4,528 and 5,106 eggs, respectively.

In addition to trapping summer steelhead, we also capture spring Chinook salmon (*O. tshawytscha*), bull trout (*Salvelinus confluentus*), bridgelip suckers (*C. columbianus*), brown trout (*Salmo trutta*), and whitefish (*Prosopium williamsoni*) in the Touchet adult trap (Table 21).

Biological data collected from bull trout, brown trout and whitefish trapped at the Touchet adult trap are presented in Appendix B.

Table 20. Total number of male and female summer steelhead at the Touchet River Adult Trap (1992-1994, 1998-2011 run years).

Run	Natural			Hatchery LFH Stock			Hatchery Endemic Stock			Totals (Percent)	
Year	Male	Female	Total	Male	Female	Total	Male	Female	Total	% Natural	% Female
1992	17	36	53	2	6	8	NA	NA	NA	86.8	68.9
1993	8	35	43	1	1	2	NA	NA	NA	95.6	80.0
1994	2	6	8	1	1	2	NA	NA	NA	80.0	70.0
1998	13	29	42	5	2	7	NA	NA	NA	85.7	63.3
1999	8	24	32	4	0	4	NA	NA	NA	88.9	66.7
2000	54	130	184	17	19	36	NA	NA	NA	83.6	67.7
2001	67	106	173	9	9	18	NA	NA	NA	90.6	60.2
2002	30	91	121	4	6	10	0	1	1	91.7	74.2
2003	29	73	102	19	8	27	11	5	16	70.3	59.3
2004	38	47	85	20	27	47	4	7	11	59.4	56.6
2005	65	99	164	6	8	14	8	28	36	76.6	63.1
2006	37	106	143	9	4	13	13	32	45	71.1	70.6
2007	35	84	119	9	6	15	7	20	27	73.9	68.3
2008	52	92	144	13	13	26	27	49	76	58.3	62.6
2009	267	334	601	35	47	82	42	108	150	72.2	58.7
2010	92	242	334	21	45	66	14	42	56	75.1	73.9
2011	61	114	175	2	8	10	16	33	49	74.8	66.2

Table 21. Total number of fish trapped and passed upstream to spawn naturally at the Touchet River Adult Trap, 1992-1994, 1998-2011 run years.

Run		Natural			Hatchery LFH Stock			Hatchery Endemic Stock	
Year	Trapped	Passed	% Passed	Trapped	Passed	% Passed	Trapped	Passed	% Passed
1992	53	49	92	8	7	88	NA	NA	NA
1993	43	43	100	2	2	100	NA	NA	NA
1994	8	8	100	2	2	100	NA	NA	NA
1998	42	42	100	7	7	100	NA	NA	NA
1999	32	9	28	4	0	0	NA	NA	NA
2000	184	142	77	36	10	28	NA	NA	NA
2001	173	136	79	18	3	17	NA	NA	NA
2002	121	84	69	10	1	10	1	1	100
2003	102	69	68	27	1	4	16	16	100
2004	85	42	49	47	17	36	11	11	100
2005	164	120	73	14	0	0	36	34	94
2006	143	109	76	13	0	0	45	44	98
2007	119	93	78	15	1	7	27	27	100
2008	144	116	81	26	0	0	76	75	99
2009	601	566	94	82	0	0	150	150	100
2010	334	300	90	66	0	0	56	56	100
2011	175	143	82	10	0	0	49	49	100

Table 22. Summary of fresh and salt-water age composition of natural origin adults from the Touchet River, 1994-1995 and 1999-2012 brood years.

BY	Age 1.1		Age 1.2		Age 2.1		Age 2.2		Age 3.1		Age 3.2		Age 4.1		Age 4.2		% Repeat spawners
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	
1994	0	0.0	0	0.0	6	28.6	8	38.1	3	14.3	3	14.3	0	0.0	0	0.0	4.8
1995	0	0.0	0	0.0	0	0.0	6	85.7	0	0.0	0	0.0	0	0.0	1	14.3	0.0
1999	0	0.0	1	3.2	18	58.1	9	29.0	2	6.5	0	0.0	0	0.0	0	0.0	3.2
2000	1	3.2	1	3.2	17	54.8	8	25.8	3	9.7	1	3.2	0	0.0	0	0.0	0.0
2001	1	0.6	14	8.0	84	48.3	40	23.0	15	8.6	9	5.2	1	0.6	0	0.0	5.7
2002	6	4.8	3	2.4	84	67.7	20	16.1	6	4.8	3	2.4	0	0.0	0	0.0	1.6
2003	0	0.0	8	6.7	20	16.7	73	60.8	2	1.7	10	8.3	0	0.0	0	0.0	5.8
2004	0	0.0	1	0.8	47	39.2	18	15.0	18	15.0	2	1.7	1	0.8	0	0.0	10.3
2005	0	0.0	0	0.0	37	44.0	21	25.0	15	17.9	8	9.5	0	0.0	0	0.0	3.6
2006	2	1.3	7	4.5	85	54.8	38	24.5	7	4.5	11	7.1	0	0.0	0	0.0	3.2
2007	2	1.4	11	7.9	46	32.9	54	38.6	7	5.0	14	10.0	1	0.7	0	0.0	2.9
2008	2	1.7	6	5.2	47	40.5	38	32.8	7	6.0	7	6.0	0	0.0	0	0.0	7.8
2009	3	2.1	0	0.0	81	56.3	21	14.6	19	13.2	8	5.6	0	0.0	0	0.0	8.3
2010	15	4.1	14	3.8	230	62.8	74	20.2	23	6.3	4	1.1	0	0.0	0	0.0	1.9
2011	3	1.4	9	4.3	54	25.6	114	54.0	16	7.6	10	4.7	0	0.0	0	0.0	2.6
2012	13	8.5	3	2.0	45	29.4	69	45.1	13	8.5	4	2.6	1	0.7	1	0.7	2.6
Totals	**48**	**1.8**	**78**	**3.3**	**901**	**41.8**	**611**	**34.5**	**156**	**8.3**	**94**	**5.1**	**4**	**0.2**	**2**	**0.9**	**4.0**

Table 23. Total number of spring Chinook, bull trout, brown trout, whitefish, northern pike minnow, and bridgelip sucker captured in the Touchet River Adult Trap (1993-1995, 1999-2012). Data presented in this table is through the month of December, 2012. Numbers in parenthesis indicate fish removed and not passed upstream.

Year	Spring Chinook Natural	Spring Chinook Hatchery	Bull trout	Brown trout	Whitefish	Pike Minnow	Bridgelip Sucker
1993	0	0	0	0	0	NA	NA
1994	0	0	3	3	0	NA	NA
1995	0	0	0	0	0	NA	NA
1999	0	0	20	4	5	NA	NA
2000	2	2	22	8	16	NA	NA
2001	24	7	43	14	4	NA	NA
2002	0	0	22	0	5	NA	NA
2003	2	1	45	19	40	2 (2)	663
2004	4	6	65	17	7	0	226
2005	4	1	49	6	8	1 (1)	171
2006	0	0	53	31	34	0	54
2007	1	3	31	13	18	0	13
2008	1	2	34	11	28	5 (5)	16
2009	15	13	104	10 (10)	32	2 (2)	64
2010	13	3	121	18 (18)	120	0	227
2011	1	0	124	2 (2)	59	0	36
2012	9	1	59	5 (5)	14	0	11

Creel Surveys – Snake River and Tributaries

Staff surveyed sport anglers within the LSRCP area of Washington to recover CWTs from tagged steelhead using methods described in Schuck et al. (1990). The number of LFC steelhead in the sport catch in SE Washington was estimated using WDFW sport harvest estimates from Washington catch record cards. When possible, data from weekly surveys were summarized during the season and provided to the local news media to inform anglers. Summary results from surveys conducted for the 2010 and 2011 run years are presented (Table 22).

Table 24. Steelhead angler interview results for fall/winter/spring of the 2010 and 2011 run years from Washington State licensed anglers.

River Basin River section description [a]	River section number	Anglers Surveyed	Total hours fished	Natural fish released	Hatchery fish kept	Hatchery fish released	Catch rate (hr/fish)
2010 Run Year							
Columbia River Basin							
McNary Dam to Pasco	533	880	3,263	119	83	11	15.3
Snake River Basin							
Mouth to IHR	640	22	62	8	0	0	7.8
IHR to LMD	642	2,134	8,029	258	159	4	19.1
LMD to LGD	644	1,604	9,327	263	257	12	17.5
LGD to LGR	646	377	1,527	40	26	0	23.1
LGR to Hwy 12 Br.	648	1,855	9,973	189	321	4	19.4
Hwy 12 Br. Upstream	650	2,249	14,737	779	538	23	11.0
Lower Grande Ronde							
(Washington Only)	592	1,883	8,160	309	797	520	5.0
Tucannon River	653	45	1,002	37	36	4	13.0
Totals		**11,049**	**56,080**	**2,002**	**2,217**	**578**	**11.7**
2011 Run Year							
Columbia River Basin							
McNary Dam to Pasco	533	1,361	4,299	84	128	5	19.8
Snake River Basin							
Mouth to IHR	640	216	714	9	18	0	26.4
IHR to LMD	642	3,281	10,898	291	352	6	16.8
LMD to LGD	644	1,858	9,273	141	363	10	18.0
LGD to LGR	646	598	1,952	31	65	1	20.1
LGR to Hwy 12 Br.	648	3,113	17,016	621	829	68	11.2
Hwy 12 Br. Upstream	650	1,079	5,750	384	202	47	9.1
Lower Grande Ronde							
(Washington Only)	592	2,038	8,991	572	1,284	1,088	3.1
Tucannon River	653	347	1,094	38	11	71	9.1
Touchet River	657	54	66	1	2	0	22.0
Walla Walla River	659	255	591	29	24	1	10.9
Totals		**14,200**	**60,608**	**2,201**	**3,277**	**1,297**	**8.9**

[a] Abbreviations as follows: IHR=Ice Harbor Dam, LMD=Lower Monumental Dam, LGD=Little Goose Dam, LGR=Lower Granite Dam, Hwy=Interstate Highway. Creel information from sections 648 and 650 include data collected by IDFG.

Grande Ronde River

In addition to the creel surveys on the Snake River, Tucannon River, and in the Walla Walla Basin, we cooperate with ODFW in conducting a joint survey of anglers on the lower Grande Ronde River of Washington and Oregon. The area of the Grande Ronde within Washington included here is from Highway 129 to the Oregon state border, and it does not include downstream portions of the Grande Ronde River. Angler effort, catch rates, and harvest were estimated by ODFW staff as described in Carmichael et al. (1988). The total number of fish sampled during the fishery and estimated harvest by the joint surveys from the Grande Ronde fishery in the Washington portion were supplied by ODFW for the 2009 run year (Table 23). Data for the 2010 and 2011 run year were not yet available and will be presented in a future report.

Table 25. Estimated angler effort, catch rates, and harvest for steelhead anglers on a portion of the Grande Ronde River in Washington, but near the Oregon border, run year 2009 (Mike Flesher, ODFW).

	2009				2010				Total
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	
Effort Hours	375.5	5,978.3	4,513.3	372.6	3,742.8	14,461.0	11,820.1	1,260.8	42,524.4
Catch Rate [a]	0.0893	0.0918	0.1240	0.1075	0.2127	0.3567	0.4001	0.8251	0.3035
Total Catch [b]	34	549	559	40	796	5,158	4,730	1040	12,906
Fish Kept	0	287	355	24	489	3,010	2,547	578	7,290
Hatchery Released	19	60	51	0	166	1,061	1,225	414	2,996
Natural Released	15	201	153	16	141	1,087	958	48	2,619

[a] Catch rate here is defined as the estimated fish captured divided by the hours fished.

[b] Estimated fish captured have been rounded to whole numbers, so total of fish kept and released may not always add up to total catch.

Spawning Ground Surveys

During the springs of 2011 and 2012, evaluation staff attempted spawning ground surveys to estimate the number of summer steelhead redds in index areas of the Tucannon and Touchet rivers, as well as in Asotin Creek. Stream flows were very high in both years and resulted in limited surveys, or no surveys on some streams (Table 24). High stream flows prevented any surveys on the Tucannon River or Cummings Creek in 2011 and 2012, and while surveys were attempted in Asotin Creek in 2012, high stream flows had washed the gravel clean in all areas surveyed so it was impossible to identify redds. Redds estimated for Asotin Creek in 2012 were based on the adult weir/trap estimates from the Asotin Creek Assessment Project (Crawford et al. 2012), and average redd composition based on previous surveys for the main stem, North, South and Charley forks of Asotin Creek.

Table 26. Summer steelhead spawning ground survey results, 2011 and 2012.

Stream Section surveyed	Estimated river kilometers surveyed	Dates surveyed	Redds counted	Total expanded redds in index area
2011				
Touchet River				
North Fork	10.1	5/2	51	140
Wolf Fork	13.0	4/27, 5/02, 5/09	49	88
South Fork	19.1	4/27, 5/11	74	146
Robinson Fork	8.2	5/10	25	34
Asotin Creek				
Main Stem	10.5	4/15, 4/29	106	253
North Fork	5.0	4/15, 4/29	45	174
Charley Creek	No Surveys Conducted in 2011 due to landowner access issue			
South Fork	9.1	4/15, 4/26, 5/6, 5/10	69	81
2012				
Touchet River				
North Fork	10.1	5/27	21	61
Wolf Fork	8.4	5/14, 5/17	18	50
South Fork	19.1	4/14, 5/16	37	116
Robinson Fork	8.2	5/10	15	33

We continue to standardize all spawning ground survey estimates for summer steelhead in the Touchet River and Asotin Creek. We are frequently requested to provide estimates of spawning steelhead for areas that we survey. Unfortunately, changes in survey methodology over the years and sections surveyed, and years in which high stream flows cut surveys short, have made it very difficult to provide data that were consistent among years. By applying area-under-the-curve methodologies, average redd erasure rates by stream and regression analyses, we provide these standardized summer steelhead redd estimates for Asotin Creek (Table 25) and the Touchet River (Table 26). These estimates should be used for trend analysis only. The estimated number of spawners within each of these streams, as derived from these redd estimates, can be provided upon request, but are not provided here due to the uncertainty in some of the redd estimates.

Table 27. Standardized redd estimates and redds/kilometer within index reaches of Asotin Creek in southeast Washington, 1986-2012.

Year	Mainstem		North Fork		South Fork		Charley Creek		Total
	Redds	Redds/km	Redds	Redds/km	Redds	Redds/km	Redds	Redds/km	Redds
1986	223	10.8	295	22.2	173	14.3	77	7.3	768
1987	129	6.3	194	14.6	89	7.4	91	8.6	503
1988	56	2.7	141	10.6	87	7.2	48	4.5	332
1989	130	6.3	50	3.8	28	2.3	16	1.5	224
1990	134	6.5	43	3.2	33	2.7	21	2.0	231
1991	147	7.1	58	4.4	28	2.3	20	1.9	253
1992	49	2.4	56	4.2	30	2.5	40	3.8	175
1993	354	17.2	145	10.9	63	5.2	48	4.6	610
1994	70	3.4	50	3.8	18	1.5	15	1.4	153
1995	199	9.7	79	5.9	38	3.1	27	2.6	343
1996	231	11.2	73	5.5	63	5.2	32	3.0	399
1997	140	6.8	69	5.2	13	1.1	19	1.8	241
1998	153	7.4	55	4.1	38	3.1	18	1.7	264
1999	174	8.4	105	7.9	33	2.7	22	2.1	334
2000	120	5.8	71	5.3	46	3.8	24	2.3	261
2001	300	14.6	116	8.7	42	3.5	53	5.0	511
2002	241	11.7	131	9.8	40	3.3	36	3.4	448
2003	285	13.8	103	7.7	36	3.0	40	3.8	464
2004	281	13.6	89	6.7	5	0.4	53	5.0	428
2005	372	18.1	74	5.6	19	1.6	41	3.9	506
2006	254	12.3	62	4.7	32	2.6	32	3.0	380
2007	160	7.8	38	2.9	44	3.6	44	4.2	286
2008	160	7.8	35	2.6	32	2.6	9	0.8	236
2009	146	7.1	56	4.2	28	2.3	22	2.1	252
2010	384	18.6	148	11.1	79	6.5	54	5.1	665
2011	253	12.3	174	13.1	81	6.7	59	5.6	567
2012	274	13.3	134	10.1	65	5.4	51	4.8	524

Table 28. Standardized redd estimates and redds/kilometer within index reaches of the Touchet River in southeast Washington, 1987-2012.

Year	North Fork		South Fork		Wolf Fork		Robinson Fork		Total
	Redds	Redds/km	Redds	Redds/km	Redds	Redds/km	Redds	Redds/km	Redds
1987	99	5.2	147	5.5	100	5.7	34	3.8	380
1988	184	9.7	260	9.7	172	9.8	73	8.1	689
1989	65	3.4	71	2.7	42	2.4	20	2.3	198
1990	88	4.6	90	3.4	88	5.0	23	2.5	289
1991	66	3.5	61	2.3	72	4.1	14	1.6	213
1992	152	8.0	180	6.8	95	5.4	41	4.6	468
1993	65	3.4	107	4.0	36	2.1	20	2.2	228
1994	135	7.1	121	4.5	81	4.6	26	2.9	363
1995	98	4.6	116	4.3	83	4.8	17	1.9	314
1996	64	3.4	104	3.9	72	4.1	23	2.6	263
1997	56	2.9	39	1.4	65	3.7	16	1.8	176
1998	118	6.2	112	4.2	84	4.8	30	3.3	344
1999	82	4.3	131	4.9	49	2.8	19	2.1	281
2000	65	3.4	70	2.6	45	2.6	22	2.5	202
2001	55	2.9	84	3.1	57	3.3	17	1.9	213
2002	115	6.0	123	4.6	60	3.4	29	3.2	327
2003	160	8.4	125	4.7	100	5.7	37	4.1	422
2004	68	3.6	48	1.8	44	2.5	16	1.8	176
2005	116	6.1	94	3.5	91	5.2	28	3.1	329
2006	91	4.7	78	2.9	58	3.3	38	4.2	265
2007	160	8.4	133	5.0	97	5.5	32	3.5	422
2008	80	4.2	99	3.7	46	2.6	22	2.4	247
2009	88	4.6	102	3.8	56	3.2	25	2.8	271
2010	195	10.2	235	8.8	84	4.8	25	2.8	539
2011	140	7.4	146	5.5	88	5.0	34	3.8	408
2012	61	3.2	116	4.3	50	2.9	33	3.7	260

Smolt-to-Adult Survival Rates

Coded-wire tag recoveries from fisheries, hatcheries, or from traps in river have provided the basic data to estimate minimum smolt-to-adult return rates on LFH and Wallowa stock summer steelhead from the program. These estimates are considered a minimum because there is no available adjustment to account for fish that escape to the spawning grounds. Under the original program design, the size of the steelhead programs was based on an assumed smolt-to-adult survival rate of 0.5% to the LSRCP project area, and an assumed 2:1 lower river to upper river (project area) harvest ratio. In 2012, WDFW and the other LSRCP cooperators conducted a steelhead program review. To prepare for the review, WDFW re-compiled all past CWT recoveries and updated all smolt-to-adult survival estimates previously reported. The following CWT recovery data (Figures 5-11) demonstrate the success of both the LFH and Wallowa stock summer steelhead programs.

With initiation of the endemic stock programs on the Touchet and Tucannon Rivers, reductions were made in the LFH stock releases beginning with the 2001 release (in agreement with the co-managers). Further analysis of the CWT data prompted additional reductions that began for the 2003 brood year. Depending on the group, smolt-to-adult return rates since the 2000 brood have been slightly higher, the same, or lower that the long-term average, but are still well above the original assumed LSRCP rate of 0.5%.

In addition to the CWT data, WDFW began PIT tagging the standard mitigation production groups (LFH and Wallowa stocks) for estimating total adult returns back to the project area. This was done because we know that some proportion of the fish that return escape the fisheries and return to the spawning grounds.

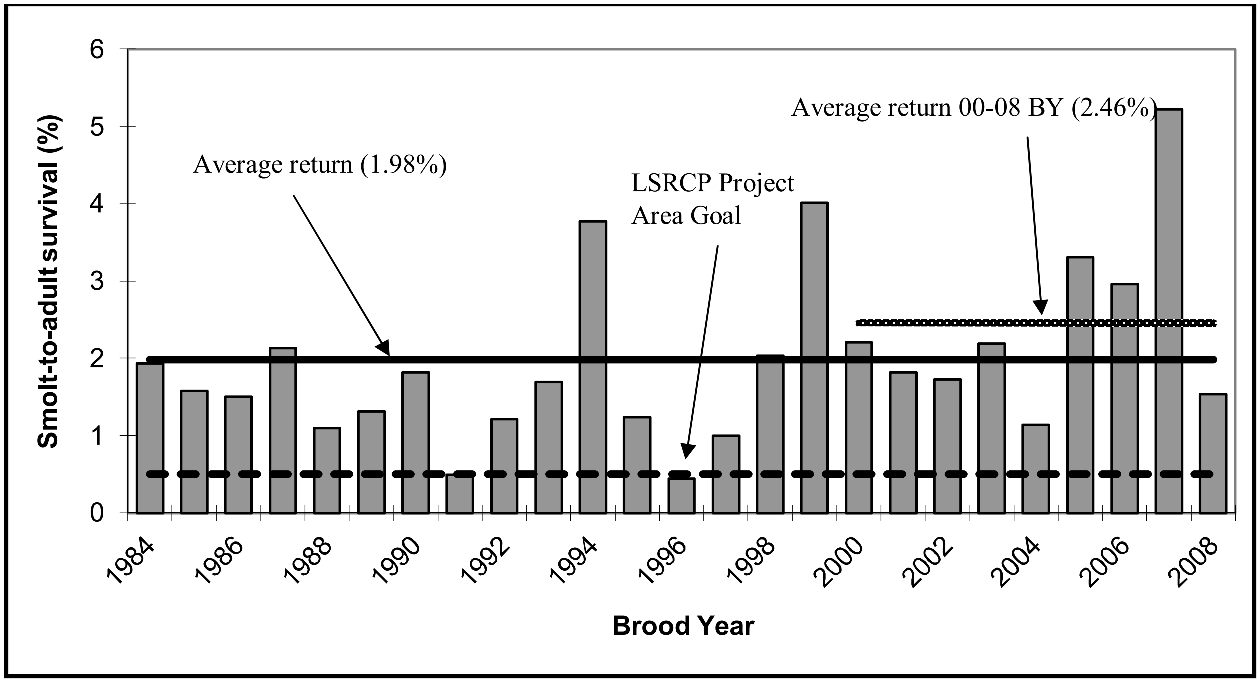


Figure 5. Estimated smolt-to-adult survival (to the LSRCP project area) of summer steelhead released from Cottonwood Acclimation Pond in the lower Grande Ronde River, 1984-2008 brood years.

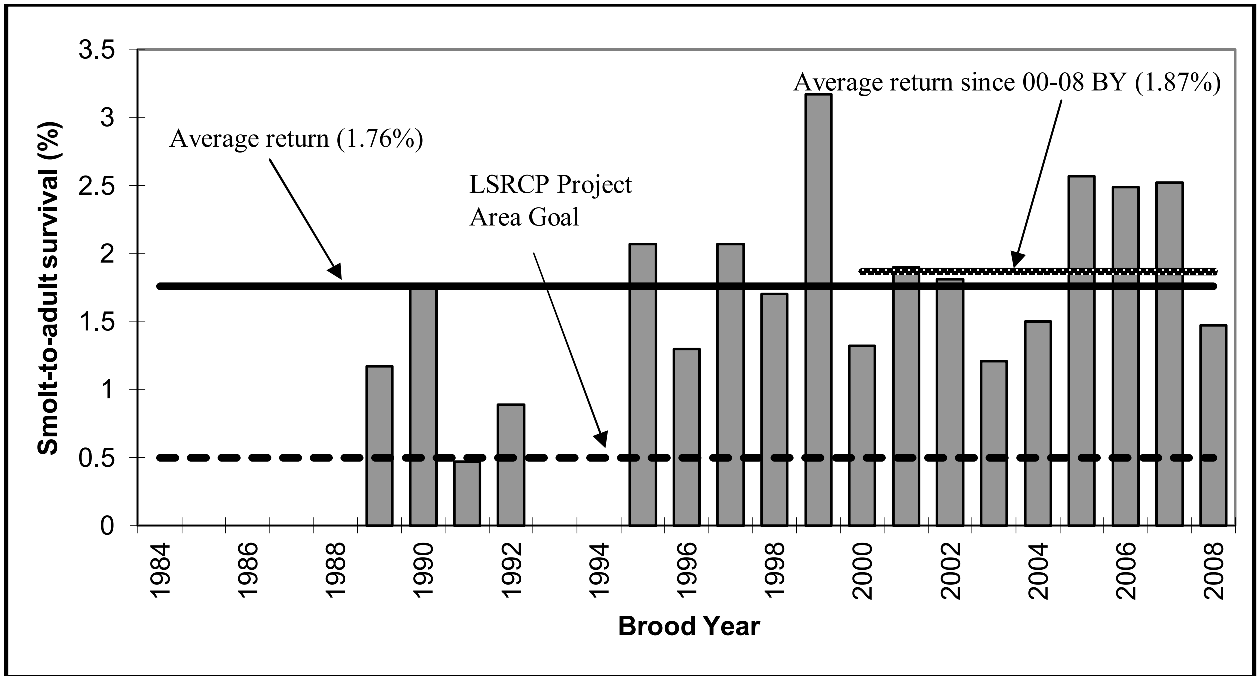


Figure 6. Estimated smolt-to-adult survival (to the LSCRP project area) of summer steelhead released directly into the middle or lower Tucannon River.

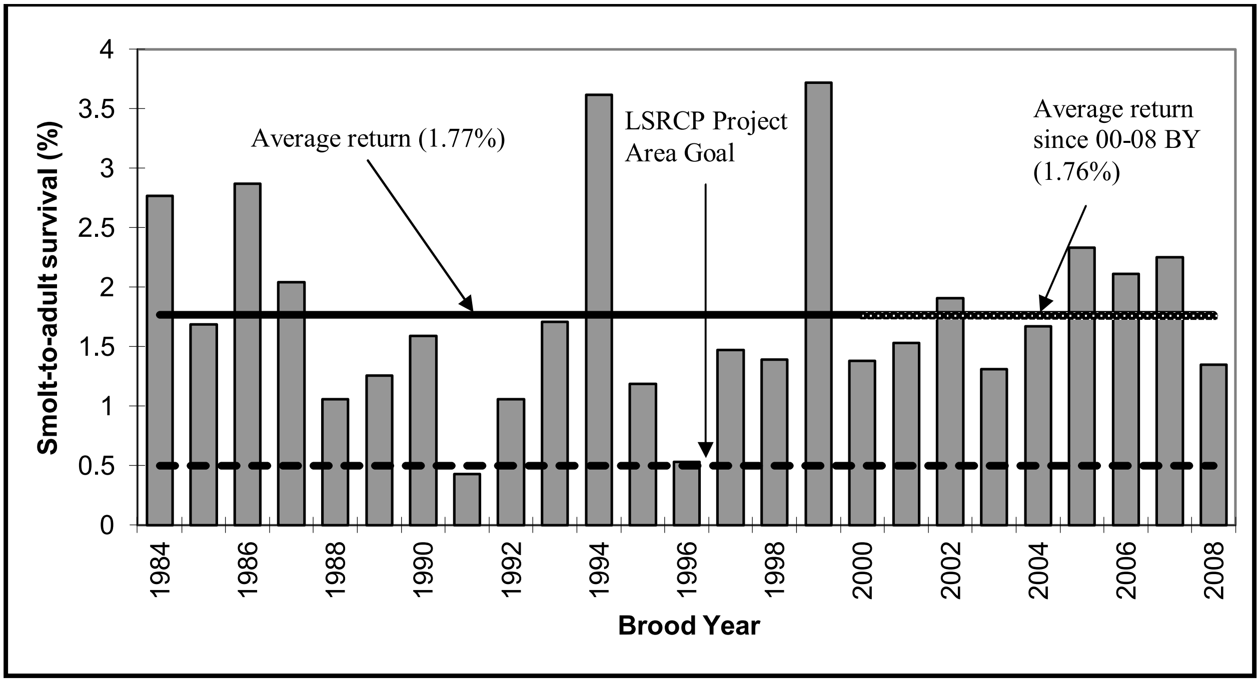


Figure 7. Estimated smolt-to-adult survival of summer steelhead released directly into the Snake River at Lyons Ferry Hatchery.

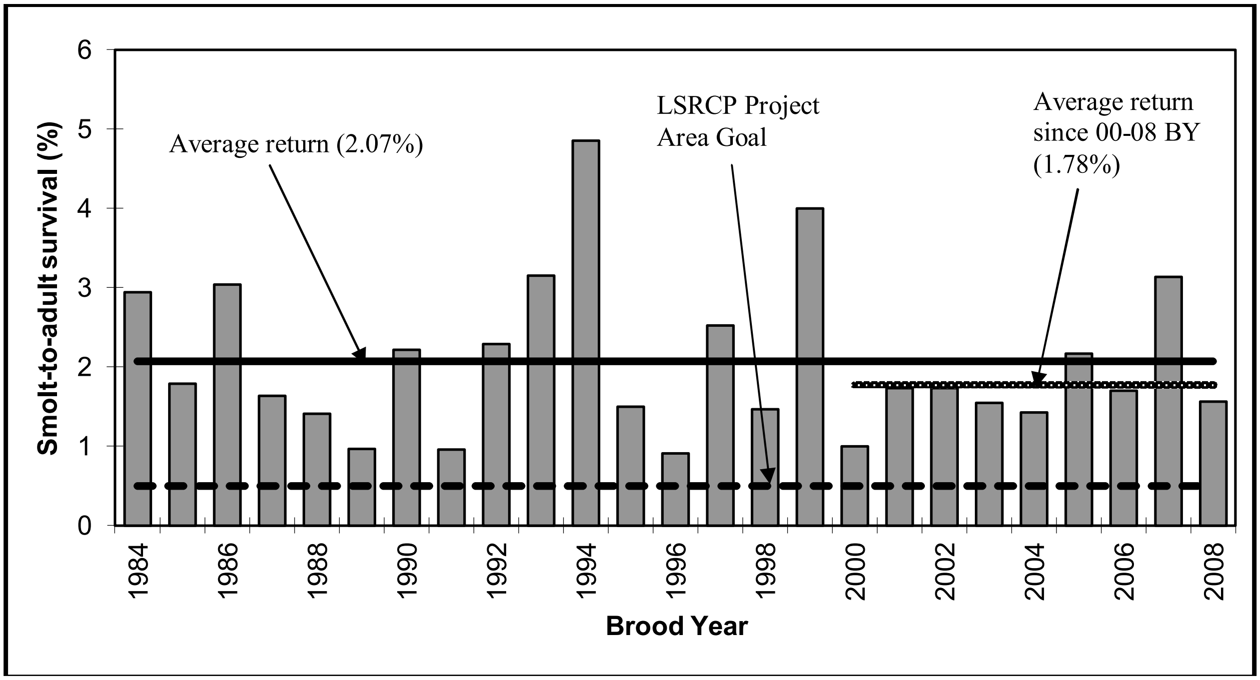


Figure 8. Estimated smolt-to-adult survival of summer steelhead released from Dayton Acclimation Pond in the Touchet River.

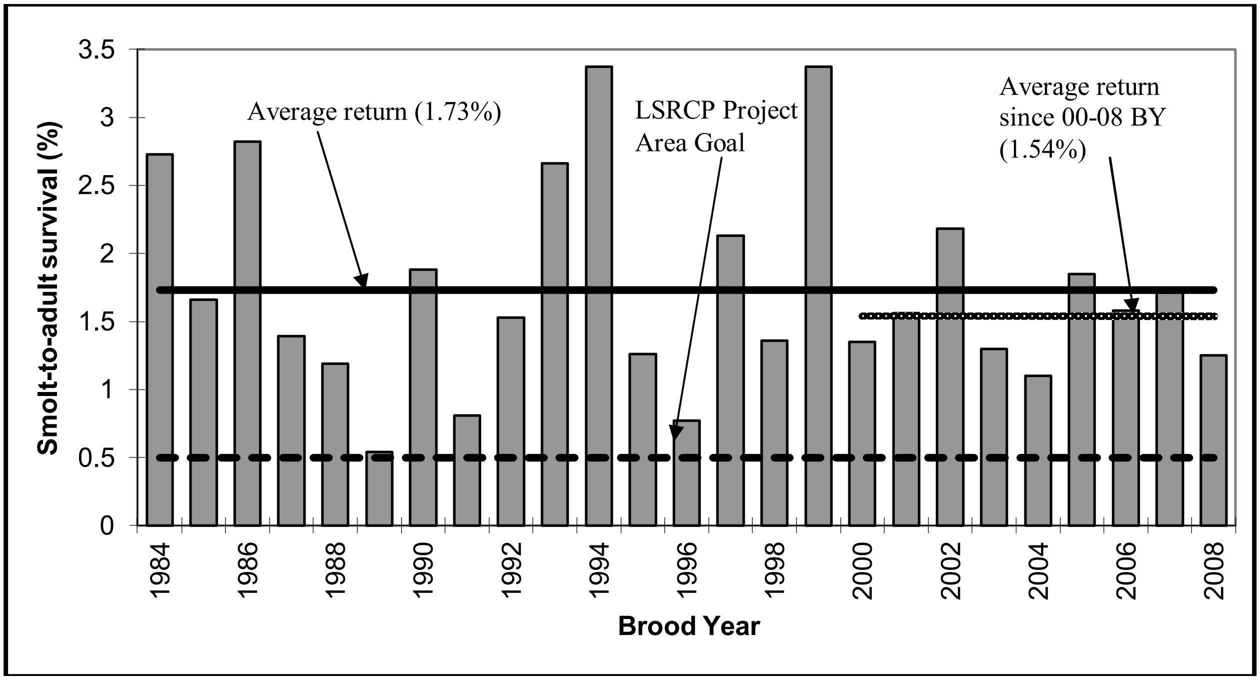


Figure 9. Estimated smolt-to-adult return rates of summer steelhead released directly into the Walla Walla River.

Smolt-to-adult survivals (based on PIT tags) to Bonneville Dam for the LFH stock (Tucannon and Touchet river releases) and Tucannon and Touchet river endemic stocks are provided below (Figures 10 and 11). For the 2006-2010 migration years (excluding 2009), Tucannon endemic stock survivals were on average 54% of the LFH stock. In the Touchet River groups (2007-2010 migration years), the endemic stock survivals were 24% of the LFH stock. While both endemic stocks have not performed to the same level as the LFH stock, these comparisons have been useful in allowing managers to compare the programs and make decisions about expanding them for mitigation purposes (Tucannon), or not expanding them (Touchet).

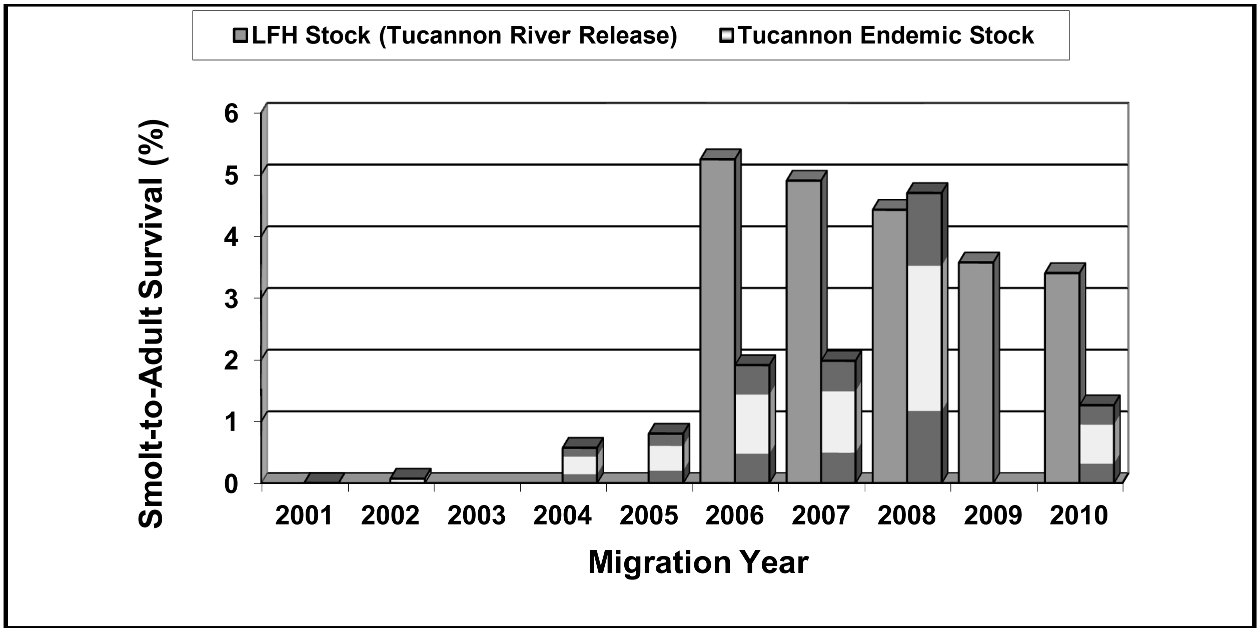


Figure 10. Smolt-to-adult survival estimates (to Bonneville Dam) of LFH or Tucannon River endemic stock steelhead, 2001-2010 Migration Years.

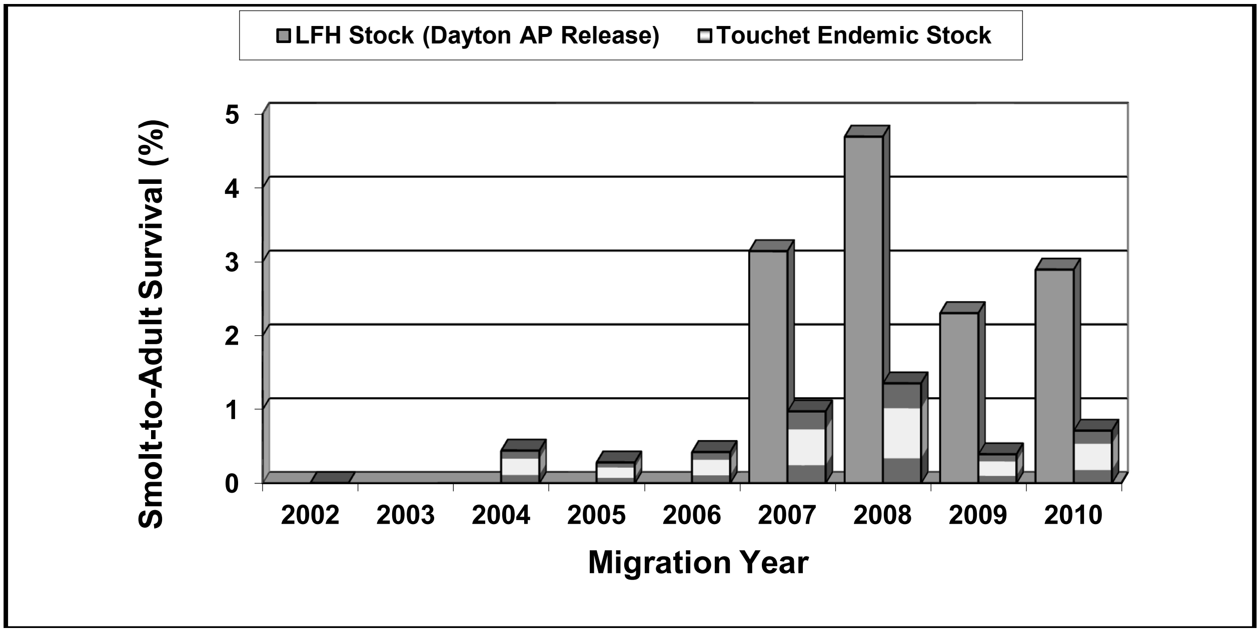


Figure 11. Smolt-to-adult survival estimates (to Bonneville Dam) of LFH or Touchet River endemic stock steelhead, 2002-2010 Migration Years.

Contributions to LSRCP Mitigation Goals

The LFC summer steelhead harvest mitigation programs (LFH and Wallowa stock only) continues to meet and/or exceed its original mitigation goals by supplying large returns of hatchery steelhead for harvest to the Snake River Project area. This is in part due to the fact that fishery harvest rates in the lower Columbia River fisheries have declined substantially since the program was initiated; which called for a 2:1 lower river to project area fishery harvest ratio. Hence the same, and sometimes even more, numbers of fish are returning to the project area even though hatchery production has been reduced in recent years (beginning with the 2002 release year).

Based on total CWT recoveries (fisheries, adult traps, other surveys), we estimate that a minimum of 5,614 (3,155 goal) LFH stock and 2,511 (1,501 goal) Wallowa stock fish returned to the Snake River project area in the 2010 run year (Table 27), representing 178% and 167% of the project area goal for each stock. Since program inception, both stocks have averaged 280% of the mitigation goal to the project area. The percent of the mitigation goal to the project area in the last eight run years (2003-2010) has averaged 212% and 286% for the LFH and Wallowa stocks, respectively, (Table 27) to the project area. Contributions such as these would suggest that further production cuts may be needed so the numbers of hatchery fish returning are closer to project area goals, or promote an increase in downriver harvest to remove these fish prior to returning to the project area. Increasing downriver harvest seems unlikely given the status of ESA listed populations within the Columbia and Snake river basins. However, during that time period, there were a couple of years with excellent smolt-to-adult survival rates (Figures 5-9), resulting in large escapements of adult steelhead back to the LSRCP project area, and may not represent normal returns.

As previously mentioned, the original mitigation goal assumed a 2:1 downriver to project area harvest rate; therefore, the total mitigation goal is 9,465, and 4,503 adult steelhead for the LFH and Wallowa stocks, respectively. We estimated that a minimum of 6,967 LFH stock (74% of goal) and 3,050 Wallowa stock (68% of goal) fish returned as adults in the 2010 run year (Table 28). Since program inception, the LFH stock has averaged 111%, and the Wallowa stock has averaged 115% of the total mitigation goal. The percent of the total mitigation goal in the last eight run years (2003-2010) has averaged 79% and 106% for the LFH and Wallowa stocks, respectively (Table 28), hence further cuts to production are not recommended at this time.

Table 29. Contribution of Lyons Ferry stock (LFH, Tucannon, Touchet, Walla Walla release groups) or Wallowa stock (Grande Ronde release group) summer steelhead back to the lower Snake River project area.

Run Year **(Goal)**	LFH [a] **(630)**	Tucannon **(875)**	Touchet **(750)**	Walla Walla [a] **(900)**	Grande Ronde [a] **(1,501)**	Total **(4,656)**	Percent of Goal
1984	1,013	1,233	736	1,054	424	4,460	95.8%
1985	1,553	1,836	1,439	1,671	3,261	9,760	209.6%
1986	3,771	1,495	4,076	3,838	6,161	19,341	415.4%
1987	2,786	770	2,303	2,149	2,645	10,653	228.8%
1988	5,047	1,571	3,754	3,729	2,781	16,882	362.6%
1989	4,378	2,353	4,070	4,345	6,011	21,157	454.4%
1990	1,494	1,234	2,013	1,789	3,363	9,893	212.5%
1991	2,038	1,506	2,346	1,155	2,476	9,521	204.5%
1992	2,107	2,160	2,511	3,038	5,304	15,120	324.7%
1993	548	1,217	2,055	2,123	2,835	8,778	188.5%
1994	2,199	978	1,517	913	3,414	9,021	193.8%
1995	4,468	1,594	4,752	4,923	4,844	20,581	442.0%
1996	3,003	2,112	4,287	5,188	9,222	23,812	511.4%
1997	2,201	1,834	3,737	3,270	4,938	15,980	343.2%
1998	701	744	1,379	1,560	1,844	6,228	133.8%
1999	1,099	2,531	2,524	2,983	1,591	10,728	230.4%
2000	1,210	2,822	1,994	2,529	4,681	13,236	284.3%
2001	2,418	5,240	4,949	5,825	11,450	29,882	641.8%
2002	778	1,894	1,620	1,937	5,659	11,888	255.3%
2003	937	1,740	1,709	1,261	3,443	9,090	195.2%
2004	1,229	2,839	2,011	2,418	3,279	11,776	252.9%
2005	838	1,067	1,073	909	4,509	8,396	180.3%
2006	1,167	1,282	1,734	1,380	1,578	7,141	153.4%
2007	1,330	2,693	1,776	1,764	4,504	12,067	259.2%
2008	1,250	2,374	1,268	1,542	5,185	11,619	249.5%
2009	1,378	2,592	2,561	1,684	9,335	17,550	376.9%
2010	858	1,652	1,635	1,469	2,511	8,125	174.5%
Average	***1,918***	***1,902***	***2,438***	***2,461***	***4,343***	***13,062***	***280.5%***
% of Goal (all years)	**304.5%**	**217.4%**	**325.1%**	**273.4%**	**289.3%**	**280.5%**	
% of Goal (last 8 years)	**178.3%**	**232.0%**	**229.5%**	**172.6%**	**286.0%**	**230.3%**	

[a] The LFH group includes releases of fish in other locations of the Snake River and Asotin Creek, the Walla Walla group includes releases of fish in Mill Creek, and the Grande Ronde include releases of fish from Wildcat Creek in Oregon.

Table 30. Contribution of Lyons Ferry stock (LFH, Tucannon, Touchet, Walla Walla release groups) or Wallowa stock (Grande Ronde release group) summer steelhead back to the Columbia River.

Run Year **(Goal)**	LFH [a] **(1,890)**	Tucannon **(2,625)**	Touchet **(2,250)**	Walla Walla [a] **(2,700)**	Grande Ronde [a] **(4,503)**	Total **(13,968)**	Percent of Goal
1984	1,547	1,447	882	919	741	5,536	39.6%
1985	2,247	2,272	1,853	1,852	4,310	12,534	89.7%
1986	4,955	2,009	5,363	5,042	8,076	25,445	182.2%
1987	4,309	1,076	3,420	3,213	4,286	16,304	116.7%
1988	7,462	2,025	5,296	5,321	4,991	25,095	179.7%
1989	5,648	2,858	5,313	5,873	8,105	27,797	199.0%
1990	1,830	1,466	2,676	2,430	4,152	12,554	89.9%
1991	2,603	1,820	2,900	1,532	3,067	11,922	85.4%
1992	3,223	2,908	3,748	4,159	6,564	20,602	147.5%
1993	692	1,460	2,560	2,834	3,444	10,990	78.7%
1994	2,959	1,324	1,968	1,306	4,435	11,992	85.9%
1995	5,676	2,127	5,876	6,615	5,966	26,260	188.0%
1996	3,206	2,486	4,539	5,662	10,055	25,948	185.8%
1997	2,543	2,177	4,121	4,031	5,550	18,422	131.9%
1998	756	780	1,442	1,682	2,040	6,700	48.0%
1999	1,141	2,735	2,622	3,165	1,704	11,367	81.4%
2000	1,304	3,281	2,134	2,754	5,433	14,906	106.7%
2001	2,663	5,899	5,501	659	12,797	27,519	197.0%
2002	935	2,457	1,882	2,079	5,986	13,339	95.5%
2003	1,002	2,101	1,776	1,400	3,631	9,910	70.9%
2004	1,557	2,973	2,221	2,531	3,423	12,705	91.0%
2005	1,020	1,356	1,535	1,350	5,085	10,346	74.1%
2006	1,326	1,391	1,857	1,480	1,731	7,785	55.7%
2007	1,459	2,892	2,212	2,321	5,337	14,221	101.8%
2008	1,531	2,691	1,565	1,797	5,809	13,393	95.9%
2009	1,597	3,011	2,899	1,819	10,208	19,534	139.8%
2010	1,097	1,959	1,904	2,007	3,050	10,017	71.7%
Average	***2,455***	***2,259***	***2,965***	***2,809***	***5,184***	***15,672***	***112.2%***
% of Goal (all years)	**129.9%**	**86.0%**	**131.8%**	**104.0%**	**115.1%**	**112.2%**	
% of Goal (last 8 years)	**70.0%**	**87.5%**	**88.7%**	**68.1%**	**106.2%**	**87.6%**	

[a] The LFH group includes releases of fish in other locations of the Snake River and Asotin Creek, the Walla Walla group includes releases of fish in Mill Creek, and the Grande Ronde include releases of fish from Wildcat Creek in Oregon.

Conclusions and Recommendations

In an effort to maintain successful mitigation in an ESA environment, we offer the following conclusions/recommendations from our monitoring and evaluation work, and suggest additional critical questions that should be pursued in the future:

1) The NOAA Fisheries ruled that the WDFW LSRCP hatchery steelhead programs (LFH and Wallowa stocks) jeopardized listed steelhead populations within the Snake and Columbia river basins (NMFS 1999), and called for the development of new endemic broodstocks where possible to eventually replace these programs. Since 2000, WDFW has been evaluating two new steelhead broodstocks (Tucannon and Touchet rivers) as a means to address this issue.

PIT tag data shows that as many as 50% of the returning steelhead destined for the Tucannon River (natural, endemic hatchery and LFH stock), never return to the river, but rather bypass the Tucannon River and remain upstream of Lower Granite Dam, where they may stray into other natural spawning areas such as Asotin Creek, Alpowa Creek, or elsewhere. Further, adult returns from natural origin steelhead in the Tucannon River suggests that the number of spawning steelhead is very low, and below critical population thresholds described in the WDFW's Fishery Management Enhancement Plan (FMEP) submitted to NOAA Fisheries. According to the FMEP, fisheries may not be allowed to continue in areas where the natural origin adults are below such thresholds.

Further, many of the Touchet River endemic fish are entering the Tucannon River in March and April, apparently not being able to find their way downstream past Lower Monumental Dam or Ice Harbor Dam to enter the Walla Walla Basin. The cause of the "straying" in both endemic stocks is likely an effect of the Snake River dams hindering the downstream movement of adults once they pass upstream. Also, harsh environmental conditions in the Walla Walla River when the adult steelhead first return to the system (July-September), may prevent steelhead from entering. Whatever the cause, this "straying" effect in both populations needs further investigation (radio telemetry studies) and possible solutions to lessen the effects on natural production areas where these fish end up.

> <u>Recommendation:</u> Continue with the implementation of endemic broodstock in the Tucannon River. Continue PIT tagging large representative groups of all stocks of steelhead for program evaluation (adult return rates) and straying. Continue, and increase if possible, the number of natural origin smolts PIT tagged at the Tucannon River Smolt Trap to document SARs and for estimating total natural origin returns to the Tucannon River for future consideration of fishery management options.

Recommendation: Work with the US Army Corps of Engineers and others to conduct a telemetry study to develop a better understanding of behavior of returning Tucannon steelhead near the mouth of the Tucannon River, and potentially why there is such a high rate of fish bypassing that river and crossing Lower Granite Dam. It is imperative that this high bypass rate be understood and rectified for WDFW to be able to achieve either LSRCP mitigation fisheries or ESA/WDFW wild stock conservation goals.

Recommendation: Discontinue the Touchet River endemic stock program as a possible replacement for the LFH stock for mitigation in the Touchet River. Coordinate with co-managers, LSRCP and BPA to discuss the possibility of continuing this as a conservation program only (RPA #40 – 2008 NOAA Fisheries FCRPS Biological Opinion), or to completely terminate this program in the future.

2) The Tucannon River steelhead population was defined by the ICTRT as including the Tucannon River and other smaller tributaries to the Snake River (between Lower Monumental and Lower Granite dams). The abundance of natural origin adults in these smaller tributaries is relatively unknown, but recent trapping efforts (Trump et al. 2013) have helped expand our knowledge. Further, we have yet to confirm the genetic similarities between these small streams and the Tucannon River. Yet, these smaller tributaries could have enough natural origin adults present (of the appropriate stock) that if added to the Tucannon River natural origin adults, could raise the population level above the critical threshold, and allow for continued fisheries within the Tucannon River under the LSRCP mitigation program.

Recommendation: Continue to support/assist adult monitoring efforts within these small Snake River tributaries and conduct a genetic analysis that compares the adult steelhead sampled in the Tucannon, Asotin, Almota, Alpowa, Penawawa, Deadman and Alkali Flat creeks against the Tucannon and Asotin population baselines and the LFH stock that has been used for mitigation in the lower Snake Basin.

Literature Cited

Bumgarner, J., M. Small, L. Ross, and J. Dedloff. 2003. Lyons Ferry Complex Hatchery Evaluation: Summer Steelhead and Trout Report 2001 and 2002 Run Years to USFWS Lower Snake River Compensation Plan Office. Report # FPA03-15.

Carmichael, R.W., R. T. Messmer and B.A. Miller. 1988. Summer Steelhead Creel Surveys in the Grande Ronde, Wallowa and Imnaha rivers for the 1987-88 Run Year. Progress Report, 1988. Oregon Department of Fish and Wildlife, Portland, Oregon.

Crawford, E., M. Schuck, and M. Herr. 2012. Asotin Creek Assessment Project: 2011 Annual Report to U.S. Department of Energy, Bonneville Power Administration, Environment, Fish and Wildlife, Portland, OR 97208. Project #2002-053-00, Intergovernmental Contract No. 00052290. 45 pages.

Hudson, J. M., J. R. Johnson, and B. Kynard. 2011. A Portable Electronarcosis System for Anesthetizing Salmonids and Other Fish. North American Journal of Fisheries Management. 31:2, pages 335-339.

Trump, J., G. Mendel, and M. Gembala. 2013. Estimate Adult Steelhead Abundance in Small Streams Associated with the Tucannon and Asotin Populations: 2010-2012 Annual Report to U.S. Department of Energy, Bonneville Power Administration, Environment, Fish and Wildlife, Portland, OR 97208. Project #2010-028-00 Contract Numbers 49149 and 55446. 53 pages.

National Marine Fisheries Service. 1999. Biological Opinion on Artificial Propagation in the Columbia Basin – Section 7 Consultation. NOAA/NMFS, March 29, 1999. 175 pp.

Schuck, M., A. Viola and S. Nostrant. 1990. Lyons Ferry Evaluation Study: Annual Report 1988-89 . Washington Department of Wildlife Report to the USFWS. Report No. AFF1/LSR-90-04.

Zydlewski, G. B., W. Gale, J. Holmes, J. Johnson, T Brigham, and W. Thorson. Use of Electroshock for Euthanizing and Immobilizing Adult Spring Chinook Salmon in a Hatchery. North American Journal of Aquaculture. 70:4, pages 415-424.

Appendix A

Rainbow Trout Plants from Lyons Ferry Complex
2011 and 2012

Appendix A: Table 1. **Summary of rainbow trout plants (catchable size) from Lyons Ferry Complex, 2011.**

County	Location	Number of Plants	LSRCP lbs of fish planted	LSRCP # of fish planted
Asotin	Golf Course Pond	11	7,602	22,478
	Headgate Park Pond	2	436	1,525
	Silcott Pond	1	217	500
	West Evans Pond	11	7,779	22,481
Asotin Total		**25**	**16,036**	**46,984**
Columbia	Big Four lake	2	1,459	2,410
	Blue Lake	12	8,283	26,302
	Curl Lake	7	3,481	10,650
	Dam Pond	2	431	1,025
	Dayton JV Pond	5	1,043	3,075
	Deer Lake	2	343	750
	Orchard Pond	4	854	2,050
	Rainbow Lake	12	7,276	21,509
	Spring Lake	10	4,468	14,073
	Watson Lake	9	7,693	21,704
Columbia Total		**65**	**35,331**	**103,548**
Franklin	Dalton Lake	8	9,023	24,898
	Marmes Pond	4	873	2,050
Franklin Total		**12**	**9,896**	**26,948**
Garfield	Casey Pond	1	132	500
Garfield Total		**1**	**132**	**500**
Lincoln	Sprague Lake	1	1,154	3,000
Lincoln Total		**1**	**1,154**	**3,000**
Walla Walla	Bennington Lake	9	8,146	21,236
	Fishhook Park Pond	3	1,898	5,150
	Hood Park Pond	6	1,560	3,000
	Jefferson Park Pond	7	981	2,200
	Lions Park Pond	3	251	650
	Quarry Pond	6	9,041	24,952
Walla Walla Total		**34**	**21,877**	**57,188**
Whitman	Garfield Pond	4	873	3,050
	Pampa Pond	6	2,318	6,200
	Riparia Pond	2	625	1,525
	Union Flat Creek	1	606	2,000
Whitman Total		**13**	**4,422**	**12,775**
Totals for Year		**151**	**88,846**	**250,943**

Appendix A: Table 2. **Summary of rainbow trout plants (catchable size) from Lyons Ferry Complex, 2012.**

County	Location	Number of Plants	LSRCP lbs of fish planted	LSRCP # of fish planted
Asotin	Golf Course Pond	13	8,413	21,615
	Headgate Park Pond	3	606	1,525
	West Evans Pond	13	7,813	19,544
Asotin Total		**29**	**16,832**	**42,684**
Columbia	Big Four lake	2	1,156	2,300
	Blue Lake	15	9,146	22,450
	Curl Lake	10	4,781	11,115
	Dam Pond	1	179	500
	Dayton JV Pond	8	1,505	3,565
	Deer Lake	4	1,229	3,350
	Orchard Pond	4	799	2,050
	Rainbow Lake	13	6,261	15,269
	Spring Lake	13	5,084	11,847
	Watson Lake	13	7,529	18,324
Columbia Total		**83**	**37,669**	**90,770**
Franklin	Dalton Lake	6	6,356	16,800
	Marmes Pond	6	1,046	2,535
Franklin Total		**12**	**7,402**	**19335**
Lincoln	Sprague Lake	1	837	2,000
Lincoln Total		**1**	**837**	**2,000**
Walla Walla	Bennington Lake	8	8,914	21,148
	Fishhook Park Pond	3	2,327	5,150
	Hood Park Pond	7	1,447	2,800
	Jefferson Park Pond	10	1,486	3,235
	Lions Park Pond	3	286	725
	Quarry Pond	7	6,526	17,790
Walla Walla Total		**38**	**20,986**	**50,848**
Whitman	Garfield Pond	4	1,038	3,050
	Pampa Pond	6	2,519	6,200
	Riparia Pond	2	378	1,025
	Rock Lake	1	9,979	27,242
	Union Flat Creek	1	185	500
Whitman Total		**14**	**14,099**	**38,017**
Totals for Year		**177**	**97,826**	**243,654**

Appendix B

Bull Trout, Whitefish, and Brown Trout Capture Data from the Touchet River Adult Trap, 2011 and 2012

Appendix B: Table 1. Bull trout captured at the Dayton Adult Trap on the Touchet River, 2011. Data shown represents first time captures that were then PIT tagged, or fish that were recaptures from previous years.

Date	Length	PIT Tag #	Recap	Date	Length	PIT Tag #	Recap	Date	Length	PIT Tag #	Recap
1/5	390.0	3D9.1C2CCC6B4D		5/13	340.0	3D9.1C2DCA5D9C		6/15	480.0	3D9.1C2CCC693E	
1/25	285.0	3D9.1C2CCA718F		5/16	430.0	3D9.1C2CCA33A6	2 Year	6/15	500.0	3D9.1C2CCC66D8	3 Year
2/14	335.0	3D9.1C2C43F195		5/16	370.0	3D9.1C2DCAC02B		6/15	520.0	3D9.1C2C876748	4 Year
3/10	390.0	3D9.1C2CC99432		5/16	320.0	3D9.1C2DCAA741		6/15	370.0	3D9.1C2DCBC814	
3/14	340.0	3D9.1C2C4B76EA		5/19	330.0	3D9.1C2DCA5185		6/15	440.0	3D9.1C2C412562	2 Year
3/21	320.0	3D9.1C2C4BB7F7		5/19	350.0	3D9.1C2DCAA4C4		6/15	390.0	3D9.1C2DCB5273	
3/21	320.0	3D9.1C2C4BE91A		5/19	510.0	3D9.1C2CC9C746	2 Year	6/15	440.0	3D9.1C2DCAE505	
3/23	380.0	3D9.1C2C3EAC98		5/23	520.0	3D9.257C5C9FDC	3 Year	6/21	430.0	3D9.1C2CC9DA2D	2 Year
3/25	330.0	3D9.1C2D811999		5/23	490.0	3D9.1C2C4BAF13	3 Year	6/21	460.0	3D9.1C2DCA9FC2	
3/29	390.0	3D9.1C2D80F620		5/23	470.0	3D9.1C2CCA47B3	2 Year	6/21	400.0	3D9.1C2DCB8CB1	
4/12	320.0	3D9.1C2C413D81		5/23	590.0	3D9.257C5ADEB0	3 Year	6/21	350.0	3D9.1C2DCA9CFF	
4/18	380.0	3D9.1C2CC9DB84		5/23	450.0	3D9.1C2DCA9B71		6/21	390.0	3D9.1C2DCA6517	
4/26	420.0			5/23	410.0	3D9.1C2DCA771B		6/21	580.0	3D9.257C59E540	4 Year
4/26	480.0	3D9.1C2C44076C		5/23	420.0	3D9.1C2CCC61BE	2 Year	6/21	350.0	3D9.1C2DCB9C6B	
4/28	360.0	3D9.1C2C4B78BD		5/26	430.0	3D9.1C2DCAAF8F		6/21	370.0	3D9.1C2DCBA5FF	
4/28	400.0	3D9.1C2CCC5FB1		5/31	490.0	3D9.1C2DCA9BA8		6/21	350.0	3D9.1C2DCAB3E3	
5/3	430.0	3D9.1C2DCA81E7		5/31	500.0	3D9.1C2C438C56	2 Year	6/21	360.0	3D9.1C2DCAF1EB	
5/5	340.0	3D9.1C2DCA7679		6/4	480.0	3D9.1C2CCC5EDF	2 Year	6/21	340.0	3D9.1C2DCA8502	
5/5	270.0	3D9.1C2CCA333C		6/4	340.0	3D9.1C2D814E89		6/22	460.0	3D9.1C2CC950CE	2 Year
5/9	390.0	3D9.1C2CCA3554	2 Year	6/4	360.0	3D9.1C2CCA385C	2 Year	6/22	440.0		
5/9	520.0	3D9.1C2CC9C67F	3 Year	6/8	360.0	3D9.1C2DC9DE9A		6/22	450.0	3D9.1C2CC9D557	2 Year
5/9	620.0	3D9.1BF1CF0563	6 Year	6/8	450.0	3D9.1C2CC9CA44	2 Year	6/22	430.0	3D9.1C2CC9D2DD	2 Year
5/9	470.0	3D9.1C2CCA3503	2 Year	6/8	370.0	3D9.1C2CC9D16B		6/22	380.0	3D9.1C2DCA3CB1	
5/9	450.0	3D9.1BF242D832	2 Year	6/8	370.0	3D9.1C2DCA5F99		6/24	360.0	3D9.1C2DCB2F8B	
5/9	350.0	3D9.1C2DCABFE5		6/8	360.0	3D9.1C2DC98547		6/24	360.0	3D9.1C2DCB8E86	
5/9	540.0	3D9.1C2C4BE06B	3 Year	6/8	370.0	3D9.1C2DC9C5A7		6/24	360.0	3D9.1C2DCB8FB6	
5/9	430.0	3D9.1C2CC9FD7A		6/8	310.0	3D9.1C2D82772F		6/24	310.0	3D9.1C2DCB16A3	
5/9	400.0	3D9.1C2CC959B1	2 Year	6/8	420.0	3D9.1C2CC9C545	2 Year	6/24	350.0	3D9.1C2DCB59EF	
5/11	350.0	3D9.1C2DCA5CA9		6/8	360.0	3D9.1C2DCA48BD		6/24	330.0	3D9.1C2DCAF203	
5/11	350.0	3D9.1C2CCA03EB		6/8	430.0	3D9.1C2DCA5F79		6/24	380.0	3D9.1C2DCA6E3A	
5/11	430.0	3D9.1C2CC9DDED	2 Year	6/8	340.0	3D9.1C2DCA8E93		6/27	360.0	3D9.1C2DCB75A1	
5/13	600.0			6/13	450.0	3D9.1C2C437A12	2 Year	6/27	350.0	3D9.1C2DCA87FB	
5/13	360.0	3D9.1C2DCAA688		6/13	480.0	3D9.1C2DC9F4F3		6/27	350.0	3D9.1C2DCAACE8	
5/13	440.0	3D9.1C2CC9C93E	2 Year	6/13	450.0	3D9.1C2C3E1B10	2 Year	6/27	340.0	3D9.1C2DCB0986	
5/13	390.0	3D9.1C2DC9F221		6/13	340.0	3D9.1C2DCABFC7		6/27	270.0	3D9.1C2DCBC008	
5/13	380.0	3D9.1C2DCA76A3		6/13	440.0	3D9.1C2CCC433A	2 Year	6/27	440.0	3D9.1C2DCBD05B	
5/13	420.0	3D9.1C2C4BC445	2 Year	6/13	350.0	3D9.1C2DCAB948		6/27	410.0	3D9.1C2CCC9066	2 Year
5/13	440.0	3D9.1C2CC9D674	2 Year	6/13	400.0	3D9.1C2DCAAFF0		6/27	350.0	3D9.1C2DCB647A	
5/13	350.0	3D9.1C2DCA5E47		6/13	430.0	3D9.1C2CCA4037	2 Year	6/27	330.0	3D9.1C2DCB9DD7	
5/13	470.0	3D9.1C2DC9CE15		6/13	470.0	3D9.1C2D6FA098		6/27	350.0	3D9.1C2DCBB443	
5/13	450.0	3D9.1C2CC9D8B8	2 Year	6/13	450.0	3D9.1C2CCC6A4C	2 Year	6/27	360.0	3D9.1C2DCA649C	
5/13	390.0	3D9.1C2D81466E		6/15	500.0	3D9.1C2CC99841	3 Year	6/29	270.0	3D9.1C2DCBB5FB	
5/13	410.0	3D9.1C2DCA490C		6/15	360.0	3D9.1C2DC9FF70		7/1	340.0	3D9.1C2DCAFA61	

Appendix B: Table 2. Bull trout captured at the Dayton Adult Trap on the Touchet River, 2012. Data shown represents first time captures that were then PIT tagged, or fish that were recaptures from previous years.

Date	Length	PIT Tag #	Recap	Date	Length	PIT Tag #	Recap	Date	Length	PIT Tag #	Recap
3/24	39.0	3D9.1C2DCAF098		5/25	30.0	3D9.1C2DCA7A07		6/8	47.0	3D9.1C2CC9D2DD	
3/26	53.0	3D9.1C2CBAD8ED	4 Year	5/25	56.0	3D9.1C2C876748	5 YEAR	6/11	32.0	3D9.1C2D03D57D	
4/13	35.0	3D9.1C2DCB6086		5/25	45.0	3D9.1C2DCA6517	2 YEAR	6/12	31.0	3D9.1C2D6A87AA	
4/13	43.0	3D9.1C2D3EAC98		5/25	40.0	3D9.1C2DC9B8F4		6/13	38.0	3D9.1C2DD3FB2B	
4/23	47.0	3D9.1C2CCC5FB1	2 YEAR	5/29	42.0	3D9.1C2DC9DE9A	2 YEAR	6/13	35.0	3D9.1C2D023A97	
5/7	48.0	3D9.1C2DCA81E7	2 YEAR	5/29	49.0	3D9.1C2CC9DA2D	3 YEAR	6/13	31.0	3D9.1C2DD31B5A	
5/10	47.0	3D9.1C2CCC61BE	3 YEAR	5/29	43.0	3D9.1C2DC9FF70	2 YEAR	6/14	32.0	3D9.1C2DCDCE08	
5/14	42.0	3D9.1C2DCAA688	2 YEAR	5/29	49.0	3D9.1C2DCBD05B	2 YEAR	6/18	31.0	3D9.1C2D04DFE1	
5/14	52.0	3D9.1C2CCA3503	3 YEAR	5/29	37.0	3D9.1C2D7392F2		6/18	34.0	3D9.1C2D72C763	
5/17	44.0	3D9.1C2DCA5E47	2 YEAR	5/29	31.0	3D9.1C2DCA3F73		6/18	38.0	3D9.1C2DD46E3D	
5/17	44.0	3D9.1C2CC99432	2 YEAR	5/29	40.0	3D9.1C2DD42107		6/18	43.0	3D9.1C2DCB8FB6	2 YEAR
5/17	36.0	3D9.1C2DCBC008	2 YEAR	5/29	34.0	3D9.1C2DAA8D5C		6/18	32.0	3D9.1C2DD60673	
5/17	59.0	3D9.1C2C4BE06B	4 YEAR	6/1	47.0	3D9.1C2CC9D68A		6/18	38.0	3D9.1C2D73FD5B	
5/17	51.0	3D9.1C2CC9C93E	3 YEAR	6/1	43.0	3D9.1C2CC9D16B	2 YEAR	6/18	41.0	3D9.1C2DCAB935	
5/17	53.0	3D9.1C2C4BAF13	4 Year	6/1	30.0	3D9.1C2DD3474F		6/22	28.0	3D9.1C2D73E9E3	
5/17	47.0	3D9.1C2CC950CE	3 YEAR	6/1	35.0	3D9.1C2D64CB99		6/25	35.0	3D9.1C2D0200EB	
5/17	33.0	3D9.1C2DCAABD8		6/4	52.0	3D9.1C2DCA9FC2	2 YEAR	6/27	36.0	3D9.1C2DD495B3	
5/22	45.0	3D9.1C2DCAAFF0	2 YEAR	6/4	37.0	3D9.1C2DD5A144		7/2	33.0	3D9.1C2DD535DC	
5/22	34.0	3D9.1C2DCB6B49		6/4	37.0	3D9.1C2DAA5181		7/2	59.0	3D9.257C5D22B0	3 YEAR
5/22	36.0	3D9.1C2DCAE025		6/7	62.0	3D9.257C59E540	5 YEAR				

Appendix B: Table 3. Whitefish and Brown Trout captured at the Dayton Adult Trap on the Touchet River, 2011 and 2012.

Date	Species	Ln (cm)	Date	Species	Ln (cm)	Date	Species	Ln (cm)	Date	Species	Ln (cm)	Date	Species	Ln (cm)
2011														
1/10	WF	26.5	5/9	WF	34.0	5/16	WF	30.0	5/26	WF	33.0	6/13	WF	35.0
3/29	WF	32.0	5/11	WF	33.0	5/19	WF	31.0	5/26	WF	29.0	6/22	WF	37.0
4/18	WF	30.0	5/11	WF	28.0	5/19	WF	31.0	6/4	BRN	40.0	6/22	WF	31.0
4/18	WF	31.0	5/11	WF	32.0	5/19	WF	32.0	6/4	WF	32.0	6/27	WF	23.0
4/19	WF	31.0	5/11	WF	31.0	5/19	WF	30.0	6/4	WF	32.0	7/1	WF	28.0
4/20	WF	31.5	5/11	WF	28.0	5/23	WF	33.0	6/4	WF	30.0	7/1	WF	23.0
5/2	WF	32.0	5/13	WF	33.0	5/23	WF	32.0	6/8	WF	30.0	7/1	WF	33.0
5/2	WF	30.0	5/13	WF	31.0	5/23	WF	32.0	6/8	WF	32.0	7/5	WF	22.0
5/2	WF	29.0	5/13	WF	32.0	5/23	WF	31.0	6/8	WF	32.0	7/5	WF	31.0
5/2	WF	27.0	5/16	WF	27.0	5/23	WF	29.0	6/8	WF	31.0	7/5	WF	22.0
5/9	WF	32.0	5/16	WF	27.0	5/23	WF	32.0	6/13	WF	32.0	7/5	WF	34.0
5/9	WF	31.0	5/16	WF	31.0	5/26	WF	32.0	6/13	WF	33.0	7/5	BRN	40.0
												7/14	WF	23.0
2012														
5/10	WF	36.0	5/29	WF	36.0	6/12	WF	27.0	6/22	WF	32.0	7/6	BRN	64.0
5/17	WF	31.0	5/30	WF	34.0	6/12	BRN	48.0	6/22	WF	33.0	7/9	BRN	42.0
5/17	WF	34.0	6/4	WF	34.0	6/13	BRN	33.0	6/27	WF	33.0			
5/25	WF	34.0	6/4	WF	34.0	6/18	WF	34.0	6/27	WF	32.0			

Attachment 1

WDFW Policy Document for the Use of Electronarcosis at WDFW Facilities

Washington Department of Fish and Wildlife

Electro-narcosis

An alternative to MS-222 for hatchery and field sampling of adult salmon and steelhead to allow immediate release.

A review of the efficacy and adoption of a non-chemical method for handling adult salmonids

08/15/2012

Issue

Fisheries professionals are in need of an approved immediate release sedative for fisheries research and management activities as a viable alternative to chemical anesthesia (MS-222 or CO^2) or the stressful practice of V-trough handling without anesthesia. Although the use of electrical sedation in fisheries research and at hatcheries is not new, recent advancements in technology have improved the safety of and reduced the negative effects from electrical-anesthetic (EA) by applying both pulse and wave form technology, and by utilizing low-voltage electronic units capable of inducing lower voltage approaches termed electro-narcosis (EN). Although no method of handling can be completely benign, WDFW has compiled a review of the efficacy of EN that clearly show its utility as a low-voltage method for handling fish in an effective, time efficient, and reasonably benign manner.

This document summarizes the review of the efficacy of electro-narcosis as an alternative sedation/anesthetic to MS-222. A companion document will outline the operating procedures and safety protocols for adopting and implementing this method in the field.

EFFICACY STUDIES AND LITERATURE REVIEW

Purpose of the Review: To encourage and inform a discussion among fish managers and researchers regarding a new technique for safely handling adult salmon and steelhead within hatcheries, at established instream fish traps or during remote field sampling. It is the responsibility of the fisheries agencies and their employees to preserve, protect and perpetuate the fish resources for which they have or share responsibility. To that end utilizing best management practices in the pursuance of fish propagation and research is consistent with the management of those resources and with the ethical pursuit of science.

Background: Large numbers of adult salmon and steelhead are captured throughout the Pacific Northwest (PNW) annually to monitor population status, collect hatchery broodstock and conduct population viability research. Trapping often results in handling large numbers of hatchery and natural origin (wild) salmonid adults that may be retained for hatchery or research purposes or handled, sampled, tagged (in some cases) and released. For fish that are released, the best possible outcome is for them to be released unharmed and unaffected so that they may either contribute to fisheries or complete spawning; this is particularly important when working with iteroparous species such as steelhead, whitefish and bull trout. Handling adult salmonids safely can be difficult for both fish and personnel. In hatchery operations this often requires the use of some form of anesthesia to control fish response and enable data collection, fish examination, broodstock collection, spawning and marking. Currently, MS-222 is the only accepted chemical anesthetic approved for use in fish culture, however if fish are to eventually be released into a natural aquatic system, a 21-day withdrawal period is required to allow the chemical to be purged from the fish's body. The use of carbon-dioxide (CO_2) is not technically approved by the Food and Drug Administration (FDA), but is allowed by FDA under Low Regulatory Priority. Carbon dioxide has been used at hatchery and research facilities throughout the PNW including Lyons Ferry Hatchery (WDFW), Three Mile Falls (CTUIR), Dryden Dam (Wenatchee River), Wells Dam (Columbia River) and other locations in the Columbia Basin. The required equipment (air stones and compressed gas tanks) is cumbersome and fish response can be violent when introduced into CO_2 charged water, which can result in injury or death. Further, because of the chemical imbalance induced by CO_2 anesthesia, a significant recovery time (several minutes) may still be required prior to release so that the fish is capable of orienting itself within a stream. The general call from the fisheries community for an alternative anesthetic to those currently available has also been formalized by Bowker and Trushenski (2011) in the Journal of the American Fisheries Society, *Fisheries*.

The use of electricity for fisheries research and at hatcheries is not new. Electro-anesthesia (hereafter EA) has been evaluated in facilities and several studies of its effects are available in the literature. Historically, and even recently, controlled studies have been conducted with modified electrofishing equipment using direct (DC) or pulsed DC current at voltages ranging 100-300V (Tipping and Gilhuly, 1996; Cho et al. 2002; Vandergroot et al. 2011). Despite extensive studies of the effects of electrofishing on numerous species that described harmful side effects of the technique such as; intramuscular hemorrhage (bruising); vertebral compression, displacement or fracture; reduced gamete viability; reduced juvenile growth rates; delayed hatching; and delayed mortality (Sharber and Carothers 1988; Hollender and Carline 1994; Thompson et al. 1997; Ainslie et al. 1998; Keefe et al. 2000), other studies suggest that EA represents a potentially useful alternative to chemically induced anesthesia with adult response and egg survival well within acceptable performance levels for a production hatchery (Tesch et al. 1999) or in research (Jennings and Looney 1998). The majority of these studies utilized available technology that normally relied upon voltages > 100-120V. However, recent advancements in electronics has fostered the development of lower voltage (<120V) AC and low voltage (<60 V) DC equipment that has and is being used to safely conduct fish research (Hudson et al. 2011) and fish cultural activities (Tesch et al. 1999; Zydlewski et al. 2008).

To facilitate this discussion a clear distinction between the traditional higher voltage equipment and the newer low voltage equipment must be made, and requires a standard lexicon to prevent misconceptions about the technology and its proposed uses. We therefore propose to ascribe the term electro-anesthesia (EA) to the higher voltage (>100V) AC or DC equipment and define the result of its implementation as a persistent quiescence or anesthesia lasting 3 to 5 minutes, during which the fish can be easily handled out of water (e.g., tagging, determination of ripeness for spawning, etc.). For systems using low voltage (≤60V DC only) technology and its resultant effect we propose to ascribe the term electro-narcosis (EN), which results in a temporary sedation with muscle relaxation of fish only while within the in-water electric field, but sufficient to allow easy observation, sampling and tagging; removal is therefore expected to result in near immediate (< 5 seconds) recovery from the effect.

Many authors however, (Cho et al. 2002; Schill and Elle 2000; Tipping and Gilhuly 1996; Sharber and Carothers 1988) recommended that further studies be conducted on the long term effects of electrical shock. The weight of evidence is that electricity can cause harm and thus demands care when evaluating the acceptability of newer equipment and/or procedures for fish handling activities. Moreover, much of the research conducted by management agencies affects populations protected by the ESA, and decisions to adopt new methods and equipment for handling sensitive species requires careful consideration.

It is to that end that this document strives to provide a synopsis of work conducted by staffs at various WDFW field offices at evaluating the effects of EN on different species, and on different life stages of those fish. The efficacy and effects of EA will not be addressed in this document: the use of EA in hatcheries with commercial units (e.g., Smith-Root EA unit at Cowlitz Salmon Hatchery) is beyond the scope of studies completed for this review. The authors suggest that before a broader application of EA at hatcheries is pursued that studies similar to those presented here are conducted to evaluate the effects of EA on adult mortality and gamete viability.

Data and Discussion: to better understand the applicability and limitations of EN in hatchery and research settings, research teams within the Hatchery Wild Interactions Unit of the Fish Science Division conducted tests with low DC voltage EN at three different locations within Eastern Washington over the last two years. We provide a brief synopsis of the current literature on EN, a summary of the results of studies conducted in 2010 and 2011 by the HWI Unit, and suggested applications for EN in hatcheries and research.

1. Snake River Preliminary Evaluation – 2010-2011.

Staff from Snake River Lab researched current EN equipment after viewing an online video of EA use during surgical implantation of radio tags into bull trout (Hudson et al. 2011). The video showed USFWS personnel implanting radio tags quickly and efficiently into bull trout under EN with near immediate recovery to a stable swimming state following the surgery.
Study design: Details of the equipment were obtained from the USFWS research staff and one test unit was purchased (< $300) for experimentation. Snake River Lab staff devised an electro-anesthetic chamber using a section of an 8” PVC pipe (cut open along the top), with EN unit leads attached to 8” round thin-plate aluminum to act as the electrodes. A few hatchery steelhead captured from the Touchet River adult trap in Dayton were introduced to the pipe via dip net at various settings ranging from 30-60 volts DC and their response observed.
Results: We found that levels of sedation were related to fish size, voltage and emersion time, although initial effects of sedation and quiescence occurred nearly immediately. Fish reached the state of EN generally at or above 50 V output. Personnel handling fish within the pipe with bare hands were aware of, though unaffected by, the electrical current; but only when both hands were present in the field. Upon removal from the electrical field, fish resumed their normal orientation and were capable of swimming nearly immediately (< 3 s). Multiple exposures of individual hatchery fish to the field did not appear to induce a cumulative sedative effect, although longer immersion times (> 60 s) generally produced a deeper narcosis; but recovery time was unaffected. Results were consistent with those on bull trout as described by USFWS personnel (Hudson et al. 2011). Internal discussions with WDFW Fish Management identified additional concerns about long term effects (e.g. – survival, egg or sperm viability, internal skeletal/muscular injury, etc.), specifically with respect to the use of EN on ESA listed natural fish heading to their spawning ground and the potential for a population level effect if EN was used. This led to the development and completion of a more intensive study of effects on spinal/musculature injury, and egg and fry survival from spawned hatchery steelhead at Lyons Ferry Hatchery.

2. Lyons Ferry Hatchery Test – 2011 Brood Spawning.

Beyond the efficacy of electro-narcosis, there remained much concern about the potential long term or delayed effects of using EN on salmon and steelhead. To assess those concerns we worked with LFH staff, local fish manager Glen Mendel and fish health specialist Steve Roberts to devise a study using Lyons Ferry hatchery steelhead at LFH during spring 2011.

Study Design: A study group of 40 adult females and 60 adult males would be subjected to a minimum of one-minute EN during the 1st week's sorting and spawning process. Output settings for the EN unit targeted 0.66 V/cm at 60 V output and not to exceed 0.15 amps. Water temperature at Lyons Ferry is a constant 11.0° C, and conductivity was measured at 220-240 µS/m. This output was considered to be in the mid-range of current needed to induce narcosis (0.25 – 1.2 V/cm) depending on fish size and conductivity of the water source. The control group was represented by broodstock spawned using standard hatchery procedures and the use of MS-222 anesthesia for sorting and spawning. Spawning crosses were restricted to each study group (EN x EN, MS-222 x MS-222). Study and control group fish were killed at spawning and carcasses filleted and photographed using the methods described in Zydlewski et al. (2008) to document hemorrhaging and possible spinal damage (Fig. 1). Eggs from study fish were fertilized, water hardened, held separate and incubated and handled in a manner consistent with the control fish. Egg mortality and survival to eye-up was documented for each female in both study and control groups and those numbers reported. Survival to hatching was also documented, although not originally part of the study plan.

Results: Incidence of spinal and intramuscular hemorrhage was similar between EN and MS-222 treated adult steelhead (Table 1), with slightly lower observed injury in EN fish. This study subjected treatment male and female steelhead to one additional EN exposure weekly during the spawning season until the fish ripened and was spawned. As such some males and females were EN treated once, while others were EN treated up to six times. We examined the carcasses of fish EN treated multiple times and found no evidence of greater numbers of hemorrhages. Since the incidence of spinal/muscle hemorrhage was nearly identical in both groups, we conclude that these injuries were most likely due to trapping/handing procedures and not related to the EN treatment. Further, we saw neither a measurable difference in egg viability (Table 2), nor did we detect a cumulative effect of multiple exposures to EN on survival (Table 3), although the sample sizes for comparisons were small.

Table 1. Incidence of hemorrhaging near the spine and non-spinal for male and female steelhead spawned at LFH in 2010.

	MS-222		EN	
	Males	Females	Males	Females
Number examined	40	39	43	31
Number of injuries				
Non-Spinal	4	0	2	0
Spinal	0	1	1	1
Total	4	1	3	1
Percent	6.3%		5.4%	

Figure 1. Filleting of study fish was completed to document hemorrhaging and whether associated with the spine or intramuscularly (a hemorrhage associated with the spine is clearly visible in this male).

There was no significant difference ($P = 0.69$) in green egg to eyed egg stage survival between the groups (Table 2), although the variability in egg survival was very high among females in both groups, which is typical for steelhead. Individual fish accounting was lost at eye-up when eggs were combined for hatching, but we observed similarly close survival from eyed egg to the fry stage with MS-222 treated fish survival estimated at 97.3% and EN treated fish survival estimated at 96.9%

Table 2. Green egg to eyed egg survival rates for two study groups of fish at LFH in 2011.

	MS-222		EN	
	N	% Survival	*N*	% Survival
All fish	88	76.4	32	78.7

We examined the potential cumulative effect of multiple exposures to EN on egg viability. Over six weeks (Fig. 2) there was no discernible trend toward increasing egg mortality, and though sample size was small (5-7 fish/wk) analysis with Fisher’s least significant difference procedure showed the means to be homogeneous. Week 4 did not plot as sample size (n= 1) was too small.

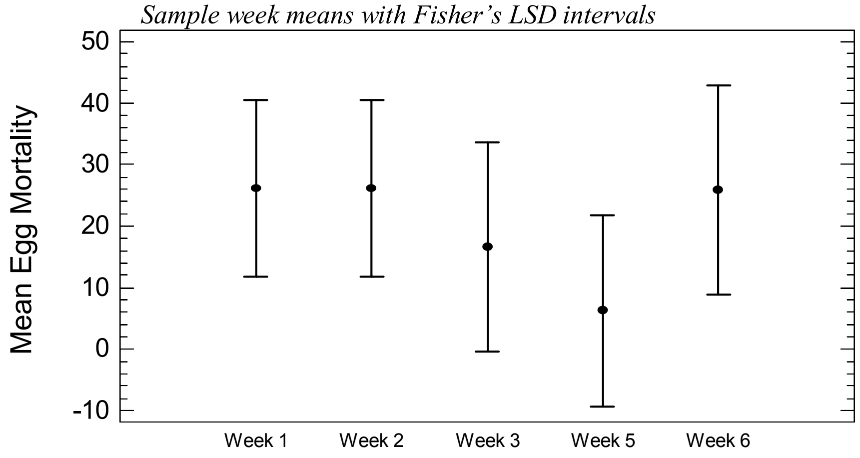


Figure 2. Egg mortality over time for groups of female steelhead exposed to successively greater amounts of electro-narcosis at LFH, 2011. (Mean cumulative exposure for groups is displayed in seconds for each week)

These results were consistent, and even slightly better than those reported in the literature for salmon, which we attributed to the use of a lower voltage DC current. Based on this test we concluded that the use of EN for handling pre-spawn steelhead is not likely to significantly increase mortality or compromise gamete viability. However, a second test of the long term effects was proposed at LFH for fall 2011 to directly measure delayed mortality over a 3 month post exposure period; which is a similar time to spawning that fish may have to survive after handling at a research trap or selection for broodstock at a hatchery.

3. Lyons Ferry Hatchery Test – Fall 2011 2012 Broodstock.

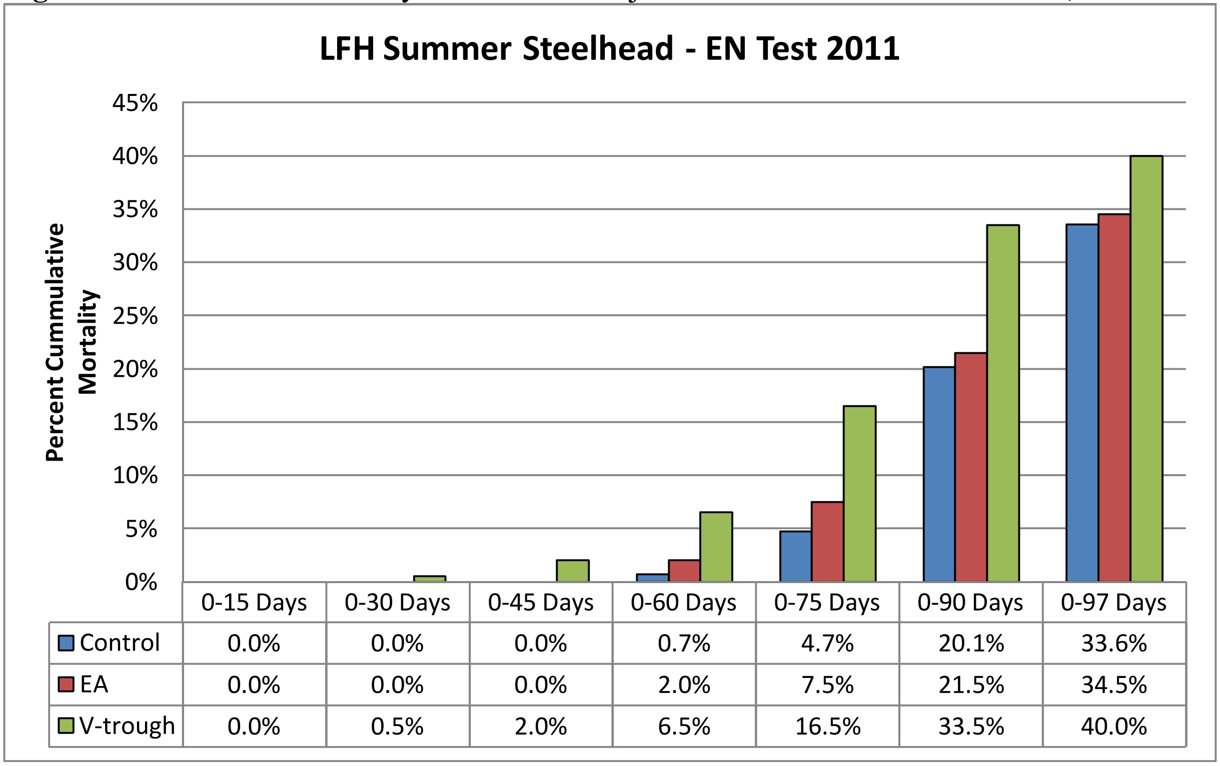
Study Design: An important distinction of this study over the previous year was the inclusion of a control group not exposed to any form of anesthesia or handling. WDFW operates steelhead trapping facilities around SE Washington, and standard handling protocol in recent years has been to use water filled V-troughs to sample and release adult steelhead without the use of anesthetic. This has been done to allow for the immediate release of hatchery fish into rivers where active sport fisheries are often scheduled to occur. Although the forward 20 cm of the V-troughs is covered with black rubber and fish will often lie quiet once their head is within this dark area, capturing and inserting fish into the troughs can require tight physical restraint to prevent thrashing. Moreover, not all fish respond equally to the dark area; many will continue to fight the trough which requires a sampler to continually restrain the fish, while another person samples the fish – doubling the staff required. The possibility of inducing trauma to the fish is real during this type of sampling. A direct comparison of the physical effects of current handling protocol (v-trough) with EN and the inclusion of a control group (no handling of any kind during the duration of the study) seemed a logical follow up to the previous study.

Approximately 600 summer steelhead were to be trapped at LFH in early October, 2011. On 12 October 2011, SRL staff sampled 200 fish using EN, 200 fish with a v-trough, with an unknown number of other fish (approximately 150-200) that were not handled to use as a control. Sampling study groups consisted of netting individual fish, determining their sex, length, collection of a scale sample, and then clipping either the top/bottom portion of the caudle fin depending on the group (EN=top caudal, v-trough=bottom caudal). The EN group treatment was similar to the previous year, although fish were exposed to EN only as long as necessary to collect the required data. Handling of the v-trough group was completed similarly to normal field sampling activities to provide a functional comparison of how fish might be affected by the two methods. All steelhead were held within the same adult holding raceway (10' x 80' x 6') at LFH but were **not treated** with formalin to control fungus. Because of a high density of adults in the raceway, water flow into the pond was increased. All mortalities were sampled on a daily basis by LFH hatchery staff and were sampled per hatchery protocols, with caudal fin clips recorded.

Results: The average time required to net, sample, and release fish in the EN group was 40 seconds when scales were collected, but required a significantly greater time ($P < 0.0005$) of 51 seconds for handling fish in the v-trough. There was no significant difference ($P > 0.50$) in average handling time between groups when scales were not collected (mean = 33 seconds for EN: 36 seconds for v-trough). Fish handled with the v-trough had the highest mortality throughout the duration of the study (Figure 3). Mortality in all three groups was very low 45 days into the study, but rapidly increased for all groups 75-90 days into the study. This increased mortality was likely the result of rapid ripening for spawning since mortality increased concurrently within all treatment groups. At the completion of the study seven v-trough fish (bottom caudal fin clip) could not be accounted for. Based on the raw data sheets and notes of mortalities kept by hatchery staff, seven of the recorded control fish were changed to bottom caudal fish. This manipulation of the data occurred because fungus, which in many cases severely eroded the caudal fin tissue, complicated positive identification on mortalities. All EN fish (top caudal fin clip) were identified. Statistical analyses of the results are currently incomplete but will be available soon.

We conclude from this test that EN treated fish required less handling time when complex sampling occurred, and experienced fewer traumas and less overall mortality as a result of handling than fish sampled with no anesthetic using our standard handling methods (e.g., V-trough). Further, mortality within the v-trough sampled group began sooner than for EN and control groups (Figure 3).

Figure 3. Cumulative mortality of steelhead subjected to three treatements at LFH, 2011.



	0-15 Days	0-30 Days	0-45 Days	0-60 Days	0-75 Days	0-90 Days	0-97 Days
🟦 Control	0.0%	0.0%	0.0%	0.7%	4.7%	20.1%	33.6%
🟥 EA	0.0%	0.0%	0.0%	2.0%	7.5%	21.5%	34.5%
🟩 V-trough	0.0%	0.5%	2.0%	6.5%	16.5%	33.5%	40.0%

4. Wells summer Chinook test, 2011.

Introduction: the goal of this study is to determine if the use of EN as an alternate method of anesthetizing adult Chinook salmon has any negative effects on the maturation and viability of gametes as it relates to egg fertilization, eyed egg survival and if possible, fry/juvenile stage survivals. In a previous study evaluating the use of EN on adult spring Chinook, Zydlewski et al. (2008), found no significant differences in fecundity or progeny survivals at the eyed egg and fry stages between females that were immobilized by tricaine methanesulfonate (MS-222) and those that were immobilized using EN.

Study Design: An equal number of adult male (N = 92) and female (N = 92) summer Chinook were randomly collected from the "volunteer" trap at the Wells Hatchery Complex. At the time of collection, each fish was placed in a watered vessel and subjected to EN immobilization using a 60V maximum DC continuous current regulated power supply (BK Precision Model 1667). Based on historic egg data, this sample size should provide statistical power to detect a 5% difference in egg mortality between groups with a power of 0.78. While immobilized, each fish was externally marked and PIT tagged to ensure tracking of individuals throughout holding and spawning. Water temperature, water conductivity, voltage readings and duration of immobilization (min) will be monitored and recorded. Treatment and control group fish were randomly assigned to one of four possible mating (fertilization) groups. Live and dead eggs from each cross group will be enumerated at the eyed stage via standard hatchery methods and an eyed egg survival proportion calculated. Appropriate statistical tests (i.e. ANOVA) will be applied to the preliminary survival proportions to determine if differences in survival to the eyed egg stage exist. In addition, after spawning a subsample of the fish subjected to EN was examined for hemorrhaging near the spinal column and in the surrounding musculature. After filleting, pictures will be taken of all fish examined.

Preliminary Results: During trapping operations (7/12 – 7/28) at the Wells Hatchery "Volunteer" trapping facility, we anesthetized 200 (100 females, 100 males) adult summer Chinook using electro-narcosis. We decided to EN, PIT tag and collect data on 200 fish rather than 184 fish (as stated in the study design), in an effort to compensate for any mortality that should occur and thus keeping the sample sizes sufficient. Each fish was subjected to EN for an average time of 1.53 minutes. Voltage and amperage used averaged 49.46 and 0.63, respectively. The water temperature and conductivity during the sampling period averaged 18 C and 135.81 ms/cm, respectively. Logistical difficulties during hatchery spawning resulted in unequal sample sizes among the study groups. Average egg survivals across all groups was relatively high (89.2%) and was very much representative of historic survivals for this specific stock (Table 4). Differences in survival were tested using Kruskal-Wallis ANOVA because data were not normally distributed. Significant differences in survival among some study groups were found ($P = 0.01$). Interestingly, the study group comprised of fish which were not subject to EN (Non-EN x Non-EN) had significantly lower survival than those of the other three groups having at least one parent being subjected to EN (Table 5). We attributed this small but significant difference in survival to the larger sample in that group. Furthermore, we found no evidence of hemorrhaging in the musculature or around the spinal column in the subsample sample of study fish ($N = 105$).

Table 4. Green egg to eyed egg survival with standard deviations for four study groups of summer Chinook spawned at Wells Hatchery, 2011.

Study Group	Sample size	Mean survival	SD	Minimum survival	Maximums survival
EN x EN	48	0.912	0.152	0.086	0.991
EN x Non-EN	44	0.904	0.203	0.008	0.989
Non-EN x EN	40	0.910	0.131	0.271	0.995
Non-EN x Non-EN	59	0.854	0.182	0.211	0.988
Grand Total	191	0.892		0.008	0.995

Table 5. Significance levels (P-values) of multiple comparisons test of mean ranks of survival rates for all possible mating groups of Wells hatchery summer Chinook exposed and not exposed to EN.

Mating group (F x M)	Non-EN x EN	EN x EN	Non-EN x Non-EN	Non-EN x EN
Non-EN x EN	-	1.0000	***0.0165***	1.0000
EN x EN	1.0000	-	***0.0475***	1.0000
Non-EN x Non-EN	***0.0165***	***0.0475***	-	0.4386
Non-EN x EN	1.0000	1.0000	0.4386	-

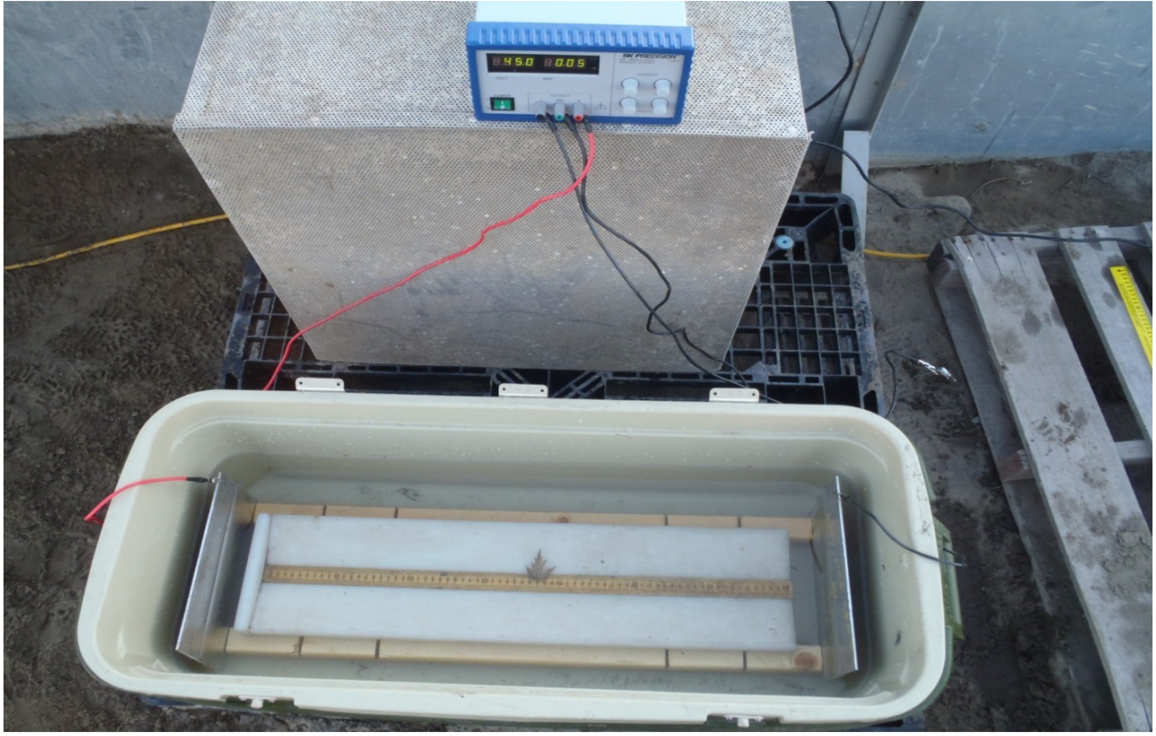
The results presented here are preliminary, but at this time we have found no significant evidence that the use of EN for immobilizing salmon for examination and spawning inflicted any measurable physical trauma or negatively affected gamete viability. We propose continued use of EN at this facility and in other locations where salmon and/or steelhead are handled.

5. Yakima River coho sampling and spawner success.

To directly evaluate the natural production potential for coho salmon in Taneum Creek Washington, we released sexually mature coho adults into three 400-m long study sections. Although reintroduction programs commonly plant fry, parr, or smolts in areas identified for rehabilitation, many years are required to determine the natural production potential in those areas. Furthermore, factors located outside of the stream of interest can have a profound influence on the survival of those fish prior to the returning adult stage. Planting sexually mature adult fish circumvents rearing and migration issues that can influence survival, and gives some insight on the quality of a given stream for natural production of progeny.

HWI staff from Ellensburg tagged 315 coho (size range 60-75cm) between 31 October 2011 and 2 November 2011 at Prosser Dam on the lower Yakima River. The EN unit was set at 45.0 volts and 0.05 amps (Fig. 4). The positive wire on the plate was situated towards the head of the board and the negative plate towards the tail. The water level was approximately 10cm above the measuring board and the coho inserted into the EN unit filled most of the cooler. Each individual coho was netted and taken out of the raceway and placed into our EN cooler. Fork length was noted and a Floy tag was inserted into the dorsal musculature of each fish. Water was changed in the cooler every 15-20 fish to prevent a hypoxic condition from developing in the cooler and to ensure adequate oxygen was available for respiration; the average time the fish was in the cooler was approximately 10 seconds.

Figure 4. Portable electro-narcosis unit.



We conclude from the results and experiences of the biologists and other staff (e.g., State and Tribal staffs) involved that this EN tool was both highly effective and safe. In addition, we did not observe significant reduction in the number of successful spawners (redd counts) that were sedated using EN relative to previous years (Kruskal-Wallace ANOVA; $P = 0.28$). Our observations also suggest that female performance (in terms of egg retention/or deposition) was consistent with previous observations and similar to previous years (Mann-Whitney U-test; $P = 0.54$). Thus, it does not appear that the EN system negatively affected the spawning performance of adult coho in study sites in Taneum Creek. Although not significant at the traditional 0.05 level, we did see slightly higher prespawn mortality rates relative to other years (Mann-Whitney U-test; P=0.07), however, the weight of evidence does not indicate it was due to the EN or tagging. Many of these fish were in pretty poor shape when they arrived at the hatchery facility. In retrospect, the application of EN was superior to the alternatives in this experiment for our purposes. It worked so well in fact, we have been working on designing a small portable unit similar to that presented in Hudson et al. (2011) to use on resident rainbow trout for routine field sampling.

Summary: Fisheries professionals are desperately in need of an approved immediate release sedative for use in fisheries research and management activities (Bowker and Trushenski 2011). Although the use of electrical sedation in fisheries research and at hatcheries is not new, recent advancements in technology have improved the safety of and reduced the negative effects from EA by applying both pulse and wave form technology developed by companies such and Smith-Root and Coffelt (not previously discussed), as well as new companies providing low voltage electronic units capable of inducing EN in an efficient and minimally harmful way. Although no method of handling can be completely benign, the results from multiple studies and literature citations contained herein clearly show a method for handling fish in an effective, time efficient and reasonably benign way. In short, we believe that EN now represents a viable alternative to chemical anesthesia (MS-222 or CO^2) or the stressful practice of V-trough handling without anesthesia for research and hatchery operations.

Anticipated uses in Washington – With the array of low-voltage DC power supply units now commercially available, we believe that EN has application across Washington and the Pacific Northwest for fisheries research and hatchery operations. Increasingly, we must handle populations of salmon and steelhead that have mixed origin and uses; from fisheries to population status and trend monitoring. The ability to release large numbers of fish quickly, legally and relatively unharmed is crucial to obtaining the data necessary for fish Management Agencies to formulate best management practices (BMP). The abandonment of chemical anesthesia for EN is one of those BMP decisions. For research or in hatcheries required to handle ESA listed populations where adults may need to be examined and released, or in the case of steelhead that are released to possibly spawn again, the use of low voltage EN seems prudent. The use of higher voltage commercial units in hatcheries handling traditional hatchery stocks of fish may also be a viable alternative to chemical anesthesia and where EN does not fully meet a particular facility's work need. However, we encourage the completion of additional tests of the immediate and lasting effects of EA on salmonids similar to those studies discussed here. Should that technology prove benign, or nearly so, adopting its use would clearly reduce the release of chemicals into surface or ground waters.

Preliminary discussions with NOAA Fisheries – After preliminary discussions with USFWS personnel on the use of EN with bull trout and following testing at LFH, Snake River Lab contacted NOAA Fisheries staff engaged in the development of a Biological Opinion for the Touchet River hatchery steelhead program. Mr. Rich Turner was aware of both EN and EA, and had observed EA use at two lower Columbia River hatcheries (Lewis River and Cowlitz Salmon) where commercial Smith-Root EA units are being used (http://www.smith-root.com/electroanesthesia), and he believes the method to have substantial merit and potential. NOAA is familiar with the limited choices for fish anesthesia and desires that BMP handling procedure be implemented in all cases where ESA listed fish must be handled. He further understands the difficulties of releasing hatchery fish that have been subjected to controlled chemical anesthesia. He expressed willingness for us to use EN on ESA listed populations and encouraged us to engage with the other fishery co-managers to discuss the merits of EN and its possible adoption as a BMP sedation technique.

Desired outcomes and actions:

1. Managers and policy representatives throughout the Pacific Northwest are fully informed about the advantages, efficacy and risks associated with the use of electro-narcosis (EN) for handling adult salmonids in research situations and production facilities,
2. A regional policy level decision is desirable. The acknowledgement of the appropriateness (effects on ESA listed fish and operator safety) of expanded use of EN for handling ESA listed adult salmon, steelhead and other salmonids through the adoption of standard protocols will enable the use of EN in State and federally funded production and research.

Actions:

1. WDFW engages with co-managers such as Tribes, NOAA Fisheries and other States in a dialogue regarding the use of alternative fish sedation techniques and those entities adopt a similar EN use policy.
2. Management entities identify further research, if necessary, into the effects of EN to inform the involved entities in consideration and immediate adoption of EN as an appropriate immediate release sedative.
3. Identify available funding to complete needed research on the effects of EA, if required, inform the involved entities in consideration and timely adoption of EA as an appropriate immediate release sedative.

Prepared by WDFW Staff:
Snake River Lab: Mark Schuck, Joseph Bumgarner
Ecological Interactions Team: Gabriel Temple, Trenton De Boer
Eastbank Complex Evaluations: Travis Maitland
Lyon Ferry Hatchery: Jon Lovrak

Reviewed by WDFW Staff::
District 3 Fisheries Manager: Glen Mendel
HWI Unit Leader: Andrew Murdoch
Snake River Lab: Michael Gallinat
Fish Health: Steve Roberts

Literature Cited

North American Journal of Fisheries Management

Volume 18, Issue 4, 1998; pages 905-918

Effects of Pulsed and Continuous DC Electrofishing on Juvenile Rainbow Trout

Barbara J. Ainslie, John R. Post & Andrew J. Paul

Abstract

Three hundred fifty juvenile rainbow trout *Oncorhynchus mykiss*, reared under captive conditions, were exposed to 300-V continuous DC or low-frequency (30-Hz) pulsed DC (PDC) for one or three electroshocking passes to evaluate the effects of electroshock on mortality, injury, and growth over 147 d. Mortality was negligible (~1%) in all treatments. Injury rates varied from 15% to 39%, with PDC causing a greater number (but typically less severe) injuries than analogous DC sampling. Multiple-pass sampling designs caused more spinal injuries than single-pass designs. Longer (heavier) fish sustained more spinal injuries. Electroshocking reduced mean growth rates, but there were no statistically significant differences in growth between treatment groups. Growth in length was significantly reduced with increasing severity of injuries. Thus, it appears that growth was not directly impaired by electroshocking but rather by the occurrence of spinal injury, the severity of which was directly proportional to the magnitude of the growth depression. Extrapolation of the experimental data to field studies in which 20% or less of the population is sampled suggested reductions of 3% or less in mean population growth with DC or low-frequency PDC electroshocking.

Fisheries

Volume 36, Issue 3, 2011. Pages 132-135

http://www.tandfonline.com/doi/abs/10.1080/03632415.2011.10389085

Guest Director's Line: AFS Policy Statement Regarding the need for an Immediate-Release Anesthetic/Sedative for Use in the Fisheries Disciplines

Jim Bowker & Jesse Trushenski

Abstract

Availability of safe and effective fish sedatives or anesthetics is crucial to fisheries research, management, and culture activities. If fish are sedated prior to handling, the risk to both fish and handler is minimized. Currently, there is no ideal compound that can be legally used on fish without adhering to a lengthy withdrawal period. The absence of a suitable immediate-release sedative jeopardizes fish, fisheries, fish culture, and research, posing a risk to aquatic resources as well as those handling fish. A document, "AFS Policy Statement on the Need for an Immediate-Release Anesthetic/Sedative for Use in the Fisheries Disciplines," has been drafted to (1) describe the impediments preventing fisheries professionals from having access to a suitable immediate-release sedative; (2) characterize the constraints that this issue places on aquatic natural resources management, fisheries research, and the private aquaculture industry; and (3) recommend a course of action to facilitate the timely approval of such a sedative, which will minimize risk to fish, fisheries professionals, the general public, and the environment.

Transactions of the American Fisheries Society

Volume 131, Issue 2, 2002; pages 224-233

Electroshocking Influences Chinook Salmon Egg Survival and Juvenile Physiology and Immunology

Grace K. Cho, John W. Heath & Daniel D. Heath

Abstract

While electrofishing has become a common capture technique in fisheries research, the potential impact of this technique on the fish is not completely understood. Mature female Chinook salmon *Oncorhynchus tshawytscha* and eggs at key developmental stages were electroshocked with 10-s pulsed DC from a standard backpack electroshocker in a controlled environment. Eggs from one-third of the shocked females showed extreme mortality (>93%), while the remaining shocked families shared egg mortality (12-20%) similar to the controls (9.9%). Eggs shocked at the early eyed stage showed significantly higher mortality (34.2%) than control (unshocked) eggs, while mortalities were low (≤2.1%) for shocked eggs and for controls at all other developmental stages. Upon examination of fish radiographs, we found that the electroshocked juvenile fish had significantly more spinal aberrations than the unshocked fish. Hematocrit, serum cortisol and glucose, serum lysozyme activity, and total leukocyte counts were monitored in control and shocked juvenile fish for 3 weeks. Hematocrit declined over 3 weeks in both groups. Serum cortisol and glucose levels increased significantly in both groups within 12 h, but shocked fish showed a slower return of cortisol levels to preshock values and an overall higher glucose response. The combination of electroshock and handling did not affect serum lysozyme levels, but unshocked (handled) fish exhibited immediate and significantly reduced lysozyme activity for up to 2 weeks. Total leukocyte numbers were higher in shocked fish late in the experiment (at 2 and 3 weeks). Although electrofishing is useful to determine the precapture physiological status of field-caught fish, our data show that electrofishing can have significant detrimental impacts on the fish.

North American Journal of Fisheries Management

Volume 14, Issue 3, 1994; pages 643-649

Injury to Wild Brook Trout by Backpack Electrofishing

Bruce A. Hollender & Robert F. Carline

Abstract

Most studies of salmonid injuries caused by electrofishing have been conducted on adult brown trout *Salmo trutta* and rainbow trout *Oncorhynchus mykiss* in medium- or high-conductivity waters. The objective of this study was to assess internal injuries of wild brook trout *Salvelinus fontinalis* that were captured with AC and pulsed-DC backpack electrofishing units in four small, low-alkalinity streams. We used X rays and autopsies to assess the injury rate of 579 brook trout (95–237 mm total length, TL) captured by electrofishing. Injuries consisted of either internal hemorrhages, spinal misalignment and fracture, or both. We found a total of 74 hemorrhages and 91 spinal injuries. Injury rates of brook trout captured by electrofishing were not significantly different ($P > 0.05$) between electrical wave forms: 26% for AC and 22% for pulsed DC. Injury rate increased with fish length, ranging from 14% for fish smaller than 125 mm TL to 42% for fish 175 mm TL or larger. In spinal-injured fish, damage occurred to an average of six vertebrae, usually ones in the posterior region of the spinal column between the dorsal and anal fins. We also examined 89 brook trout (87–225 mm TL) captured by angling. Less than 7% of the angled fish had injuries, all detected by X ray. We conclude that the incidence of electrofishing-induced injury can be substantial, even for relatively small brook trout in low-alkalinity waters. The relation of these injuries to mortality remains to be explored.

North American Journal of Fisheries Management

Volume 31, Issue 2, 2011; pages 335-339

A Portable Electronarcosis System for Anesthetizing Salmonids and Other Fish

J. Michael Hudson, Jeffrey R. Johnson & Boyd Kynard

Abstract

The physiological responses of fish to continuous (nonpulsed) direct current were first described in the 1960s. One of these responses, electronarcosis (anesthesia, accompanied by muscle relaxation, through electrical inhibition), has been used in fisheries research and management as an anesthetic since the 1970s. We provide details on the assembly and operation of a portable electronarcosis unit for fish anesthesia and describe its performance with respect to two species

of salmonids. The portability and effectiveness of this approach make electronarcosis a viable alternative to existing anesthetics that can be used for a number of applications.

North American Journal of Fisheries Management

Volume 18, Issue 1, 1998; pages 187-190

Evaluation of Two Types of Anesthesia for Performing Surgery on Striped Bass

Cecil A. Jennings & Gregory L. Looney

Abstract

Tricaine (MS-222) is the most widely used anesthetic for fishes, but induction and recovery times are rather long. Studies on salmonids have shown that electroanesthesia is a good alternative to MS-222 for short term (<1 min) immobilization. However, data on longer-duration (3–5-min) immobilization needed for surgical procedures are lacking. We analyzed induction and recovery times for 20 adult (52–81-cm) striped bass *Morone saxatilis* immobilized with electroanesthesia and MS-222. We defined induction time as the interval from the onset of each treatment until the fish was immobilized (i.e., did not respond to tactile stimuli) and recovery time as the interval from the fish's return to the water to its resumption of normal swimming. Surgical procedures similar to those necessary to implant a radio transmitter were performed on each fish. Induction time for fish immobilized with electroanesthesia (geometric mean, 8 s; 95% confidence interval [CI], 3–21 s) was much shorter than that for fish immobilized with MS-222 (geometric mean, 47 s; 95% CI, 38–58 s) ($P = 0.0006$). Additionally, fish immobilized with electroanesthesia recovered much faster (geometric mean, 9 s; 95% CI, 4–19 s) than fish immobilized with MS-222 (geometric mean, 206 s; 95% CI, 156–272 s) ($P \leq 0.0001$). Faster induction and recovery times of fish immobilized with electroanesthesia and the ability to process more fish per unit time are major benefits of this technique.

North American Journal of Fisheries Management

Volume 20, Issue 2, 2000; pages 320-327

Induced Mortality and Sublethal Injuries in Embryonic Brook Trout from Pulsed DC Electroshocking

Mary Louise Keefe, Timothy A. Whitesel & Peter Angelone

Abstract

Despite heightened concern for potential adverse effects of electrofishing on fish, little information is available on the effects of electrofishing on juvenile fish. The purpose of our study was to determine if electrofishing impairs the survival and development of embryonic brook trout *Salvelinus fontinalis.* Brook trout embryos, both uncovered and buried in an artificial redd, were electroshocked at 21 d post-fertilization (pre-eyed). Uncovered embryos also were electroshocked at 37 d post-fertilization (eyed). When electroshocked, pre-eyed embryos suffered greater embryo mortality (85%) and incidence of hatchling morphological anomalies (22%) than unshocked embryos (14% and 7%, respectively), whereas hatching times and hatchling weights were similar between groups. Emergence from electroshocked pre-eyed embryos also was significantly lower (23%) than from unshocked embryos (67%), and the mean time at which fish emerged was longer for shocked embryos (88 d) than for unshocked embryos (85 d). Survival and development of electroshocked eyed embryos were not affected. Our results demonstrate the potential of electrofishing to impair development of brook trout embryos through sublethal and lethal effects.

The Progressive Fish-Culturist

Volume 60, Issue 1, 1998; pages 44-49

Effects of Immobilization by Electricity and MS-222 on Brown Trout Broodstock and Their Progeny

Steven D. Redman, Jeffery R. Meinertz & Mark P. Gaikowski

Abstract

To determine the effects of electrically and chemically induced immobilization on post spawn broodstock and their progeny, age-2 and age-3 female broodstock and age-2 male broodstock of brown trout *Salmo trutta* were immobilized with electricity or tricaine methanesulfonate (MS-222), stripped of their eggs or milt, and weighed. Eggs taken from electrically immobilized females were fertilized with milt taken from age-2 males that were immobilized with electricity, and eggs taken from females immobilized with MS-222 were fertilized with milt taken from age-2 males that were immobilized with MS-222. After spawning, the mortality and weight of broodstock were compared twice over a 6-month period. Egg viability and growth of offspring fry from each treatment group were also compared. Electricity induced complete and consistent immobilization in brown trout broodstock. Electrically immobilized fish were more easily handled than fish immobilized with MS-222; however, electrically immobilized fish survival (70%) was significantly less than fish immobilized with MS-222 (83%). Broodstock growth differences were only noted at 6 months post exposure, when the mean weight of electrically immobilized fish was slightly less than the weight of fish immobilized with MS-222. Broodstock immobilization by electricity did not reduce egg viability or fry growth.

North American Journal of Fisheries Management

Volume 20, Issue 3, 2000; pages 730-736

Healing of Electroshock-Induced Hemorrhages in Hatchery Rainbow Trout

Daniel J. Schill & F. Steven Elle

Abstract

We monitored healing in electroshock-induced hemorrhages of myomere blood vessels produced by individually exposing hatchery rainbow trout *Oncorhynchus mykiss* to direct current (*N* = 502) and pulsed direct current (*N* = 708). We used voltage gradients and exposure times that were suspected to produce high injury rates to facilitate observation of injury duration in muscle tissue. At 1 d postexposure, 86.1% of the test fish exposed to DC and 81.6% of those exposed to pulsed direct current (PDC) had at least one hemorrhage. Fish exposed to DC averaged 1.86 injuries at 1 d postshocking, and those exposed to PDC averaged 1.45 injuries. Number of hemorrhage injuries per fish began declining by 15 d postshocking in both groups. The severity of injuries initially increased through 15 d postshocking and then decreased through the remaining 3–5 weeks of the tests. At the end of the test, injuries induced by DC had declined by 78.0% (36 d postshocking), and those induced by PDC declined by 92.4% (57 d postshocking). In all, 1.8% of all fish exposed to DC and 1.1% of those exposed to PDC died during the study. Our data for hatchery rainbow trout suggest that hemorrhage injuries in salmonids caused by electrofishing exposure exist for a relatively short time and do not represent a long-term mortality or health risk to the fish. Because of the ephemeral nature of blood vessel hemorrhages, compared with spinal injuries, future studies that examine electrofishing injuries should evaluate hemorrhage and spinal injuries separately and abandon the practice of combining these data.

North American Journal of Fisheries Management

Volume 8, Issue 1, 1988; pages 117-122

Influence of Electrofishing Pulse Shape on Spinal Injuries in Adult Rainbow Trout

N. G. Sharber & S. W. Carothers

Abstract

Adult rainbow trout *Salmo gairdneri* captured by electrofishing were analyzed for spinal injury by X-ray photography and autopsies. The effects of three electrical pulse shapes were compared. Of 209 fish captured, 50% suffered spinal injuries involving an average of eight vertebrae that were dislocated, splintered, or both. One-quarter-sine wave pulses injured a significantly higher proportion of fish (67%) than either exponential pulses (44%) or square wave pulses (44%; $P < 0.05$). Quarter-sine waves also damaged significantly more vertebrae per fish (average, 9.5) than did exponential pulses (6.6); the average number damaged by square waves (8.2) did not differ significantly from either of the other means. Electrofishing could bias mark–recapture studies of large rainbow trout. Electrofishing in waters containing endangered or threatened species should be considered with great caution.

North American Journal of Aquaculture

Volume 61: Number 4, 1999; pages 355-358

Effects of Varying Voltage and Pulse Pattern during Electrical Immobilization of Adult Chum Salmon on Egg Survival to the Eyed Egg Stage

Andrea Hough Tesch, Drew Aro, Geoffrey Clark, Deb Kucipeck & John D. Mahan

Abstract

Electrical shock is becoming widely used to immobilize adult salmon before gamete removal. Working with immobilized fish reduces repetitive motion injuries among workers and decreases staff requirements, but survival rates of eggs obtained from adults immobilized by electrical currents have varied. Eleven DC wave forms and voltage combinations were used to immobilize adult chum salmon *Oncorhynchus keta*, and survival rates of eggs taken from shocked fish were compared with survival rates from fish immobilized with carbon dioxide. Egg survival rates increased as voltage and pulse pattern intensity decreased. Similar egg survival rates were recorded for those obtained from the carbon dioxide controls (98%) and those obtained at the lower voltage and pulse patterns (96–98%), thus validating the use of electrical immobilization on adult chum salmon before gamete removal.

North American Journal of Fisheries Management

Volume 16, Issue 2, 1996; pages 469-472

Survival of Electroanesthetized Adult Steelhead and Eggs of Fall Chinook Salmon

Jack M. Tipping & Gary J. Gilhuly

Abstract

We evaluated the effects of the Coffelt system 91 electroanesthesia unit on survival of adult steelhead *Oncorhynchus mykiss* and the egg-to-fry stages of fall Chinook salmon *O. tshawytscha*. Adult steelhead were anesthetized at one of several voltages with the complex pulse pattern from the system 91 or with carbon dioxide gas. Fish were then tagged, transported, and released. Tags were recovered at two hatcheries and by recreational anglers. An average of 39% of electroshocked fish and 46% of fish anesthetized with carbon dioxide were recovered. However, tags from both groups were returned at similar rates by recreational anglers. Recovery rate differences appeared to be reduced at 50 and 80 V. Egg-to-fry mortality for progeny of electroanesthetized fall Chinook salmon averaged 7%, compared with 12% for control groups. We conclude that if low levels of fish damage are acceptable, electroanesthesia may be a viable alternative to other anesthetics.

North American Journal of Fisheries Management

Volume 17, Issue 1, 1997; pages 141-153

Injuries to Brown Trout and Rainbow Trout Induced by Capture with Pulsed Direct Current

Kevin G. Thompson, Eric P. Bergersen & R. Barry Nehring

Abstract

Brown trout *Salmo trutta* 10–49 cm total length and rainbow trout *Oncorhynchus mykiss* 13–51 cm total length were captured in three Colorado rivers with 60-Hz pulsed DC applied with boat-mounted (single mobile anode) and “walk” (shore-based multiple mobile anode) electrofishing systems, then X-rayed and necropsied to evaluate spinal and hemorrhage injuries resulting from exposure to electrofishing. Among three study streams, spinal injuries were found in 18–64% of rainbow trout and 18–52% of brown trout collected by boat electrofishing, and in 6–40% of rainbow trout and 27–38% of brown trout collected by walk electrofishing. Overall, more than half of the injured fish were judged to have the lowest severity of spinal injury, and in 11 of 12 samples 2.1 % or less of the fish sustained the most severe class of injury (class 3-fractured vertebra or separated spinal column). Injured rainbow trout collected by boat electrofishing tended to have more severe injuries than the other test groups. Hemorrhage injuries were found in 28–65% of rainbow trout and 24–45% of brown trout collected by boat electrofishing, and in 13–49% of rainbow trout and 13–30% of brown trout collected by walk electrofishing. Logistic regression modeling of both types of injury revealed that rates of fish injury differed among the streams studied. Length of fish was significantly related to the probability of injury in most of the best models, longer fish having a greater chance of sustaining injuries. Rates of injury were also found to vary with species in most models, and rainbow trout were usually more likely to be injured than brown trout for a given method and river. Method of capture also influenced the rate

of injury. Where this occurred, boat electrofishing always injured a higher proportion of fish than did walk electrofishing.

North American Journal of Fisheries Management

Volume 31, Issue 5, 2011; pages 914-922

Evaluation of Two Forms of Electroanesthesia and Carbon Dioxide for Short-Term Anesthesia in Walleye

Christopher S. Vandergoot, Karen J. Murchie, Steven J. Cooke, John M. Dettmers, Roger A. Bergstedt & David G. Fielder

Abstract

Anesthetics immobilize fish, reducing physical damage and stress during aquaculture practices, stock assessment, and experimental procedures. Currently, only tricaine methanesulfonate (MS-222) is approved for use as an anesthetic for food fish in Canada and the United States; however, MS-222 can only be used with certain fish species, and treated fish must be held for a specified period of time before release into the wild. Two forms of electroanesthesia and carbon dioxide (CO_2) were evaluated as anesthetics for adult walleye *Sander vitreus* to determine their suitability for use before intracoelomic implantation of telemetry transmitters. Walleyes were subjected to one of three treatment groups: constant direct current (CDC), pulsed direct current (PDC), and CO_2. Fish subjected to these treatments were monitored for induction (where appropriate) and recovery time and whether these forms of anesthesia were conducive to implanting telemetry transmitters, that is, whether they fit a surgery threshold range of 250–350 s. Additionally, all fish were monitored for post-trial survival, and radiographs were taken to determine whether any vertebral damage was associated with the electroanesthesia treatments. Although all anesthetic treatments successfully immobilized fish for enough time to implant a transmitter, PDC electroanesthesia is recommended because of its immediate induction time, quick recovery, high immediate and short-term survival, and lack of evidence of vertebral abnormalities.

North American Journal of Aquaculture

Volume 70, Issue 4, 2008; pages 415-424

Use of Electroshock for Euthanizing and Immobilizing Adult Spring Chinook Salmon in a Hatchery

Gayle Barbin Zydlewski, William Gale, John Holmes, Jeffrey Johnson, Troy Brigham & William Thorson

Abstract

This study evaluated the use of electroshock as an alternative to traditional techniques for immobilizing and euthanizing hatchery fish. We used a commercially available electroanesthesia unit at the U.S. Fish and Wildlife Service's Carson National Fish Hatchery (Carson, Washington) to euthanize adult spring Chinook salmon *Oncorhynchus tshawytscha* and to sort and collect gametes of fish at maturation. During euthanization by electroshock, the response of each fish was observed, muscular and vertebral hemorrhaging was quantified, and electrical settings were optimized accordingly. During gamete collection, fish were either electroshocked or exposed to tricaine methanesulfonate (MS-222); hemorrhaging, egg viability, egg size and quantity, and resultant fry quality were examined for each treatment group. Electroshocked fish had a higher likelihood of injury during gamete collection than did fish exposed to MS-222. On average, each electroshocked fish had less than two hemorrhages on both fillets examined. The size of each hemorrhage was less than 0.10% of the fillet surface. Fecundity and egg and fry quality were not affected by either immobilization method. Electroshock was a viable and efficient means of euthanizing adult spring Chinook salmon or sorting the fish and collecting their gametes. However, equipment settings must be optimized based on site-specific (e.g., water conductivity) and species-specific (e.g., fish size and seasonal state of maturation) factors.

Attachment 2

Electronarcosis Standard Operations and Procedures

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

Electro-Narcosis

Standard Operations and Procedures

11/05/2012

Background

Fisheries professionals are in need of an approved immediate release sedative for fisheries research and management activities as a viable alternative to chemical anesthesia (MS-222 or CO^2) or the stressful practice of V-trough handling without anesthesia. Although the use of electrical sedation in fisheries research and at hatcheries is not new, recent advancements in technology have improved the safety of and reduced the negative effects by utilizing low-voltage electronic units capable of inducing lower voltage approaches termed electro-narcosis (EN). Although no method of handling can be completely benign, the results from multiple studies (WDFW 2012) clearly show a method for handling fish in an effective, time efficient and reasonably benign way. In short, we believe that EN now represents a viable alternative to chemical anesthesia (MS-222 or CO^2) or the stressful practice of V-trough handling without anesthesia for research and hatchery operations.

EN Container Set-Up

1) Use a plastic tub, trough, cooler, etc… (Whatever fits your sampling needs at the site)
2) Use solid or screened plate aluminum for each electrode end.
3) Secure plate at the appropriate distance to maximize the effectiveness (V/cm) of the EN in your container of choice. [For Example: electrodes placed 90 cm apart works effectively on steelhead ranging from 50-80 cm in length.]
4) As needed, clean electrode plates with steel wool or wire brush to maintain maximum effectiveness of the EN.
5) Cover each electrode plate with netting or plastic mesh to prevent fish from coming in direct contact with electrode ends.
6) Secure wire leads at plates and at power source as needed to maintain desired effect.
7) Turn on EN power source unit. Turn voltage and amperage settings to maximum if using a 60V/3amp unit. Voltage of individual power units may vary. WDFW recommends that voltage units that go higher than 60V should be tested on the species of interest and dialed down to effective settings to reduce any negative effects that could occur at higher voltage settings.

Fish Sampling

1) Net the fish. If possible, try to put the head towards the positive electrode.
2) Let the fish settle for a few seconds (5-10) before sampling.

3) For best results, keep the fish mostly covered in water if possible. As more of the body is removed from the electrical field, the fish will react and make sampling harder.

4) Begin sampling you fish as needed.

5) Watch the gills while sampling occurs, especially if sampling takes more than a few minutes. If gill action ceases, remove the fish and fully revive. Put fish back in EN tank as before and continue sampling.

6) Release fish. If EN time is short, fish will generally fully recover immediately.

Safety Precautions

1) Ensure that electrical outlets are GFCI protected

2) As an added precaution, and if using an extension cord to the EN power unit, add an additional GFCI protected pigtail in line before the EN power unit.

3) All staff in immediate sampling area need to be made aware when the EN unit and sampling tank are in operation.

4) All staff in the sampling area should wear rubber boots or neoprene waders with rubber boots for shock protection.

5) All staff in sampling area that are likely to come in contact with the EN tank should have at least one rubber gloved hand for shock protection.