Redfish Lake Sockeye Salmon Captive Breedstock Rearing and Research

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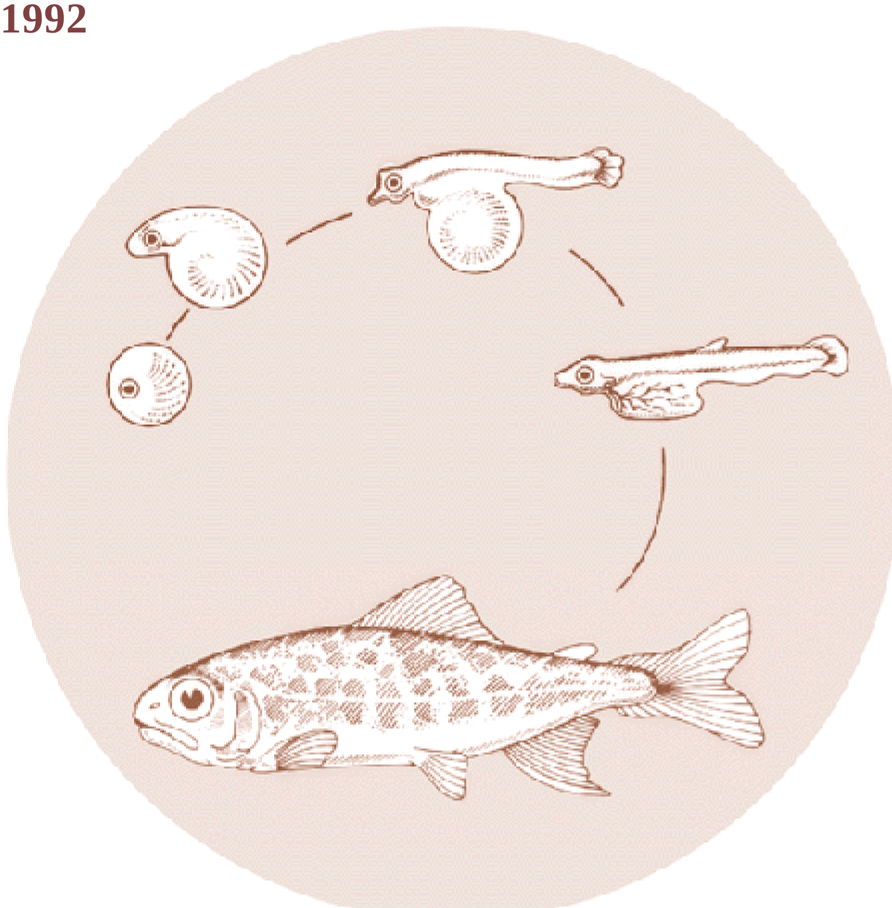

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Bonneville Power Administration
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Portland, Oregon 97208

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REDFISH LAKE SOCKEYE SALMON CAPTIVE BROODSTOCK REARING AND RESEARCH

ANNUAL REPORT 1992

Prepared by:

Thomas A Flagg

Coastal Zone and Estuarine Studies Division
Northwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97283-3621

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INTRODUCTION

This report summarizes fish culture and research activities conducted from December 1991 to October 1992 by the National Marine Fisheries Service (NMFS) on the Redfish Lake (Idaho) sockeye salmon captive broodstock study. In April 1991, the Bonneville Power Administration (BPA) initiated and funded restoration efforts for Redfish Lake sockeye salmon. Snake River sockeye salmon, now represented only by the REdfish Lake population, were formally listed as endangered under the Endangered Species Act (ESA) by the NMFS in December 1991. Restoration is being coordinated through the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC) and includes participation by state and federal agencies and private groups involved in sockeye salmon restoration efforts in Idaho.

The NMFS Northwest Fisheries Science Center (NWFSC) became actively involved in BPA's Snake River sockeye salmon restoration efforts in October 1991, and began formal cooperative work on the project in December 1991. Our efforts since then have focused on rearing of 1991-brood Redfish Lake sockeye salmon at the NMFS/BPA Stock Restoration Laboratory (SRL) at the NWFSC (Seattle, Washington), and on research to refine captive-broodstock methodology. In addition, Dr. Robin Waples or Thomas Flagg have represented NMFS at all monthly SBSTOC meetings since October 1991 and have visited Idaho Department of Fish and Game (IDFG) fish-culture and fish-trapping operations for Redfish Lake sockeye salmon.

REDFISH LAKE SOCKEYE SALMON CULTURE

Four adult sockeye salmon (three males and a female) returned to Redfish Lake in 1991 and were spawned in late October at the Sawtooth National Fish Hatchery (Stanley, Idaho) by IDFG personnel. Five mating crosses were created from this spawning (Table 1). NMFS recommendations for disposition of progeny of this female included maintaining two geographically separate captive-brood populations to reduce the risk of catastrophic loss of this gene pool due to mechanical failure, human error, or disease. On 3 December 1991, one-half the progeny of these fish were transferred to the SRL for rearing to maturity. The SRL conforms to isolation and quarantine standards and is supplied with pathogen-free water processed through a series of dechlorinators and chillers to ensure quality. IDFG was issued Washington State Department of Fisheries (WDF) Fish Transfer Permit 1275-11-91 to move these fish from Idaho to the SRL. Remaining progeny are in the custody of IDFG at the Eagle Fish Health Laboratory near Boise, Idaho.

NMFS is coordinating the Redfish Lake captive broodstock project with BPA, IDFG, SBSTOC, and others. NMFS has applied for a Federal (ESA Section 10) Scientific Research Permit for the captive rearing of Redfish Lake sockeye salmon.

Progeny from all five mating crosses of 1991-brood Redfish Lake sockeye salmon were incubated as separate groups at the SRL. The eggs accumulated a total of 365 ("C) temperature units at the Sawtooth Hatchery prior to transfer to the SRL. Records from the

Table 1.--Inventory of adult Redfish Lake sockeye salmon spawn at Sawtooth National Fish Hatchery (Idaho), 1991.

Mating cross[a]	Total eggs	Dead eggs	Fertility (%)	Eggs transferred NMFS	Eggs transferred IDFG
1.	220	0	100.0	110	110
2.	240	5	97.9	117	118
3.	235	8	97.6	109	118
4.	185	16	91.3	84	89
5.	1,297	170	86.9	560	563
Total	2,177	199		980[b]	998
Average			90.9%		

a Mating crosses: males A, B, and C were individually spawned with a portion of the eggs from the single female (groups l-3); a pool of sperm from males A, B, and C was used to fertilize another portion of the eggs (group 4); and the female spawned volitionally with an unknown combination of males A, B, and C (group 5).

b Subsequent counts indicated that 991 eggs were transferred to NMFS.

Sawtooth Hatchery indicated that a total of 980 eggs were transferred to the SRL (Table 1). Subsequent counts at the SRL revealed that the actual number was 991 eggs (Appendix A). The eggs hatched at the SRL on 4-5 January at 654 (°C) temperature units. A total of 13 blank and/or dead eggs were removed during incubation at the SRL; 978 eggs (98.7%) were hatched.

It is generally accepted that with current captive culture techniques, smolt-to-adult survival of sockeye salmon in seawater is often poor. Therefore, NMFS has established a full-term freshwater broodstock rearing project (similar to IDFG's) for Redfish Lake sockeye salmon. NMFS is providing 7-day-a-week staffing for protective culture of Redfish Lake sockeye salmon; electronic security and facilities monitoring are provided at all times. Water quantity and quality are monitored by a computerized system. The fish are reared using standard fish-culture practices and approved therapeutics and are fed Biodiet[1], a commercial ration. Mortalities are examined by a fish pathologist to determine cause of death. Selected mortalities are frozen or preserved as appropriate for genetic or other analyses. Specimens not vital to analysis or restoration will be incinerated or buried.

The 1991-brood Redfish Lake sockeye salmon were ponded at the SRL on 13 February at 965 (°C) temperature units. Progeny from the five mating-crosses of 1991-brood Redfish Lake sockeye salmon are maintained as separate groups at the SRL. At swim-up,

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1 Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

fry were moved from the incubators to 1.2-m diameter tanks. Initial fish density in tanks was established at under 2 kg/m^3 (0.1 lbs/ft^3); densities will be maintained below 8 kg/m^3 (0.5 lbs/ft^3) during rearing. In May, the 1991-brood sockeye salmon groups were fed a medicated diet containing 11% erythromycin at 2% of body weight/day for about 2 weeks. This treatment will be repeated at least twice yearly as a prophylactic for potential bacterial kidney disease (BKD)>

On 2 June, study fish groups 1 to 4 were each divided into two 1.2-m diameter tanks (8 tanks total), while study fish group 5 was divided into five 1.2-m diameter tanks. Survival of the groups during the first 9 months of rearing (from January to October) ranged from 86.9 to 95.7% and averaged 94.2%. All fish appeared healthy; their overall average weight was 20.8 g. At the end of the reporting period, NMFS had 921 1991-brood Redfish Lake sockeye salmon in protective culture at the SRL. Inventory information for 1991-brood Redfish Lake sockeye salmon is detailed in Appendix A.

Although the SRL is ideal for the early rearing of Redfish Lake sockeye salmon, it lacks adequate space to rear these fish beyond juvenile size. Therefore, in spring 1993, we plan to move juvenile Redfish Lake sockeye salmon to our freshwater rearing facility at Big Beef Creek (BBC). The NMFS fish-culture facilities at BBC will be available for the Redfish Lake sockeye salmon captive-broodstock program. The facility has si:: 2.6-m and six 3.9-m circular tanks supplied with about 450 gpm of 10°C pathogen-free well water. NMFS is proceeding with the planned upgrade of the freshwater fish-holding facilities at BBC outlined in our initial proposal; these include a building and a chain-link enclosure around the fish-rearing area to provide enhanced security.

The 1991-brood Redfish Lake sockeye salmon will be reared to maturity at NWFSC laboratories. Spawn will be used for appropriate restoration efforts.

CAPTIVE BROODSTOCK RESEARCH

Exacting fish culture methods must be developed to ensure that offspring of captive broodstock have the same genetic, physiological, and behavioral make-up as their wild cohorts. It would seem prudent for captive culture to mirror the natural life-cycle of the fish. Whenever this is not possible, potential effects of captivity on the broodstock and their offspring must be investigated.

Although full-term freshwater rearing may enhance survival, and seems the correct choice for Redfish Lake sockeye salmon captive broodstock, there are numerous unanswered questions regarding the role of seawater residence in overall fitness. In the long run, it may be advantageous to develop effective seawater culture systems for captive broodstock rather than to alter normal fish life-cycles through full-term freshwater rearing.

We believe many husbandry problems in seawater may be related to culture in net-pens exposed to near-surface environmental conditions. Several factors critical to survival are more variable at the surface than in the deeper marine waters preferred by most salmonids; these include water temperature, water quality, and occurrence of toxic plankton blooms. In addition, fish held in net-pens are vulnerable to predation from marine mammals and birds and to obliteration from catastrophe. However, land-based facilities with pumped seawater and environmental control (e.g., filtration, flow, and aeration) may provide the quality environment necessary for protective culture of salmonids in seawater.

We have initiated studies to compare sockeye salmon reared with and without a period in seawater. These studies are being conducted with Lake Wenatchee sockeye salmon so as not to jeopardize the Redfish Lake sockeye salmon gene pool.

In late spring 1992, NWFSC staff began tests to compare fish reared to maturity in freshwater with fish reared in conventional seawater net-pens and in land-based seawater tanks. Pumped and filtered seawater facilities have been temporarily constructed for the seawater portion of these experiments at the NMFS Manchester Marine Experimental Station. The freshwater phases of these experiments are being conducted at BBC. NMFS is proceeding with construction of a permanent land-based seawater laboratory for captive-broodstock research at Manchester.

About 3,000 1990-brood Lake Wenatchee (yearling) sockeye salmon were donated to this study from the BPA-funded Cle Elum Lake study (Project 86-45). Experimental groups were established for the 1990 brood in mid May 1992. Three replicates of about 300 fish each were set up in the following conditions:

1) circular tanks supplied with freshwater at BBC; 2) seawater net-pens at Manchester; and 3) circular tanks supplied with pumped, filtered, and W-sterilized seawater at Manchester. All fish were injected with bivalent vibrio vaccine (0.15 cc/fish) and erythromycin (50 mg/kg of body weight) prior to transfer and again at the end of June.

Survival of 1990-brood Lake Wenatchee sockeye salmon during the first 5 months of the experiment (from May to October) averaged 70.2% in the freshwater tanks, 53.2% in the seawater tanks, and 52.2% in the seawater net-pens. Inventory information for these groups is detailed in Appendix B. Most mortalities appear related to BKD.

In spring 1992, we also began an experiment to evaluate the performance of progeny of sockeye salmon held full-term to maturity in fresh water vs progeny of sockeye salmon parents with a period of seawater residence. Eggs from a fall 1991 spawning of a freshwater-cultured adult Lake Wenatchee sockeye salmon were donated from BPA Project 86-45.

One 1987-brood Lake Wenatchee female that was held full-term to maturity in fresh water spawned in 1991 at the SRL; the fish was 340 mm in length and contained 959 eggs. Progeny from this fish hatched in early January and were ponded at the SRL in early February 1992; survival to hatch (viability) was 65.7%. It is impossible to determine if the low viability was the result of full-term freshwater culture or other influences. Survival of the 1991 freshwater-cultured brood during the first 9 months of rearing (from early January through September) was about 90%; we have about 550 of these fish at the SRL.

About 550 juveniles from the fall 1991 spawning of wild Lake Wenatchee adult sockeye salmon will be donated from BPA Project 86-45 in January 1993. In 1993, we plan to rear both cultured and wild 1991-brood Lake Wenatchee sockeye salmon to yearling smolt-stage at the SRL. Fish culture strategies through smoltification will be similar to those outlined for Redfish Lake juveniles. Studies will evaluate fish husbandry techniques through comparisons of growth and survival, including evaluation of fish health and investigation of somatic and smoltification physiology in fresh water. At smoltification in spring 1993, the fish will be transferred to seawater net-pens at Manchester, and growth and survival between cultured and wild broods will be compared.

EXPECTED RESULTS

Maintaining geographically separate captive-brood populations will help reduce the risk of catastrophic loss of the Redfish Lake sockeye salmon gene pool. Spawn from these captive broodstock programs will aid recovery efforts for the Snake River sockeye salmon.

At the current stage of captive broodstock technology, full-term freshwater rearing is the method of choice to provide the highest possible survival for Redfish Lake sockeye salmon. However, there are many unanswered questions regarding how imposed full-term freshwater residency will affect the fish and their offspring. Research using Lake Wenatchee sockeye salmon will help answer questions regarding the effects of various captive rearing scenarios and the role of parental seawater residence in the overall fitness of offspring. This research will aid in refining captive-broodstock technology for application to the recovery of threatened and endangered salmonids. Perhaps most importantly, research using Lake Wenatchee sockeye salmon will allow selected fish-culture strategies to be evaluated prior to implementation with Redfish Lake stock, thus providing maximum safeguards for the maintenance of the Snake River sockeye salmon.

Appendix A.--Monthly inventory records for 1991-brood Redfish Lake sockeye salmon at NMFS, NWFSC, 1992.

A. Number of fish

Mating cross[a]	Eggs received	Blank/ dead eggs	Fish hatched	Jan mort	Fish ponded (13 Feb)	Feb mort	Fish 1 Mar	Mar mort	Fish 1 Apr	Apr mort
1.	107	0	107	0	107	0	107	4	103	4
2.	119	2	117	3	114	0	114	0	114	0
3.	103	2	101	2	99	0	99	1	98	0
4.	83	2	81	0	81	0	81	5	76	0
5.	579	7	572	6	566	6	560	3	557	2
Total	991	13	978	11	967	6	961	13	948	6

Mating cross[a]	Fish 1 May	May mort	Fish 1 Jun	Jun mort	Fish 1 Jul	Jul mort	Fish 1 Aug	Aug mort	Fish 1 Sep	Sep mort	Fish 1 Oct
1.	99	0	99	0	99	4	95	1	94	1	93
2.	114	2	112	0	112	0	112	0	112	0	112
3.	98	2	96	0	96	0	96	1	95	0	95
4.	76	0	76	0	76	0	76	0	76	0	76
5.	555	2	553	0	553	3	550	3	547	2	545
Total	942	6	936	0	936	7	929	5	924	3	921

Appendix A.--Monthly inventory records for 1991-brood Redfish Lake sockeye salmon at NMFS, NWFSC, 1992 (continued).

B. Survival from hatch (%)

	Mating cross'					
	1	2	3	4	5	Cumulative
13 Feb (ponded)	100.0	97.4	98.0	100.0	99.0	98.9
1 Mar	100.0	97.4	98.0	100.0	97.9	98.3
1 Apr	96.3	97.4	97.0	93.8	97.4	96.9
1 May	92.5	97.4	97.0	93.8	97.0	96.3
1 Jun	92.5	95.7	95.0	93.8	96.7	95.7
1 Jul	92.5	95.7	95.0	93.8	96.7	95.7
1 Aug	88.8	95.7	95.0	93.8	96.2	95.0
1 Sep	87.9	95.7	94.1	93.8	95.6	94.5
1 Oct	86.9	95.7	94.1	93.8	95.3	94.2

Appendix A.--Monthly inventory records for 1991-brood Redfish Lake sockeye salmon at NMFS, NWFSC, 1992 (continued).

C. Weight (g)

Mating cross[a]	Date: Ponded 13 Feb	22 Apr	2 Jun	29 Jun	29 Jul	27 Aug	30 Sep
1.	0.12	1.09	3.00	6.60	8.95	14.10	19.80
2.	0.12	1.13	3.45	6.10	9.40	13.10	19.20
3.	0.13	1.28	3.80	7.10	10.65	16.70	23.90
4.	0.12	1.35	3.85	7.30	10.75	17.00	23.90
5.	0.11	1.00	2.70	5.30	8.18	12.40	17.10
Average	0.12	1.17	3.36	6.48	9.59	14.66	20.78

[a] Mating crosses: males A, B, and C were individually spawned with a portion of the eggs from the single female (groups l-3); a pool of sperm from males A, B, and C was used to fertilize another portion of the eggs (group 4); and the female spawned volitionally with an unknown combination of males A, B, and C (group 5).

Appendix B. --Monthly inventory records for 1990-brood Lake Wenatchee sockeye salmon at NMFS< NWFSC, 1992.

A. Number of fish

Treatment/ replicate	Starting n	May mort	Fish 1 Jun	Jun mort	Fish 1 Jul	Jul mort	Fish 1 Aug	Aug mort	Fish 1 Sep	Sep mort	Fish 1 Oct
Freshwater tanks"											
1.	291	5	286	23	263	28	235	15	220	18	202
2.	291	5	286	31	255	24	231	12	219	22	197
3.	289	1	288	26	262	18	244	12	232	20	212
Total	871	11	860	80	780	70	710	39	671	60	611
Seawater tanks"											
1.		5	255	63	192	21	171	12	159	9	150
2.	260 260	10	250	69	181	23	158	23	135	7	128
3.	262	13	249	58	191	27	163	18	145	7	138
Total	782	28	754	190	564	71	492	53	439	23	416
Seawater net-pens'											
1.	252	12	240	54	186	22	164	14	150	4	146
2.	258	13	245	55	190	25	165	26	139	8	131
3.	265	14	251	65	186	23	163	24	139	12	127
Total	775	39	736	174	562	70	492	64	428	24	404

Appendix B.--Monthly inventory records for 1990-brood Lake Wenatchee sockeye salmon at NMFS, NWFSC, 1992 (continued).

B. Survival

Treatment/ replicate	Starting n	Survival (%) 1 Jun	1 Jul	1 Aug	1 Sep	1 Oct
Freshwater tanks'						
1.	291	98.3	90.4	80.8	75.6	69.4
2.	291	98.3	87.6	79.4	75.3	67.7
3.	289	99.7	90.7	84.4	80.3	73.4
Average		99.8	89.6	81.5	77.1	70.2
sd		0.8	1.7	2.6	2.8	2.9
Seawater tanks'						
1.	260	98.1	73.8	65.8	61.2	57.7
2.	260	96.2	69.6	60.8	51.9	49.2
3.	262	95.0	72.9	62.2	55.3	52.7
Average		96.4	72.0	62.9	56.1	53.2
sd		1.6	2.2	2.6	4.7	4.3
Seawater net-pens'						
1.	252	95.2	73.8	65.1	59.5	57.9
2.	258	95.0	73.6	64.0	53.9	50.8
3.	265	94.7	70.2	65.1	52.5	47.9
Average		95.0	72.5	64.7	56.7	52.2
sd		0.3	2.0	0.6	4.0	5.1

Appendix B.--Monthly inventory records for 1990-brood Lake Wenatchee sockeye salmon at NMF'S, NWFSC, 1992 (continued).

C. **Weight**[b]

Treatment/ replicate	Averaae weiaht (q)	
	Starting	1 Aug
Freshwater tanks'		
1.	32.7	102.1
2.	34.3	103.5
3.	32.9	106.0
Average	33.3	103.9
Seawater tanks'		
1.	31.2	87.2
2.	31.3	91.2
3.	30.2	88.0
Average	30.9	88.6
Seawater net-pens'		
1.	30.2	75.2
2.	31.5	79.4
3.	30.0	76.5
Average	30.6	77.1

a Freshwater replicates established at Big Beef Creek on 18 May; seawater replicates established at Manchester Marine Experimental Station on 26 May.
b Quarterly subsample