WILD FISH TRAPS IN UTAH:

A REVIEW OF THEIR HISTORY, MANAGEMENT, AND FISH PRODUCTION

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Kokanee salmon at Strawberry River trap (photo by Alan Ward)

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Introduction

In Utah, as in many states, fish in the wild have been trapped or captured by various means to obtain gametes to augment fish populations. Fertilized eggs have been transported to rearing hatcheries to improve survival over that in the wild. The purpose of obtaining wild fish is to minimize natural selection for variables related to hatchery rearing and maximize natural selection for traits that improve survival in the wild. Wild brood stocks also reduce annual maintenance costs relative to brood stocks kept in hatcheries.

Cutthroat trout (*Oncorhynchus clarkii*) management is especially dependent on wild stocks to augment existing stocks and to re-colonize waters where cutthroat trout have been extirpated or hybridized with rainbow trout. The Utah Division of Wildlife Resources (UDWR) currently utilizes wild brood for several sub-species and sub-populations of cutthroat trout. One sub-species, the Colorado River cutthroat trout (*O. clarkii pleuriticus*), is endemic to the headwaters of the Colorado River drainage. Currently four different wild brood stocks of this sub-species are being managed: one for the south-slope Uinta Mountain area (Duck Fork Reservoir and Sheep Creek Lake traps), one for the North Tavaputs Plateau (Lake Canyon Trap), one for the Boulder Mountain drainages (Dougherty Basin and Kolob Reservoir traps), and a fourth is still being developed for North-Slope Uinta Mountains stocking. Additional sites (Bear Lake; Mountain Dell, Little Dell, and Manning Meadow reservoirs) are managed for the subspecies *O. clarkii Utah,* which is split into two broad groupings. These are the Bear Lake cutthroat trout, which are primarily a lacustrine (lake-adapted) strain, and the Bonneville cutthroat trout, which are endemic to streams within the Great Basin. Using the 'nearest neighbor' principle of genetics, the closest genetically pure source population is used for repatriation programs to ensure preservation of attributes contributing to survival in that region. Using wild brood for the groups described above, the DWR is using their progeny to re-colonize historical habitat and preventing the sub-species from becoming threatened or endangered. Other management objectives of wild cutthroat trout brood program include 1) replacement of non-native cutthroat trout strains, 2) replacement of stunted brook trout populations to improve sport fishing, 3) maintain a source of fish for research on native trout, and 4) increase sport fish opportunities for cutthroat trout (Ottenbacher et al. 2009).

One objective of this review is to present the history and management of the UDWR's wild trap operations, documenting the locations, species, key personnel, methods used at each wild trap site, fish production and fish health data, and the successes and shortcomings of the program to date. The emphasis is on cutthroat trout and kokanee, but the review includes data on other species too. A second objective was to analyze factors potentially affecting cutthroat trout egg survival and to compare methods used at each trap. The data summarized in this review has been collected by a large number of individuals scattered throughout the state and through time. Management of the wild traps and collection of gametes from the wild takes an enormous collective effort, often under adverse conditions, that combines the skills of fisheries managers, fish culturists, and fish health specialists. We wish to recognize their efforts and that the data herein are the result of their work, not that of the authors.

Bear Lake Traps

Bear Lake cutthroat trout

Oncorhynchus clarkii Utah

Managers. — Bear Lake special project personnel (Northern Region UDWR); Mantua Hatchery

Location.— Bear Lake is located in Northern Utah along the border between Utah and Idaho. The lake can be accessed from Logan by traveling east on U.S. Highway 89 for 63 km. From Montpelier, Idaho, one can travel 30 km south of U.S. Highway 89. From Kemmerer, Wyoming, the lake can be accessed by taking U.S. Highway 30 and Utah Highway 30 for 72 km. The lake sits at an elevation of 1,805 m and has a surface area of 28,230 ha. The maximum depth of Bear Lake is 63 m with an average depth of 28.4 m. It is a relatively long (29.5 km), narrow (11.3 km) lake. It is classified as oligotrophic (Judd 1997) with summer surface temperatures that reach 19°C.

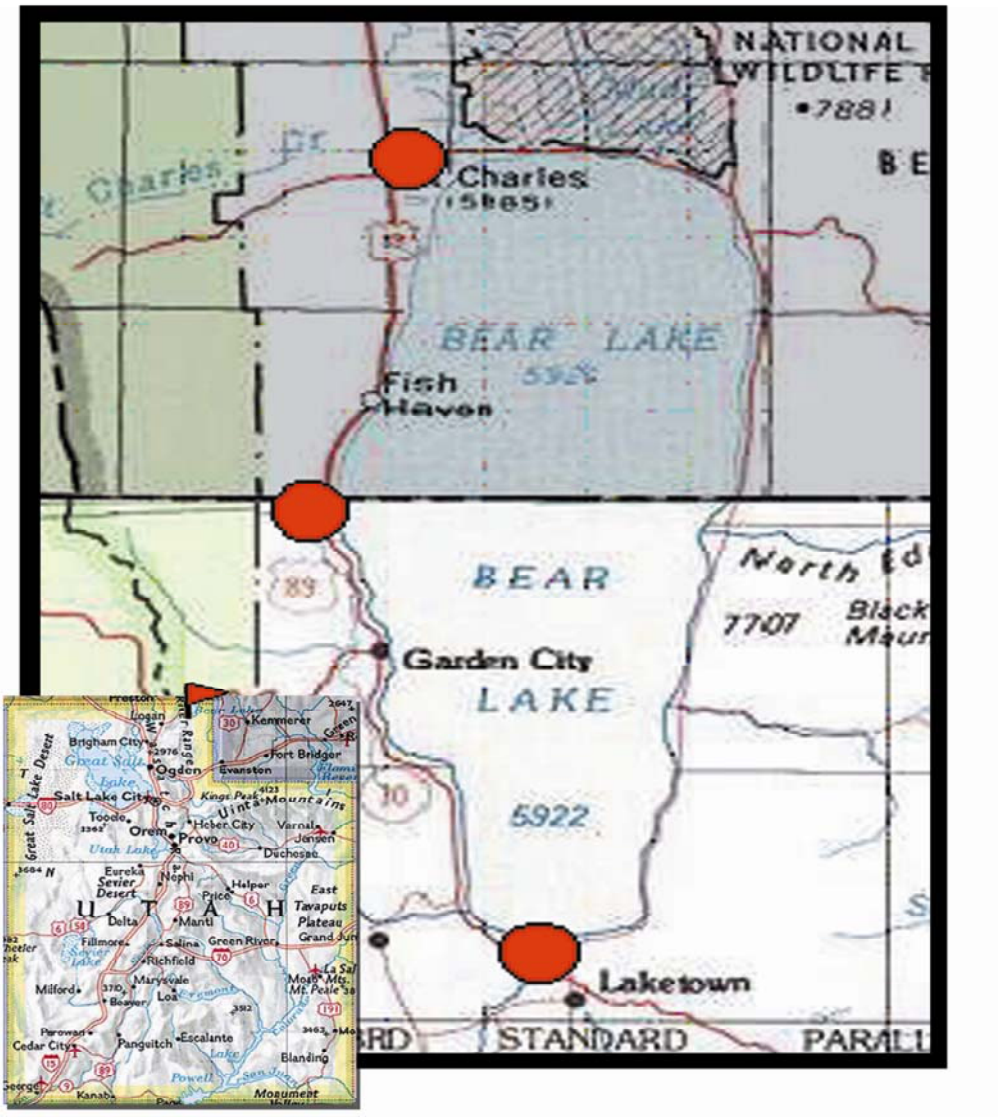

Figure 1. Location of current and historic Bear Lake wild traps (red dots).

History.— Historically, three traps have been operated at Bear Lake. The primary trap was established on Swan Creek. This trap has been operated annually since 1973 (UDWR 1974) but has operated in other years going back to 1939 (Nielsen and Birdsey 1991). Originally this trap was covered by a metal framework and tarp. In 1978, a wooden building was constructed over the holding pens. Power was installed into this building in 1981. This trap site is used today and few changes have been made in the operation of the trap through its history. The trap consists of a rectangular concrete footprint. A portion of the water from Swan Creek is directed through the building. There are eight cages that are used for sorting fish that sit along two walls of the building (four cages on each side). The cages are formed by the installation of metal bars (reminiscent of prison bars). The main flow travels through the center of the building. Fish are collected in this main flow area at least daily and are sorted by sex into the cages. Stop logs (i.e. 2"x6" boards are used to manually open and close the trap and to regulate the depth of the water within the trap. The current trap sits approximately 30 m upstream from the site of a temporary trap that was operated intermittingly from 1939-1953. From 1987-2000, a morpholine drip was used to imprint cutthroat trout to return to the trap site for spawning. No success in this technique was ever documented and health concerns over handling morpholine, both at the trap and in the in the hatcheries, were reasons for discontinuing this imprinting technique.

The Idaho Department of Fish and Game operated a temporary weir and trap on St. Charles Creek from 1975-1991 (Nielson and Birdsey 1991; S. Tolentino, personal communication). Another temporary weir and trap was installed at Big Spring Creek in 1987. Due to poor egg yield caused by lower lake levels making fish access to the trap impossible, this trap was discontinued after 1989. Fish collected in both the St. Charles and Big Spring Creek traps were transported by a fish hauling truck to the Swan Creek Trap where they were spawned. Thus, similar spawning procedures were carried out for each trap. Eggs from St. Charles and Big Spring Creek fish were collected on the same dates as the Swan Creek Trap. The eggs from all three traps were pooled into a single lot for incubation.

From 1976-2007, the majority of eggs from the Swan Creek trap were incubated at the Mantua State Fish Hatchery (UDWR). Since 2008, these eggs have been transported to the Fountain Green Hatchery, incubated in the isolation station there, and distributed to other hatcheries after eye-up. A small portion of eggs each year are earmarked as replacement fish for the captive Bear Lake cutthroat trout brood program. Since 1994, this captive brood program has been housed at the Mantua Hatchery. Prior to that, it was operated at the Egan Hatchery. Specific data on this captive brood program is not provided in this report. Historically, the Bear Lake cutthroat trout have been raised at the Fisheries Experiment Station, Kamas, Midway, Whiterocks, Glenwood, and Fountain Green Hatcheries.

Methods.— Typically, all three traps are installed in the middle of April prior to the run and are operated until the run ends (typically about the end of June). The Swan Creek trap is checked at least once daily and collected fish are sorted into cages by sex. Egg collection by manually spawning fish occurs approximately once a week during the peak of the spawning run. The St. Charles and Big Spring Creek traps were checked less frequently. Still, the fish collected at these traps were transported to the Swan Creek trap approximately once a week for spawning. From the inception of the traps through 1991, only the largest fish (regardless of source; Swan Creek, St. Charles, or Big Spring) were spawned. Fish that appeared to share characteristics with Yellowstone cutthroat trout were also not spawned. From 1992 to

present, all suspected cutthroat trout have been spawned regardless of size. The only fish that were not spawned were individuals that appeared to show introgression with rainbow trout. Periodic genetic tests have shown the majority of cutthroat trout in Bear Lake are purebred Bear Lake cutthroat (>97%; S. Tolentino, personal communication). Eggs are stripped from the females onto a knotless, mesh netting over a bowl. Once eggs from five females are collected they are placed in a dry bucket, sperm from five males is then collected in a separate container. Once the eggs and sperm are collected, the sperm is added to the eggs and a 0.5% sodium chloride diluent is added. The egg-sperm-salt-water mixture is allowed to stand for approximately 3 minutes and then the eggs are washed with fresh hatchery water and transferred to a 38 L holding container with fresh hatchery water. A minimum of one hour after fertilization, the eggs are disinfected using a 100 mg/L iodine solution. After that, they are transported to a hatchery for incubation. Upon arrival at the receiving hatchery, the eggs from all three trap sites are combined into a single lot. Therefore, data on the numbers of males, females, and eggs are available for each individual trap site, but eye-up and hatch rates are only known for the combined egg lot. Prior to 2001, all trapped fish were collected and spawned. Beginning in 2001, fish were by-passed once the egg quota was met. Typically, the spawn lasts 6-7 weeks and eggs are collected during the first 5-6 weeks of the spawning run.

Data are collected and recorded during the trapping operations. The numbers and sizes of males and females captured in the traps are recorded annually. Similarly, the numbers and sizes of eggs collected are recorded. Data on the numbers of return spawners and spawners of hatchery origin have been collected from the entire run annually. Prior to 1992, data on the numbers of return spawners and spawners of hatchery origin may have been collected on sub samples or not recorded each year.

Fish Production Data.— The trapping program at Bear Lake has been very productive. Since 1973, over 15,000 fish have been collected and the total number of eggs produced by wild, Bear Lake fish exceeds 20 million. Considerable historical data from the Swan Creek (1973-2011; Table 1) and St. Charles Creek (1975-1991; Table 2) trap sites is available. Quadratic and linear regression analyses were performed to determine whether any trends exist in the data from each trap site (Figures 2 and 3). No changes in male or female length or egg size were detected across years at both trap sites (all $P \geq 0.13$). Similarly, the percentage of fish that were return spawners and the percentage of spawners that were of hatchery (vs. wild) origin did not vary across years at both trap sites (all $P \geq 0.18$). The total number (including non-spawned fish) of males and females collected at the Swan Creek trap increased significantly with time (both $P < 0.01$; Figure 3). This increase in the number of fish collected could be indicative of many factors including increases in cutthroat trout population size in Bear Lake or increased trapping efficiency. No increase in the number of males and females collected was found at the St. Charles Creek trap site (both $P \geq 0.14$; Figure 3). A significant increase in the percentage of eggs that eyed-up was found at the Swan Creek trap (estimated 0.23% increase annually; $F_{1,34} = 7.80$, $P < 0.01$). This increase in eye-up could be attributed to refinements in the egg collection process or increased staff experience.

Improvements in fish condition could also produce increased eye-up. Changes in fish condition were not assessed because historical fish weight data is not available. The average number of eggs produced by each female did not change with time ($F_{1,37} = 1.33$, $P = 0.23$; Figure 3). The total number of eggs collected at the Swan Creek trap did not change with time ($F_{1,37} =$, $P = 0.92$). Any change in total egg production

may be influenced by the fact that beginning in 2001, females were released un-spawned once the annual egg quota was met. Interestingly, the numbers of eggs produced by females collected in the St. Charles trap decreased with time (estimated decrease of 83 eggs/female each year; $F_{1,13} = 8.82$, $P = 0.01$; Figure 3).

Table 1. Numbers and sizes of female and male cutthroat trout spawned, numbers of return of spawners, percentage of spawners from hatchery origin, and basic egg data from the Swan Creek trap. Data collected from 1973-2011.

Year	# Female	# Males	Mean Female TL (mm)	Mean Male TL (mm)	Return Spawners (%)	Spawners from Hatchery Origin (%)	# Eggs	Eggs/ oz	Eye-up (%)	Eggs/ Female
1973	115	25			0		439,896			3,825
1974	141	246	447	422	0		357,845			2,538
1975	55	10	581	557	7.7		229,851	239		4,179
1976	58	31	538	548	7.9		191,914	278	83.2	3,309
1977	82	119	504	467	2.5		213,408	276	81.6	2,603
1978	212	185	533	554	1.3		647,300	265	72.2	3,053
1979	168	116	544	588	2.1		498,312	261	83.3	2,966
1980	60	39	537	534	21.2		197,532	225	85.3	3,292
1981	168	154	520	504	3.1	58	377,550	245	87.6	2,247
1982	72	88	536	553	3.8	47	158,383	233	83.4	2,200
1983	116	85	547	582	5	49	270,039	218	83.2	2,328
1984	147	85	563	573	8.2	44	422,547	206	74.6	2,874
1985	160	116	554	534	3.6	50	510,843	230	88.8	3,193
1986	118	40	520	499	3.8	78	271,135	226	87.7	2,298
1987	210	108	530	497	0.6	80	477,156	225	86.7	2,272
1988	183	151	529	513	0.6	76	423,246	212	87.8	2,313
1989	235	210	530	510	3.4	66	614,395	215	76.5	2,614
1990	235	210	530	486	2.9	60	1,000,711	216	88.4	4,258
1991	247	183	534	541	4.4	55	535,514	213	90.4	2,168
1992	93	56	513	535	10.1	58	171,194	232	92.1	1,841
1993	91	65	542	594	7.1	54	224,842	233	89.1	2,471
1994	75	99	465	439	5.7	49	140,352	245	87.9	1,871
1995	78	48	455	502	8.7	59	127,644	251	90	1,636
1996	120	147	443	416	1.9	64	166,922	245	88.9	1,391
1997	143	106	442	465	9.2	63	264,342	263	91.1	1,849
1998	75	62	481	497	18.2	52	142,080	245	93.2	1,894
1999	213	138	494	507	9.4	52	359,032	232	89.9	1,686
2000	167	164	513	513	13	32	345,747	215	91.8	2,070
2001	83	71	521	538	4.5	69	305,944	208	95.1	3,686
2002	103	84	535	574	2.2	88	355,456	217	79.3	3,451
2003	121	115	523	558	2.3	82	288,686	214	87	2,386
2004	145	132	503	547	2.3	71	242,832	219	92	1,675
2005	156	148	522	549	4.1	83	327,792	205	92.8	2,101

2006	137	131	527	538	6.5	76	293,279	214	89.4	2,141
2007	138	123	513	541	12.3	62	333,772	241	96.3	2,419
2008	129	102	536	576	5.4	71	372,636	247	79	2,889
2009	152	142	558	588	0	56	515,200	252	83	3,389
2010	125	53	547	571	0	68	536,741	249	92	4,294
2011	153	134	546	564	10.3	60	400,378	253	85	2,617
Mean	135	111	519.9	528.3	5.5	64.3	352,627	234.1	86.8	2623
SD	52	55	33.3	45.1	4.9	13.7	173,335	19.9	5.6	759

Sufficient data from the Swan Creek trap exists to permit analysis on inter-annual trends in spawning behavior. Figure 2 shows, averaged across years, the mean number of eggs collected on each date during the spawning season. A significant quadratic function ($F_{2,61} = 11.93$, $P < 0.01$, $r^2 = 0.29$; average number of eggs = (-52.84*Julian Date^2) + (15,864*Julian Date) - 1,101,832). The vertex of this function corresponds with May 30. The data is based on averages and logically, the peak spawn date shifts from year-to-year. Regardless, the regression shows that the peak spawn typically occurs around May 30 each year. The peak spawn date at the Swan Creek trap has not shifted significantly with time ($F_{1,34} = 2.17$, $P = 0.15$).

Table 2. Spawning dates, numbers of females and males collected, average female and male length, number of return spawners, the percentage of spawners that were of hatchery origin, and total number of eggs collected from the trap operated at St. Charles Creek.

Year	# Female	# Male	Average Female TL (mm)	Average Male TL (mm)	# Return Spawners	% Spawners from Hatchery Origin	# Eggs	Eggs/ Female
1975	253	99	613	623	0	0	975,093	3,854
1976	260	129	569	619	0	0	721,592	2,775
1977	85	67	541	504	5	3	264,201	3,108
1978	154	89	571	619	1	0	533,114	3,462
1979	144	98	570	623	5	2	443,124	3,077
1980	202	102	597	637	24	8	707,933	3,505
1981	81	62	594	588	22	15	292,986	3,617
1982	33	36	562	580	1	1	66,827	2,025
1983	105	70	558	605	2	1	215,843	2,056
1984	94	52	594	598	4	3	266,249	2,832
1985	113	60	544	562	1	1	321,297	2,843
1986	44	26	548	546	2	3	108,561	2,467
1987	160	73	552	566	1	0	339,887	2,124
1988	170	115	565	572	1	0	400,900	2,358
1989	141	107	563	564	17	7	377,222	2,675

The trap at Big Spring Creek was only operated for three years (1987-1989; Table 3). The number of fish collected in the trap and egg yield decreased with each successive trapping season. Due to the limited amount of data collected from this trap, no analyses were performed.

Table 3. Spawning dates, numbers of females and males collected, average female and male length, number of return spawners, and total number of eggs collected from the trap operated at Big Spring Creek.

Year	Spawn Start Date	Spawn End Date	# Females	# Males	# Immature	Average Female TL (mm)	Average Male TL (mm)	# Return Spawners	# Eggs
1987	4/24	6/17	76	37	1	564	568	0	207,488
1988	4/20	6/14	19	12	0	545	529	0	43,336
1989	4/24	6/15	3	3	0	508	607	0	9,094

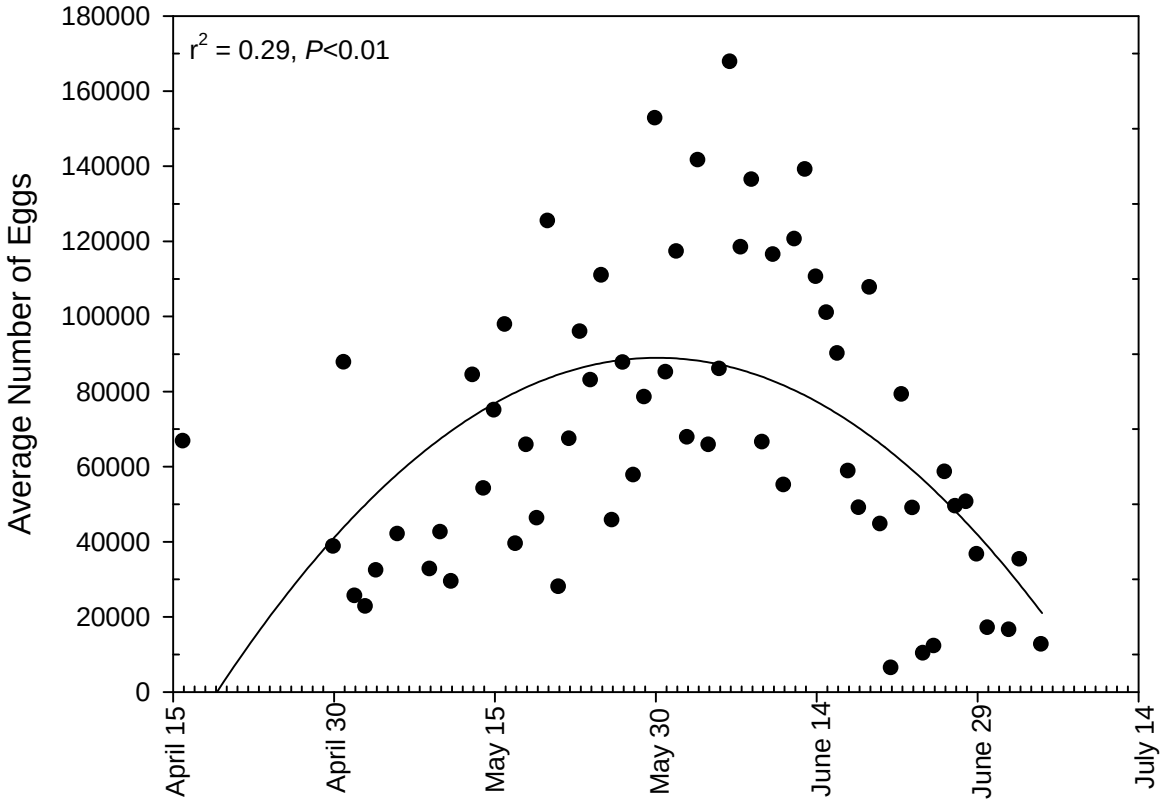

Figure 2. Average number of eggs collected from the Swan Creek trap during the spawning period. Data represents the average daily egg yield from 1973-2000.

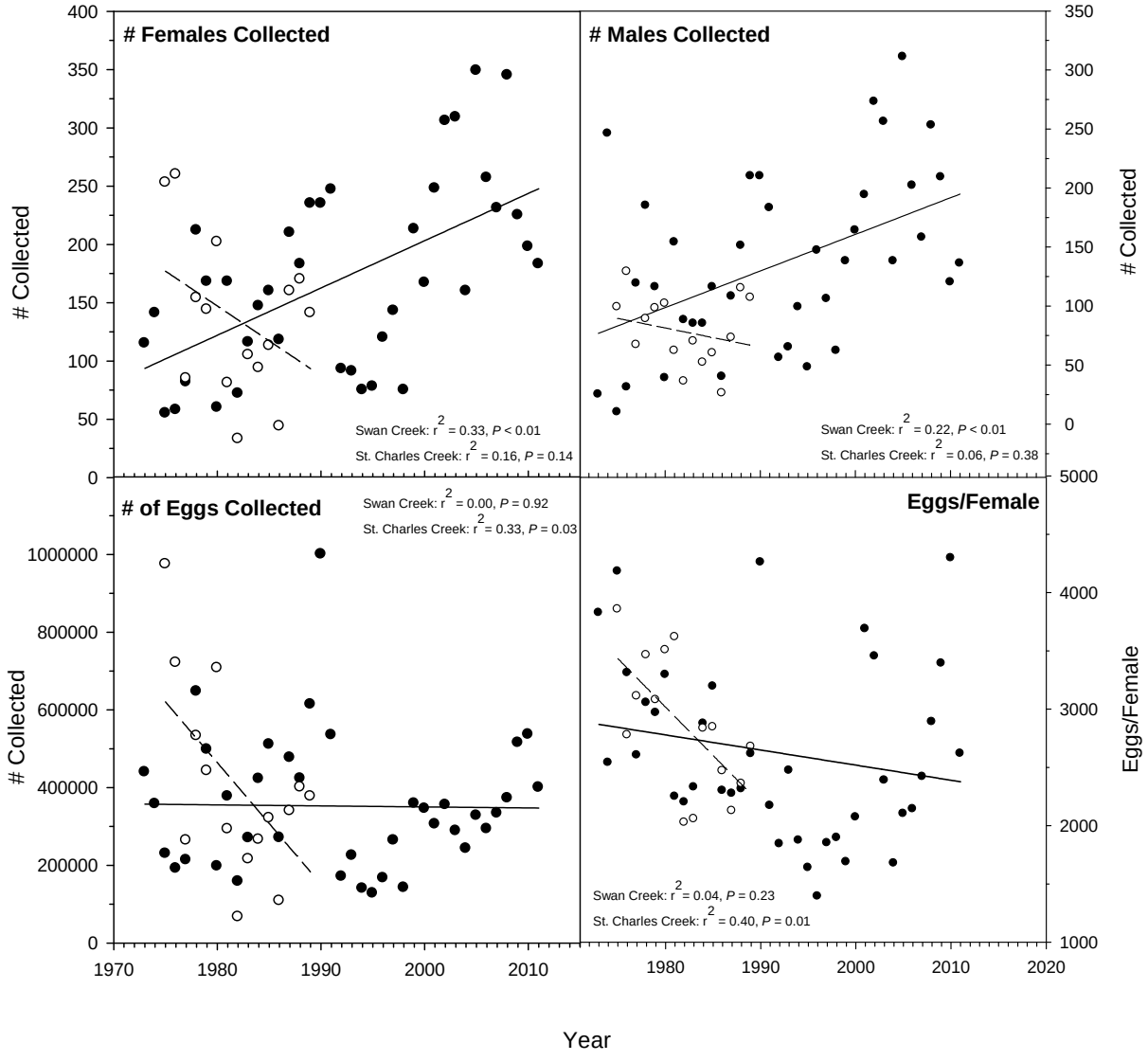

Figure 3. Total numbers of female (top left panel), male (top right panel), and eggs (bottom left panel) collected from the Swan Creek (closed circles) and St. Charles Creek (open circles) traps from 1973-2012. In addition, the average number of eggs collected from each female is shown (bottom right panel). Best-fit linear regression lines and regression statistics are shown for each trap (Swan Creek: solid lines, St. Charles Creek: dashed lines).

Dougherty Basin Lake Trap

Colorado River cutthroat trout

Oncorhynchus clarkii pleuriticus

Managers.— Southern Region UDWR; Egan and Loa hatcheries

Location.— Dougherty Basin Lake is located in the Boulder Mountains northwest of Escalante, Utah in the Dixie National Forest. It is at 2,963 m (9,720 ft) elevation and has a surface area of 1.5 ha. The lake is accessed by a 0.8 km (0.5 mi) trail that begins at Barker Reservoir, at the end of the North Creek Road. The lake inlet and outflow are about 0.4 km (0.25 mi) long, with the outflow going into Tall Four Lake (0.3 ha). The latter drains into a sinkhole, effectively isolating the lakes from other fish moving upstream. It is in the North Creek drainage, which feeds into the Escalante River in the Colorado River drainage. Tall Four Lake has been noted to winterkill and entire populations there have failed due to low water levels (Hepworth et al. 2004).

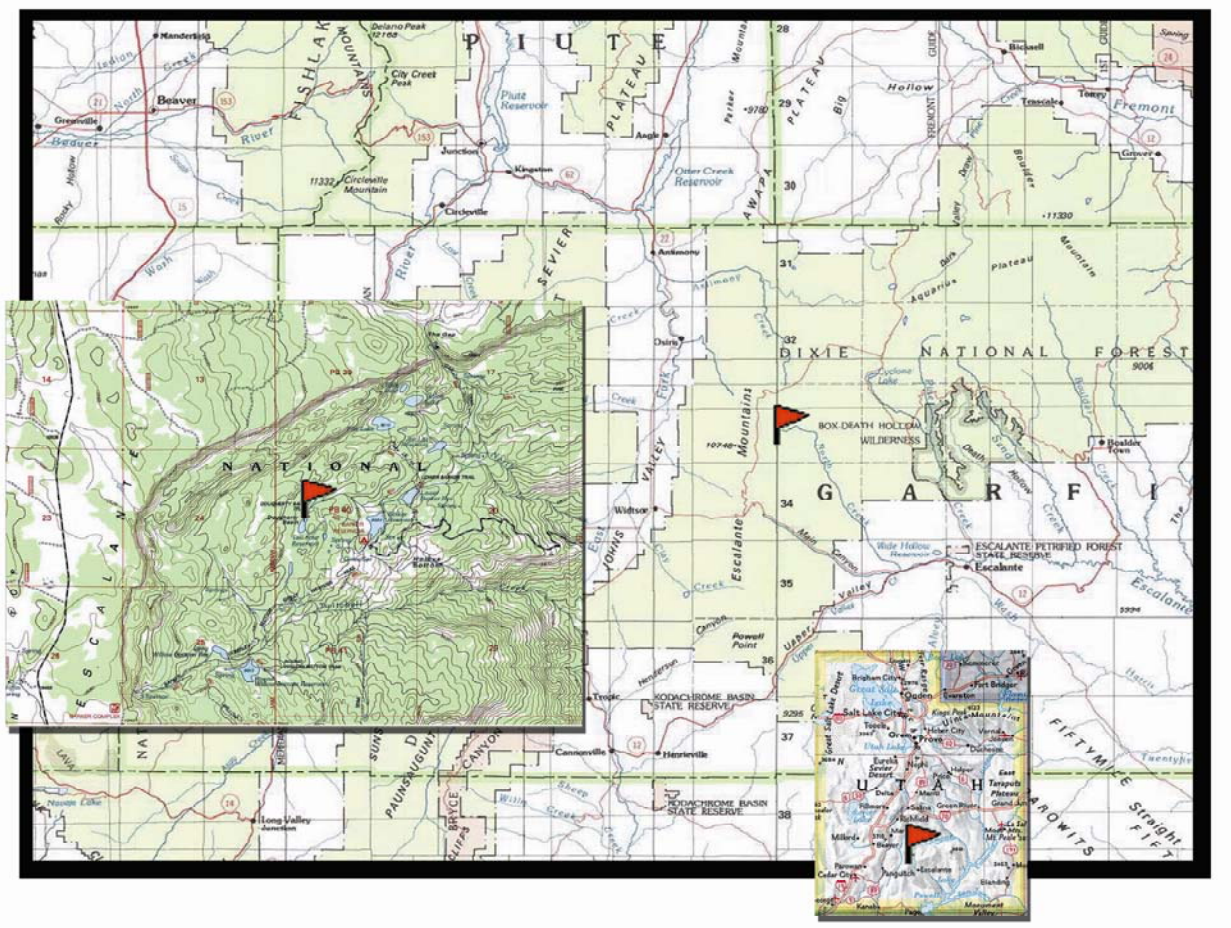

Figure 4. Location of Dougherty Basin Lake trap (see red flag).

History.— This site was selected for the wild trap program in 1996. To establish the brood population, transfers of Colorado River cutthroat trout from East and West Fork Boulder Creek, Boulder Mountains,

were made in 1997, 1998, and 1999 (Hepworth et al. 2001) after genetic testing and verification of purity (Shiozawa and Evans 1994). Disease inspections were conducted annually on trout from Boulder Creek from 1992 to 1999 (Hepworth 2000) and no prohibited pathogens were found. The first time eggs were collected from Dougherty Basin Lake was in 1999 and eggs have been collected annually since then. The first year (1999), eggs were taken June 17 and 23rd and shipped to the Fish Lake facility for egg incubation and to the Fisheries Experiment Station (FES) for rearing after eye-up. The second take eggs were poor quality and the lot was a total loss. Eggs were eyed at Fish Lake from 1999-2001; FES subsequently received green eggs for incubation in 2002. At both Fish Lake and FES, eggs were treated with formalin (1667 mg/L for 15 min) daily until eye-up. In 2003, a comparison of eye-up, hatch, and crippling percentages between FES and Fish Lake was made for each of three takes (see Table 4). Although there was no significant difference due to high variability, the average eye-up was over 20% higher at FES (77.7%) than at Fish Lake (56.1%). Water quality measurements in the summer of 2003 (5 August) indicated surface temperatures (13 C) and dissolved oxygen profiles (>9 mg/L throughout the water column) should not affect egg development and brood survival. From 2008 to present (2012), eggs have been eyed at Fountain Green Hatchery. In an effort to improve fry survival in the hatchery, Douglas Routledge and his staff at the Fisheries Experiment Station (FES) in Logan began using brine shrimp and a moist diet (Skretting Nutra-Plus®) in 2005 for initial feeding. In 2006, frozen Cyclopeeze® (5%) in conjunction with the moist diet (95%) was used for the first 2 weeks of feeding. Survival from initial feeding to stocking improved from 68% (1999-2004 average) to 84% in 2005 and 94% in 2006. Similar improvements were observed in cutthroat trout fry from Sheep Creek Lake (from 59% in 1999-2004 to 69%, 91% in 2005, 2006, respectively) reared at FES.

The water temperature of the sole tributary to Dougherty Basin Lake is about 7.5°C year round. Traps at the outlet and inlet consisted of portable aluminum frames and removable rods spaced 1.7 cm (0.5 in) apart. These funneled fish into holding compartments. Cutthroat trout are held in live cages in the reservoir or in the trap until they were ready to spawn or the project ends for the year. From 2005 on, fyke nets were used to obtain additional fish to spawn. From 2005 to 2009, the number of fish captured by this method (in order by year) was 48, 105, 81, 121, and 63. From 2006 to 2009, additional fish were captured in Tall Four Lake.

Methods.— Fish captured by net or trap are held in live cages in the lake kept at 1.2-2.4 m depth until they are used. At spawning time, the fish are sorted by gender and maturity. 'Green' females are returned to a cage for another try at the next spawn date. Ripe females are stripped onto a cloth screen, capturing ovarian fluid below for disease testing. After spawning, females are returned to the lake. Eggs from five females are pooled and are fertilized by five males that are stripped onto the eggs. Males are occasionally returned to cages for the next spawn if there is a shortage of males. When stripping males, a wire mesh screen is used to prevent feces from mixing with the eggs. Fertilization of the eggs is initiated by adding a 1% sodium chloride diluent solution to the sperm-egg mixture. Eggs are rinsed after >2 min with hatchery well water. Previously, lake water was filtered through a drinking filter typically used by backpackers, but this proved to be time consuming and more effort than packing water. The eggs are transferred to a cooler with hatchery water and left to water harden for at least 60 min. The cooler is transported on foot to the trailhead where the eggs are treated with 100 mg/L iodine

for 10 min. Clean hatchery well water is used for rinsing and transport to the isolation station at Fountain Green Hatchery. There are about 77 km (48 mi) of dirt road before pavement is reached going north toward Loa, so the ride can be rough.

Fish Production Data.— Data for the 2003 study comparing egg incubation sites is given in Table 4. Mean total lengths for spawning cutthroat trout from Dougherty Basin Lake were consistent over the years of trap operation to date (Table 5). Length frequency histograms for the last two years are given in Figure 5. Average fecundity for cutthroat trout from the lake was 581 ± 94.8 (SD) eggs per female and egg size was fairly constant across years (379 ± 31.8 eggs/oz, mean± SD; Figure 6). In 2008, poor egg survival (Table 5) was associated with use of hydrogen peroxide instead of iodine for egg disinfection. In 2009, survival to eye-up (40%) was affected by a malfunction of an eyeing jar for one take; the other two lots had 53 and 97% eye-up (Ottenbacher et al. 2009)

Table 4. Comparison of the survival between eggs transported to the Fisheries Experiment Station (FES) and eggs transported to the Fish Lake brood station for 3 takes of Colorado River cutthroat trout from Dougherty Basin Lake in 2003.

	Eye-Up (%)	Hatch (%)	Crippled (%)
Take 1, 10 June			
FES	78.8	81.5	9.2
Fish Lake	81.2	75.4	2.1
Take2, 17 June			
FES	77.6	75.0	7.6
Fish Lake	57.7	28.9	9.6
Take 3, 24 June			
FES	76.8	80.5	2.4
Fish Lake	29.5	81.2	17.0
Average (± SD)			
FES	77.7 (1.0)	79.0 (3.5)	6.4 (3.6)
Fish Lake	56.1 (25.9)	61.8 (28.7)	9.6 (7.4)

Table 5. Number of females spawned, mean length of fish used for fertilization, total eggs collected, egg size, and fecundity are presented for each year of trap operation at Dougherty Basin Lake (Hepworth et al. 2005; Ottenbacher et al. 2011; FES & FG hatchery records). The survival of fish from green egg to stocking is given for the year of the egg take. The total number of fish collected in the trap is given, with numbers of fish for each of four sub-locations (inlet, outlet, hoop net captures, and Tall Four Lake). Hatchery abbreviations: FL= Fish Lake, FG= Fountain Green, FE = Fisheries Experiment Station.

Year	Number of Females Spawned	Mean Length (mm)		Total Green Eggs	Eye-up Hatch-ery	Eye-Up (%)	Mean Eggs Per Female	Survival, Green Egg to Stocking (%)	Total Number of in Trap
		Female	Male						
1999	16	282	284	7,734	FL	36.4*	483	27	42 (31,11,0,0)
2000	10	287	279	6,428	FL	53.3*	642	26	21 (12,9,0,0)
2001	23	305	289	16,032	FL	78.0*	697	60	184 (149,35,0,0)
2002	73	307	305	44,258	FE	25.8	606	21	312 (245,52,0,15)
2003	66	325	312	35,479	FL+FE	63.8[a]	644	29	208 (130,78,0,0)
2004	20	343	322	14,589	FE	71.4[b]	729	26	144 (94,50,0,0)
2005	41	330	328	23,022	FE	84.3	561	53	130 (46,36,48,0)
2006	43	297	302	16,927	FE	62.0	394	54	237 (32,68,105,32)
2007	49	305	297	22,516	MC	75.5	460	59	172 (13,23,81,55)
2008	72	307	307	44,880	FG	22.5	623	6	255 (9,22,121,103)
2009	48	305	315	28,215	FG	48.4	588	23	151 (9,30,63,49)
2010	70	320	338	38,496	FG	9.7[c]	550	6	226 (7,6,134,79)
2011	77	302	312	50,520	FG	55.0[d]	656	30	256 (32,31,155,38)
2012	64	301	323	32,598	FG	22.6[e]	509	10.7	161 (15,36,71,39)
mean		308.3	308.0	27,264		53.1	581.6	30.8	

[*] mean percent hatch; [a] About 3,321 eggs of third take were spilt (9% of total), died, and discarded; [b] 8.9% eye-up in third take (~40% dead when received); [c] 46.5% eyeup in first take, but all eggs from second take (30,476) died due to problem with water supply; [d] all eggs died from 3rd take (5,894 eggs); [e] only 1% eyed in first take, lid lost enroute to hatchery on 2nd take.

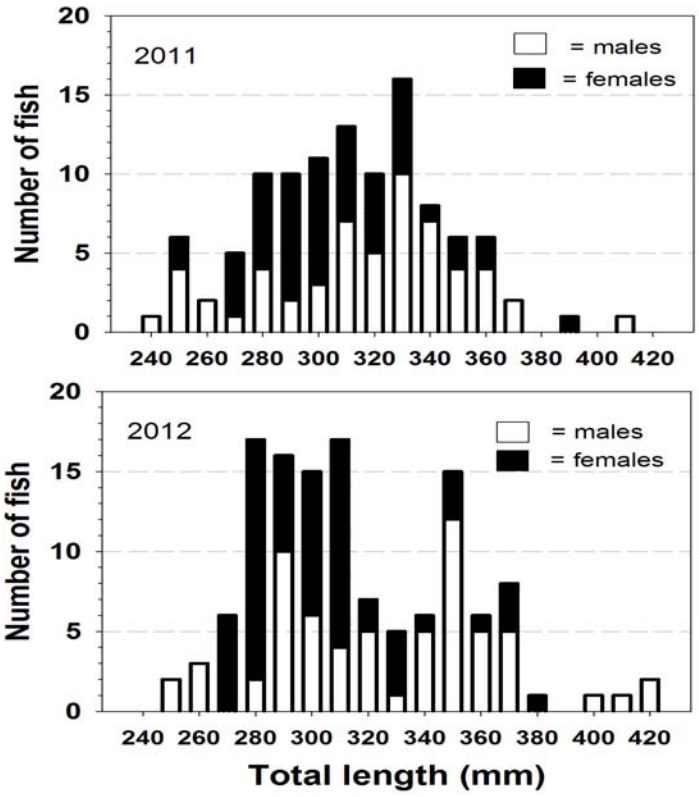

Figure 5. Frequency histograms of cutthroat trout of various size categories used for spawning at Dougherty Basin Lake in 2011 (top panel) and 2012 (bottom panel) (Ottenbacher et al. 2011; unpublished data).

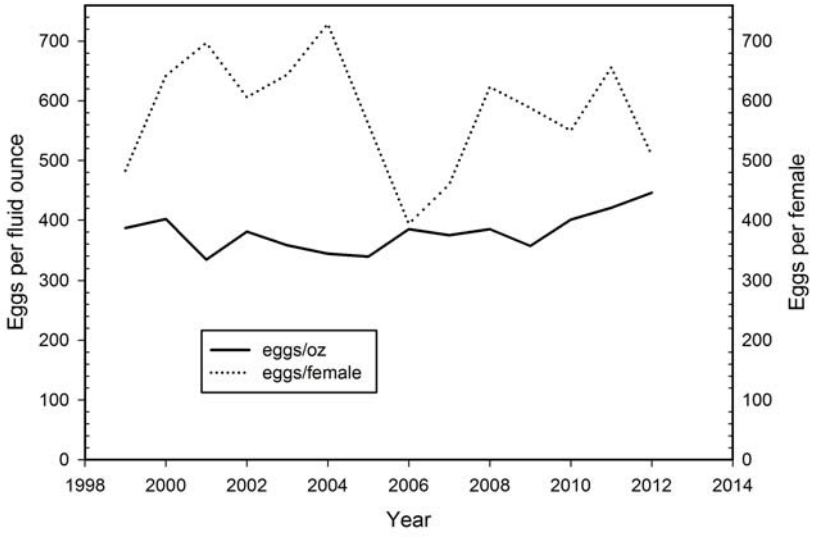

Figure 6. Comparison of eggs per fluid ounce and eggs per female for Colorado River cutthroat trout from Dougherty Basin Lake, Boulder Mountains, Utah from 1999 to 2012.

Trap- operation dates have ranged from 21 May to 28 June over the course of the trap history (Table 6). The number of green eggs per take generally declined in the third takes. The relationship between date and egg take numbers is plotted in Figure 7. The effect of take was analyzed to determine if prolonged stress of fish in cages would reduce egg survival in later takes. There was no significant linear correlation between egg survival and the number of green eggs taken (r^2 = 0.05, p = 0.18) or the take date (r^2 = 0.007; p = 0.62). Paired t-tests comparing egg survival between the first and second takes indicated no significant differences (p =0.93). However, there was a significant drop in egg survival between the second and third take (p = 0.02). Figure 8 compares box plots of egg survival among the three takes (see Table 5 for footnotes regarding issues for certain takes).

Table 6. Comparison of dates of Dougherty Basin Lake trap operations among years for the egg take from Colorado River cutthroat trout (Hepworth et al. 2005; Ottenbacher et al. 2009; Ottenbacher et al. 2011).

Year	Trap Operation Start	First Spawn Date	Last Spawn Date	Number of Takes	Lake Water Temperature °C (°F)	
					First spawn	Last spawn
1999	15 June	17 June	23 June	2	12.8(55)	14.4(58)
2000	1 June	5 June	12 June	2	14.4(58)	11.1(52)
2001	25 May	6 June	13 June	2	14.4(58)	15.6(60)
2002	21 May	30 May	12 June	3	16.1(61)	15.6(60)
2003	29 May	10 June	24 June	3	14.4(58)	13.9(57)
2004	28 May	8 June	22 June	3	15.6(60)	14.4(58)
2005	8 June	20 June	28 June	3	12.8(55)	12.2(54)
2006	26 May	8 June	13 June	2	12.8(55)	14.4(58)
2007	29 May	5 June	12 June	2	11.1(52)	12.2(54)
2008	6 June	12 June	27 June	2	10.0(50)	12.8(55)
2009	2 June	8 June	16 June	3	10.0(50)	10.0(50)
2010	7 June	9 June	14 June	2	14.4(58)	12.2(54)
2011	8 June	14 June	23 June	3	13.3(56)	11.7(53)
2012	23 May	30 May	4 June	2	7.2 (45)	10.6(51)

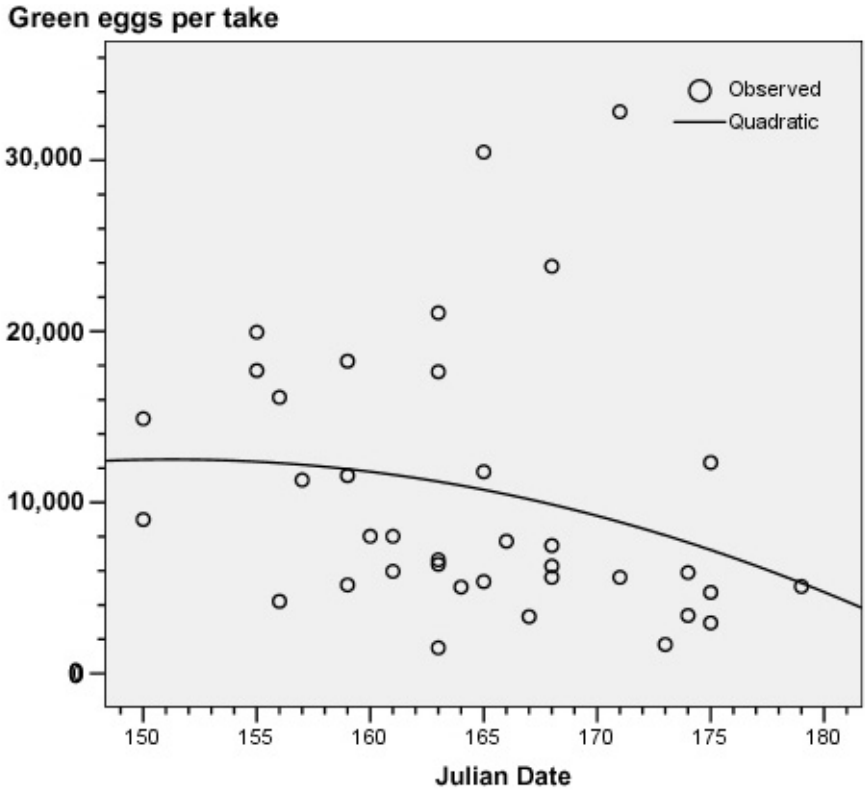

Figure 7. Quadratic plot of total green eggs per take versus date (May 30 to June 28) for Colorado River cutthroat trout from Dougherty Basin Lake, 1999-2012. Julian day 165 is June 14.

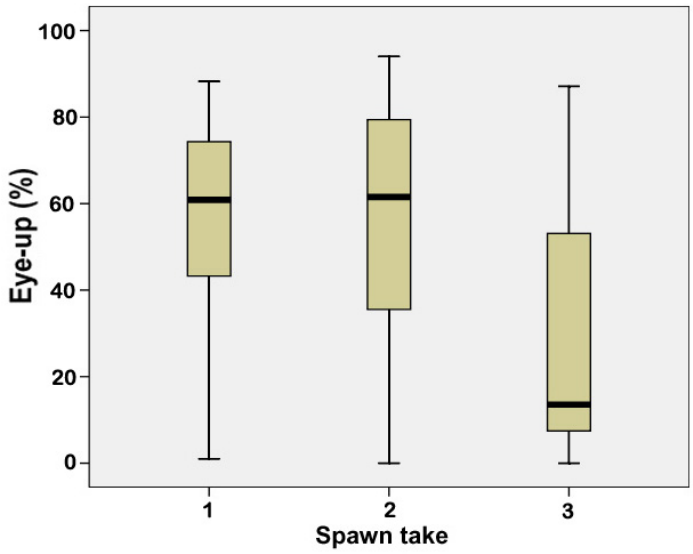

Figure 8. Comparison of egg survival (eye-up or hatch) among takes for Colorado River cutthroat trout from Dougherty Basin Lake, 1999-2012. Center line= median; box: 25th and 75th percentile; error bar= smallest/largest value**.**

Duck Fork

Colorado River cutthroat trout

Oncorhynchus clarkii pleuriticus

Managers.— Fishery biologists from the Southeastern Region, UDWR; Loa Hatchery

Location.— Duck Fork Reservoir was built circa 1963 (UDWR 1964). The reservoir is near Ferron Reservoir in the Manti La-Sal National Forest in southeastern San Pete County, east of Mayfield and west of Ferron, Utah (Figure 6). The reservoir is best accessed from the town of Ferron. From Ferron, travel east past Millsite Reservoir and continue into the Ferron Canyon. Ferron Reservoir sits 40 km up Ferron Canyon. At Ferron Reservoir, turn north and follow the road below the dam 8 km to Duck Fork Reservoir. Duck Fork Reservoir sits at an elevation of 2,837 m and has a surface area of 19.1 ha (Judd 1997). The maximum depth of the reservoir is 10.7 m with an average depth of 5.3 m (Judd 1997). The maximum storage capacity of Duck Fork Reservoir is 907,000 m^3 (Judd 1997).

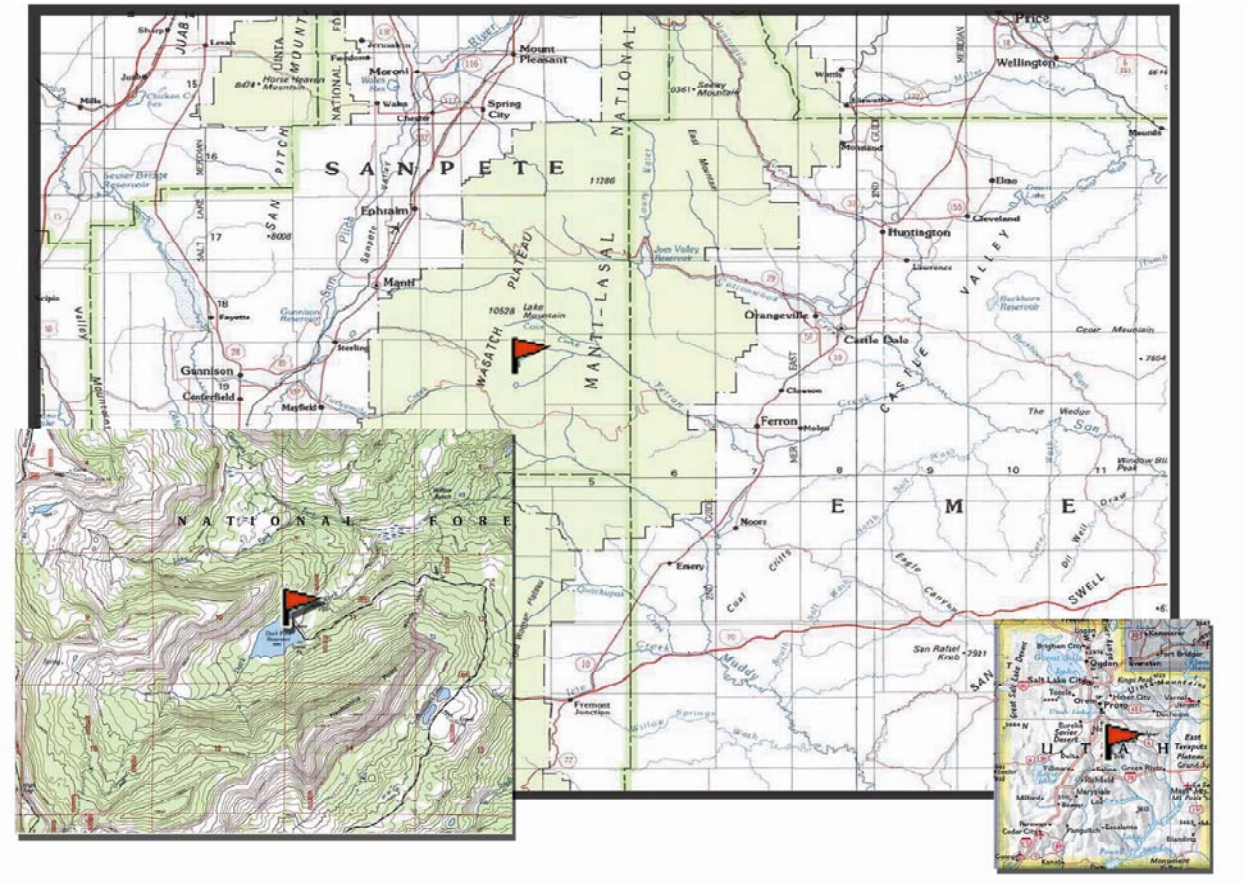

Figure 9. Duck Fork Reservoir trap location (see red flag).

History.— The reservoir was treated with rotenone for two consecutive years to remove non-native fish prior to introducing cutthroat trout. About 800 cutthroat trout were transferred to the reservoir from the White River in 2003. The White River is a headwater tributary to the Price River (Colorado River drainage) on the south slope of the Tavaputs Plateau. The trap at Duck Fork Reservoir was installed in 2005. The trap (Figure 10) is situated in Duck Creek and sits a few hundred meters upstream of the reservoir (Figure 11). The Duck Fork trap was first operated in 2007, although, no fish were trapped and spawned until 2009. High flows have been a problem at this trap and have limited its success. In addition, access to the trap site is limited. The installation of the trap can be delayed during years of high snowpack. Biologists have collected fish from Duck Creek and Duck Fork Reservoir using nets and electrofishing to obtain additional fish to supplement what is collected in the trap. A re-design of the trap has been proposed and will be installed in the future. The DWR would like to collect 75,000 eggs annually from Duck Fork Reservoir.

Figure 10: Trap that has been installed at Duck Fork Reservoir.

Methods.— Approximately 5 times each week during the spawning season, the trap and the nets set in Duck Fork Reservoir are checked. The collected fish are removed, sorted by sex, and are stored in floating net pens (4 x 4 x 3 ft) that are installed on the north end of the reservoir. For spawning, the fish are transported to shore by boat and bucket. Spawning occurs approximately three times each year. During the spawn, 'green' females are held in a trash can, then held over in the pens until the next spawn. Eggs from ripe females are stripped into dry bowls; the spent fish are returned to the reservoir. Once eggs from five females are collected, sperm from five males is collected into a Styrofoam cup. This sperm is then poured over the eggs and a 0.5% NaCl diluent is added. Egan Hatchery well water is used for egg rinsing and water hardening. After 1 h of water hardening, the eggs are disinfected for 10 min in a 100 mg/L iodine solution. The eggs are then placed into coolers with hatchery well water and transported to Fountain Green Hatchery for incubation. They are disinfected with iodine a second time upon arrival at Fountain Green.

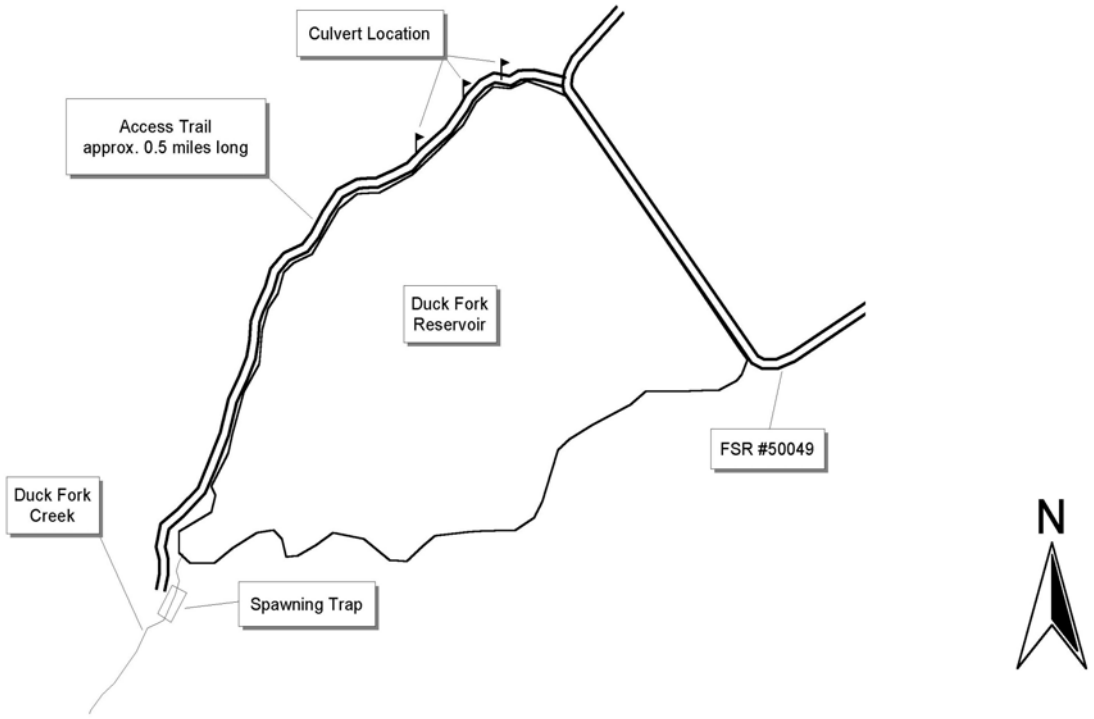

Figure 11. Map showing the placement of the spawning trap at Duck Fork Reservoir.

Fish Production Data.— Between 2009 and 2011, a total of 110 female cutthroat trout have been spawned from the Duck Fork trap, providing a total of 148,878 eggs (Table 8). The average eye-up for these eggs has been 75.5 ± 6.3% (mean ± SE). From these eggs, a total of 54,071 fish have been produced and stocked into state waters (36.3% survival from egg to stock).

Table 7. Numbers of cutthroat trout collected at Duck Fork Reservoir between 2009 and 2011, their mean length, and stream and reservoir temperatures at the time of collection.

	Total number of trout trapped				Mean length (mm)		Temperature (°C)	
Date	Trap	Hoop nets	Female	Male	Females	Males	Lake	Stream
2009	11	101	51	61			10	6.1
2010	5	84	60	66	355	364	10.6	
2011	111	19	64	66	355	353		

Table 8. Production data for cutthroat trout eggs taken from Duck Fork Reservoir between 2009 and 2011.

Date	# of Females	Eggs/ Female	Total Eggs	Eggs / oz	Eye-Up (%)	Hatch (%)	# Stocked	Egg-to-Stock Survival (%)
2009								
6/14	16	1,504	24,060	401	68.3	60.0	11,298	46.96
6/23	18	1,460	26,280	438	68.4	55.4	11,397	43.37
7/02	9	1,606	14,454	438	58.5	44.7	3,786	26.19
Totals	43	1,523	64,794	426	65.0	53.3	26,481	38.84
2010								
6/22	20	1,231	24,618	373	90.9	77.2	9,720	39.48
6/30	19	1,425	27,072	423	82.8	70.2	9,720	35.90
Totals	39	1,328	51,690	398	86.9	73.7	19,440	37.69
2011								
7/11	15	1,168	17,526	381	77.2	77.2		0.00
7/20	13	1,144	14,868	413	72.2	61.1	8,160	54.88
Totals	28	1,156	32,394	397	74.7	69.1	8,160	27.44

Fish Lake

Cutthroat trout *Oncorhynchus clarkii*, lake trout *Salvelinus namaycush,*
brown trout *Salmo trutta*, and
rainbow trout *Oncorhynchus mykiss*

Location.— Fish Lake is a natural lake at 2,695 m elevation in the Fish Lake National Forest at the headwaters of the Fremont River in Sevier County (Judd 1997). The lake has a surface area of 1,012 ha, estimated volume of 265,095,000 m^3 and a maximum depth of 53 m (Judd 1997). The lake is approximately 32 km northwest of the town of Loa. Fish Lake is accessible via Utah Highway 25, which intercepts Utah Highway 24. To access the lake from the west, travel to Koosharem and head an additional 6.8 km east along Utah Highway 24 and then turn north on Utah Highway 25. To access the lake from the east, travel to Loa and then proceed an additional 21.1 km along Utah Highway 24 until intercepting Utah Highway 25. Once Utah Highway 25 is reached, proceed 12 km to the lake.

History.— Fish Lake was stocked with lake trout in 1900 and these were well established by 1905 (Popov and Low 1950). Brook were also stocked early in the 20th century and reportedly established by 1911 (Popov and Low 1950). Currently, no brook trout exist in the lake and are not stocked, although splake (brook trout x lake trout hybrid) are planted annually. Yellow perch are present, possibly stocked as early as 1934, when some Sevier County sites were stocked (Popov and Low 1950). Cutthroat trout eggs were obtained from wild fish at Fish Lake as early as 1912 (UFG 1912). A photo of the Fish Lake trap circa 1943 is shown in Figure 12. A hatchery building (Figure 13) and a 2-room cabin were built along Twin Creek circa 1912 to facilitate the egg take effort and provide lodging while UDWR employees worked in the area (UFG 1912). The hatchery building was used most recently in the 1990s for incubation of cutthroat trout eggs which were shipped upon eye-up to various hatcheries,

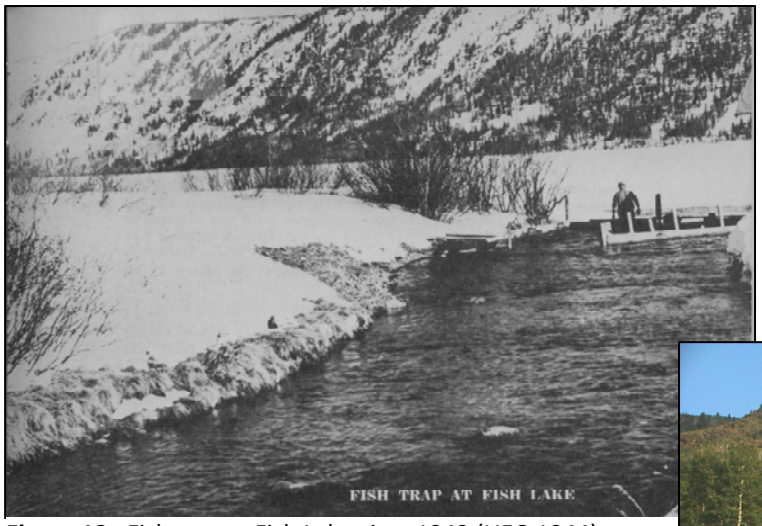

Figure 12. Fish trap at Fish Lake circa 1943 (UFG 1944)

Figure 13. Hatchery Building on Twin Creeks at Fish Lake, 2012

including the Fisheries Experiment Station. Currently, the hatchery building, which got a new roof last year, is being used for storage, not fish culture.

At present, it is uncertain when rainbow trout were introduced into the lake, but by 1935, 10 million rainbow trout eggs (as well as 4 million brook trout eggs) were obtained from spawners in Fish Lake (UFG 1936). A federal aid report (Regenthal 1960) indicated 70,500 marked and 290,915 unmarked rainbow trout (no strain or source given) were stocked in the lake between 1954 and 1957. A dam was added to Fish Lake in 1935 to raise the lake level about a meter. This water is used annually for irrigation (Judd 1997).

Methods.— Lake trout eggs have been obtained using 100' x 6' sinking gill nets with 2" mesh. Nets were pulled approximately every hour during the nights of the fall spawning period (October). Green females were released and ripe females were transferred to tubs on the boat and later to net cages. In 1994, the peak number of ripe females collected was during the third week of October. When sufficient ripe females were collected, the eggs were stripped by hand onto screens and pooled eggs fertilized by males kept in separate mesh cages. For splake production, male brook trout from Egan Hatchery were transported by boat to cages on the eastern shore where they were kept until stripped directly on the eggs. Eggs were incubated at the Fish Lake hatchery building until eyed. Eggs were treated daily with formalin (1667 ppm for 15 min) to control fungal growth.

Fish Production Data.— In 1962-1963, no rainbow trout eggs were taken, but in 1963-1964, there were 191,784 eggs taken from fish in Twin Creek (UFG 1964). A take of rainbow trout eggs from Twin Creek occurred for many years. In 1971, 1972, 1973, and 1974, there were 1,073,522, 1,073,522, 941,680, and 27,297 rainbow trout eggs taken, respectively for each year (UDWR 1972; UDWR 1974). In 1971, 240,000 brown trout eggs were obtained as well (UDWR 1972). Hatchery records from the Fisheries Experiment Station indicated that cutthroat trout eggs were received from Fish Lake in September 1970.

Fish Lake provided many lake trout eggs over the years as well (Table 9). A monthly report (Pitman 1978) indicated that lake trout eggs transferred from the lake to Kamas Hatchery 'did not come off with any percent success'. The lake trout were primarily used to produce splake (brook male x lake trout female), but lake trout and the reciprocal splake cross were produced as well. Fish production data for splake from 1983 to 1995 is presented in Table 10 (Berg and Hepworth 1994, 1995). The 1991 fish production report indicated that Bear Lake was used at least one year for splake production (211,285 eggs of which 79.2% eyed) as well as for lake trout (51,580 eggs of which 69.1% eyed). The 1993 production report indicated that Fish Lake was used again, producing 172,553 splake eggs of which 46.6% eyed); The total egg take differs from the amount in Berg and Hepworth (1994; see table below). The total egg take differs in several records, likely due to the fact that total green egg volume and eggs per unit volume data are collected both at the wild trap and at the receiving hatchery. This can affect some of the eye-up data as well. For example, splake eye-up was slightly higher in 1984 in the Statewide Fish Production Report (75.8%) than in Berg and Hepworth (73.8%). In 1994, 1,024 lake trout were collected by gill net, of which 139 females gave 372,823 eggs. The number of eggs taken per night that

year ranged from 46,216 to 104,864. In 1995, the take per night ranged from 47,840 to 90,138 eggs (Berg and Hepworth 1995).

Table 9. Egg collection data from lake trout at Fish Lake (Berg and Hepworth 1994, 1995; Statewide Fish Production Reports).

Year	Number of Nights Nets Set	Number of Females Spawned	Total Number of Eggs	Number of Eggs per Female
1971	unknown	unknown	283,211	Unknown
1972	7	unknown	383,996	Unknown
1973	12	46	320,835	6,975
1979	3	26	119,375	4,591
1983	1	15	63,900	4,260
1984	2	33	149,340	4,525
1985	2	28	105,392	3,764
1986	1	39	155,832	3,996
1987	2	30	118,300	3,943
1991	4	89	165,700	1,862
1992	4	154	175,000	1,136
1993	4	44	159,031	3,614
1994	5	139	372,823	2,682
1995	5*	78	334,133	4,284

*October 4-17

Table 10. Production of splake from lake trout eggs taken at Fish Lake, 1983-1993 (Berg and Hepworth 1994, 1995).

Year	Number of Green Eggs	Survival to Eye-Up (%)	Number of Fish Stocked	Rearing Losses (%)	Survival from Green Egg to Stocking (%)
1983	63,210	87.5	47,059	0.0	74.4
1984	149,340	73.8	62,420	36.4	41.8
1985	115,783	77.1	56,252	31.6	48.6
1986	169,246	76.4	123,395	0.0	72.9
1987	116,928	57.1	46,030	30.2	39.4
1989	112,499	78.5	72,680	11.2	64.6
1991	172,553	46.6	63,254	13.0	36.7
1992	138,007	47.4	55,983	5.6	40.6
1993	169,013	69.4	80,160	19.2	47.4
1994	275,806	100	158,650	20.2	57.5
1995	312,387				
Mean	148,239	73.8	76,588	17.4	51.7

Kolob Reservoir

Colorado River cutthroat trout

Oncorhynchus clarkii pleuriticus

Managers.—Fisheries biologists of the Southern Regional UDWR Office; Loa Hatchery

Location.— Kolob Reservoir is northwest of Zion National Park, about 40 miles north of Virgin, Utah in Washington County. The reservoir feeds into the Virgin River, a tributary of the lower Colorado River.

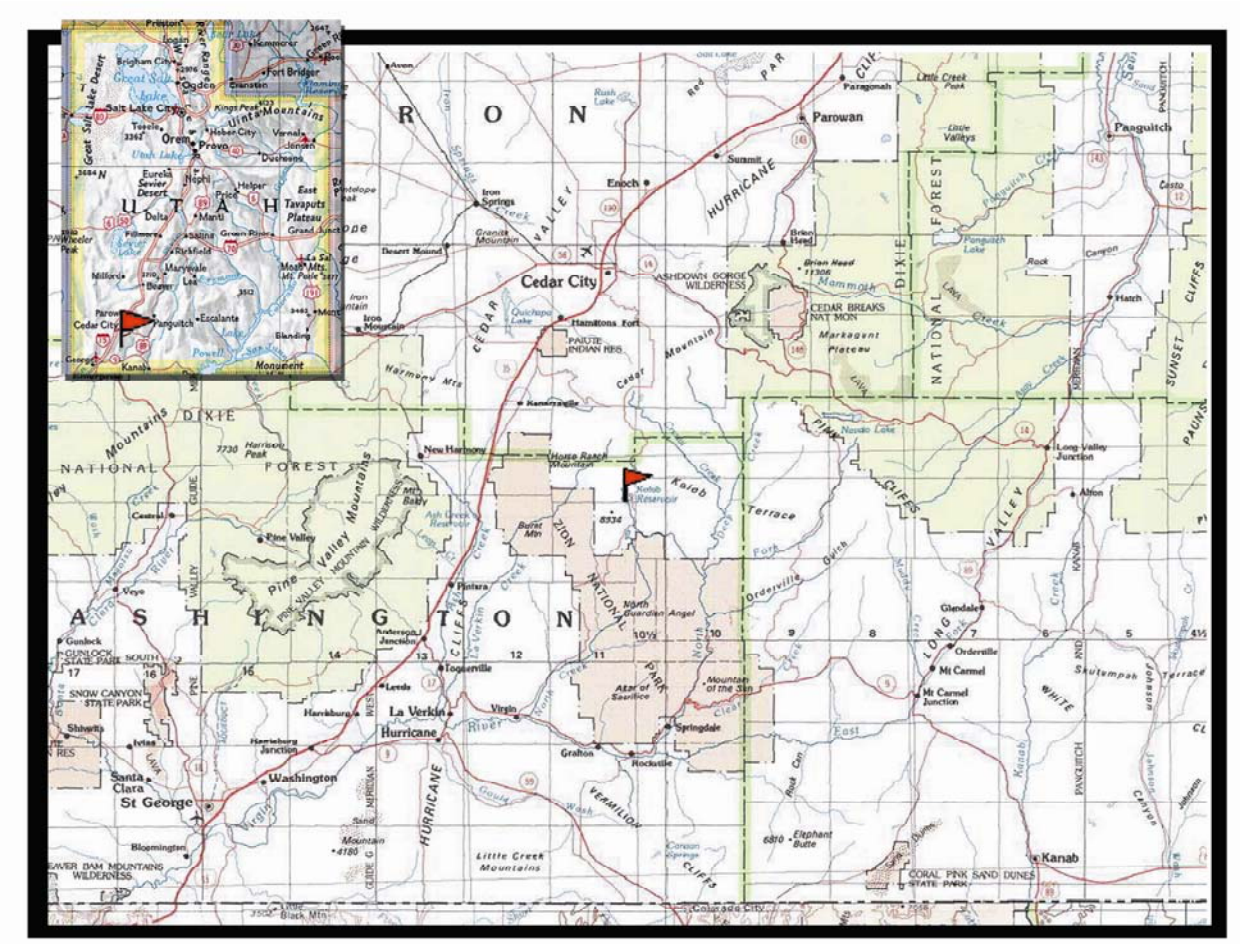

Figure 14. Location of Kolob Reservoir (see red flag)

History.— Kolob Reservoir was created in 1956 when an earthen dam impounded Kolob Creek (Judd 1997). It is a 101 ha irrigation storage reservoir at 2,474 m elevation, with an average depth of 6.3 m and 8,528 m^3 volume (Judd 1997; Ottenbacher et al. 2011). Kolob Reservoir was chosen as a site to supplement Colorado River cutthroat trout production at Dougherty Basin Lake. In 2008, 5,076 cutthroat trout from Dougherty Basin Lake were stocked into the reservoir as sub-catchable size fish (18 cm; Ottenbacher et al. 2011). In spring 2010, 566 more cutthroat trout were stocked (23 cm mean length; Ottenbacher et al. 2011).

The first egg take at Kolob Reservoir began in 2010 (Ottenbacher et al. 2011). Only stocked fish (which have an adipose fin clip) are used for spawning. In 2010, cutthroat trout were spawning about mid-June in Kolob Creek. Although, an attempt was made to take eggs in 2011, no eggs were collected. Conflicts with other work at the time and prolonged cold spring weather led to missing the narrow spawning period.

Methods.— Fish are captured by electrofishing in Kolob Creek. Fish with an adipose fin clip are used for the egg take. Fish are transferred by bucket from the creek to a truck tank. From the tank, the fish are are sorted by sex and ripe females are transferred by bucket to the spawning table under a canopy. Females that are not mature are returned to the creek (there have been problems with fish held in previous years). Eggs from ripe females are hand-stripped onto cloth-mesh screens, pooling eggs from five fish. Sperm pooled from about 5 males is added to the egg pool; a mesh screen is used to keep out fecal material when stripping males. Salt diluent is added, the egg mixture gently stirred, and left to sit for 2-10 min. After subsequent rinsing with clean water from Egan Hatchery, the eggs are water hardened in Egan Hatchery water for 1 h. Eggs are treated with 100 mg/L iodine after water hardening at the site, then again upon receipt at the Fountain Green Hatchery. The road north from Kolob Reservoir is a dirt road, so eggs have a rough trip. At eye-up and after disease certification, the eyed eggs are transferred to another hatchery for rearing (Ottenbacher et al. 2011; Michael Durfey, pers. comm.).

Fish Production Data.— In 2010 (June 17th), about 50 cutthroat trout with adipose clips were collected from Kolob Creek (temperature, 5.6 °C), of which none were ripe females (Ottenbacher et al. 2011). On 24 June 2010, water temperatures had increased to 7.2°C and 55 of 85 collected females were ripe. The eggs from these were fertilized by a total of 70 males on 28 June, resulting in 21,580 eggs. The eye-up of this lot was 88%. Survival from green egg to stocking was 55%.

In 2012, 24 ripe females were hand-stripped on 6 June and the eggs were fertilized by 26 males, resulting in 11,583 green eggs. On 8 June 2012, sperm from 11 males was used on eggs from 11 females, providing 5,166 additional green eggs. The eye-up of the two lots was 52 and 21%, respectively; For green eggs, the egg size was 351 and 369 eggs/oz. Mean size of the ripe females was 343 ± 18.0 mm (SD) and males was 299.2 ± 31.1 mm; minimum and maximum sizes were 290 and 375 mm for females and 262 and 380 mm for males, respectively.

Lake Canyon Lake

Colorado River cutthroat trout

Oncorhynchus clarkii pleuriticus

Managers.— Fishery biologists from the Northeast Region DWR; Whiterocks Hatchery

Location.— Lake Canyon Lake, Duchesne County, outflow go subsurface just below the lake then resurface near the mouth of the canyon to form two additional lakes, which then flow into the Strawberry River, a tributary to the Duchesne River. The lake is approximately 35 km southeast of Duchesne. To access the lake, travel west from Duchesne on U.S. Highway 40 for 13 km. Then, turn south on 9980 South (Strawberry River Road) and follow this road for 9 km. At this point, take a slight left on A1900 South (Lake Canyon Road) and travel approximately 13 km to the lake. The lake sits at an elevation of 2,066 m and has an area of about 14.6 ha (36 acres).

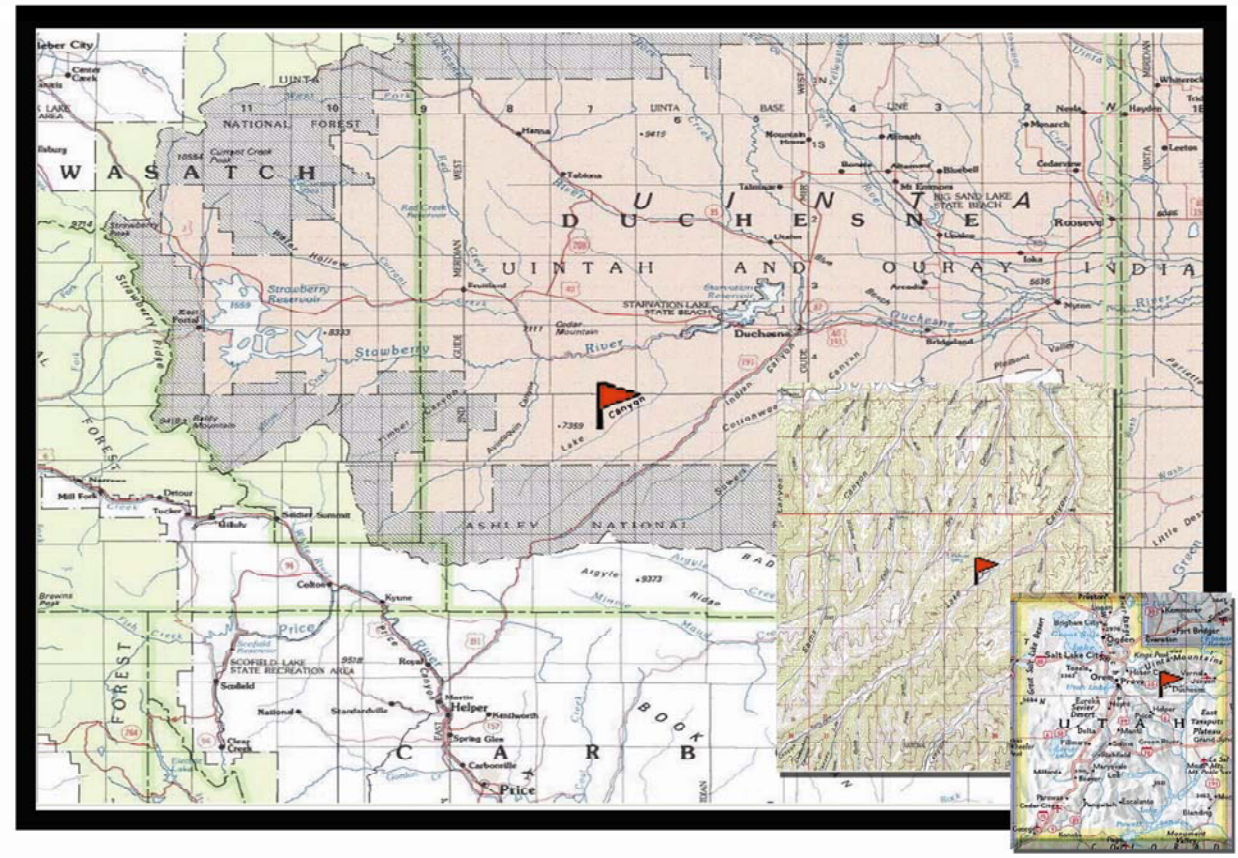

Figure 15. Location of Lake Canyon Lake (see red flag).

History.— The lake was purchased for use as a brood lake in 2002 for a total of $2,635,136 (2002 Federal Aid Annual Report, F-44-R, Utah). Soon after purchase, the inlet was dredged to deepen it for

spawning fish. Additional wildlife habitat improvement projects on the property are ongoing. Genetically pure Colorado River cutthroat trout were stocked into Lake Canyon Lake from Timber Canyon Creek, a tributary to Strawberry River on the North Tavaputs Plateau. After the second year of disease certification, the first transfer was made in 2002 (311 fish), followed by 284 in 2003, 106 in 2004, 144 in 2005, 325 in 2006, 1,948 in 2007 and 508 in 2008 (total of 3,626 fish transferred).

In 2004, the first egg take was reared on site in a streamside incubator, since disease certification was still pending. Unfortunately all the eggs in this lot were lost due to formalin drip treatments that continued on fry after hatching. From 2005 to 2007, the cutthroat trout eggs were reared at the Whiterocks State Fish Hatchery, Whiterocks, Utah. Fountain Green Hatchery incubated the eggs from 2008 to present.

Methods.— The current protocol for catching fish for the egg take is to set fyke nets overnight at mouth of Lake Canyon inlet and other locations in the lake, starting about mid May. This is done 2 to 3 times during the next few weeks, concluding by the end of the month or the first week of June. Upon pulling nets, cutthroat trout are transferred to one of three cages, one for males, one for females, and one for fish to be sacrificed for disease certification (Fig. 16). Green females are not held over since there have been problems historically holding fish over in cages. When the ripe females are spawned, 5 females are done at a time, pooling ovarian fluid below a cloth screen for disease testing. Males (usually 5, i.e., 1:1 ratio) are stripped directly on eggs using a screen to catch feces. Salt diluent is used to initiate fertilization. After 3-5 min, eggs are rinsed with hatchery well water brought from the Whiterocks Hatchery. Eggs are subsequently water hardened in a cooler using the hatchery water. After 1 hr, eggs are treated with 100 mg/L iodine for 10-15 min. These are rinsed with fresh hatchery water and transported in a cooler to Fountain Green Hatchery for incubation and isolation.

Figure 16. Holding cages in Lake Canyon Reservoir.

Fish Production Data.— In 2005 and 2006, about 48,500 and 30,537 eggs, respectively, were taken from cutthroat trout at the lake (2005 and 2006 Federal Aid Annual Reports, F-44-R, Utah; 2001-2007 F-44-R Performance Report). Of the 2006 lot, 15,420 fingerlings were produced (50.5% survival to stock). In May/June 2008, 97,824 eggs were collected, of which 2,200 fingerling resulted; the poor survival (2.2%) was attributed to the use of hydrogen peroxide on the green eggs (2009 Federal Aid Annual Report, F-44-R, Utah).

Table 11. Numbers of female and male Colorado River cutthroat trout spawned each year from Lake Canyon Lake. Also given are the total eggs collected for each take, mean fecundity, and survival to the eyed egg stage and/or to stocking (expressed as a percentage of total green eggs).

Year	Date	Number of Females	Number of Males	Mean Fecundity (Eggs/Female)	Total Number of Green Eggs	Survival to Eye-Up (%)	Survival to Stocking (%)
2005	30-May	49			48,500		0.1
2006	18-May	15			30,537		50.5
2007	17-May	6	6	1,755	10,530		21.2
	24-May	7	7	1,605	11,232		
	31-May	11	7	1,668	18,350		
	Total	24	20	1,676	40,112		
2008	28-May	5	5	1,577	7,884	6	
	4-Jun	18	18	1,491	26,832	4	2.2
	11-Jun	50	50	1,262	63,106	15	
	Total	73	73	1,443	97,822	11	
2009	20-May	14	17	1,471	20,597	ND	
	27-May	26	33	1,735	45,120	ND	
	Total	40	50	1,603	65,717	ND	
2010	25-May	14	10	1058	14,805	86	
	2-Jun	70	63	1283	89,824	48	
	Total	84	73	1,246	104,629	53	
2011	2-Jun	49	49	2066	101,250	17	
	8-Jun	56	56	1979	110,848	50	
	Total	105	105	2020	212,098	34	
2012	16-May	24	24	2272	54,528	75	
	22-May	30	30	1925	57,744	49	
	30-May	43	43	1492	64,160	41	
	Total	97	97	1819	176,432	54	

Little Dell and Mountain Dell Reservoirs

Bonneville cutthroat trout

Oncorhynchus clarkii Utah

Managers.— Fisheries biologists of the Central Region UDWR Office; Midway Hatchery

Location.— Mountain Dell and Little Dell Reservoirs are located about 18 km (11 mi) east of Salt Lake City, Utah, near the intersection of Interstate 80 and State Route 65. Little Dell Reservoir is an impoundment of Mountain Dell Creek and diverted water from Parley's Creek (Slater and Wiley 2008). It is the larger of the two reservoirs, upstream of Mountain Dell Reservoir, at 1767 m elevation, with a capacity of 25,286,750 m^3 (20,500 ac-ft; operated at 17,500 ac-ft). The surface area is 101 ha (249 ac) and maximum depth at full pool is 61 m (Judd 1997). Mountain Dell Reservoir is at the confluence of Parley's Creek and Mountain Dell Creek, with a capacity of 2,713,700 m^3 (2,200 ac-ft), surface area of 25.9 ha (64 ac), and a maximum depth of about 30 m (85 ft; Judd 1997). The creeks traditionally flowed into the Jordan River in the Bonneville Basin, but most of the water is used by municipalities along the Wasatch Front for culinary use.

Figure 17. Location of Mountain Dell and Little Dell Reservoir wild fish traps (red flags).

History.— Most of the following information is derived from Slater and Wiley (2008). Brook trout and Bonneville cutthroat trout are present in both reservoirs, though Mountain Dell Reservoir is closed to fishing. Both trout species may be caught from Little Dell, but cutthroat trout must be released. The cutthroat trout in Mountain Dell Creek above Little Dell Reservoir were determined to be genetically pure Bonneville cutthroat trout (Thompson 1998). Egg take operations began in 1996, when eggs were taken from cutthroat trout in Parley's Creek above Mountain Dell Reservoir. Eggs were incubated on site at Parley's treatment plant. Fry from the egg takes in 1996 and 1997 (total *n* = 7,313) were stocked into Lambs Creek, a tributary to Parley's Creek that had been chemically treated in 1995 to remove rainbow and rainbow-cutthroat trout hybrids. In 1998, about 100 genetically pure, pre-spawn adults were transferred from Parley's Creek to Lambs Creek (Slater and Wiley 2008), but no eggs were taken that year. Fish health certification continued in 1999 and 2000, but no eggs were collected. In 2001, fish were finally certified pathogen-free. Cutthroat trout collected by electrofishing from Mountain Dell Creek and Parley's Creek produced 17,134 eggs in 2001 and 36,554 eggs in 2002. These were reared at the Fisheries Experiment Station. In 2003, a trap constructed of angle iron and aluminum conduit was installed in Mountain Dell Creek above Little Dell Reservoir; this trap was operated from May 15 to June 6, 2003, during which time 36,015 eggs were collected. These were eyed at Mantua Hatchery and subsequently reared at Glenwood Hatchery. An additional 24,000 eggs were collected and incubated in stream-side incubators beside Mountain Dell Creek and Lambs Creek. The myxozoan parasite *Myxobolus cerebralis* was found in Little Dell Reservoir in 2003. To date, no other prohibitive pathogens have been found by annual testing.

In 2004, the trap was set between May 12 and June 7, resulting in 60,000 eggs from 208 females across four different dates. Mantua Hatchery also began to be involved with the egg take operation. In 2005, high water flows washed out the trap set May 18. It was reset May 23rd, but other restrictions by Salt Lake City Water Resources and Watershed Management led to the trap being removed until May 31, 2005, after issues had been resolved. The trap was moved upstream twice more that year due to rising water levels and high flows. The first eggs taken were June 13; Additional eggs were taken July 5th and 12, 2005. A total of five tagged fish (visual implant tag) were spawned of 186 fish tagged in 2004. Assuming a retention rate of 50-58%, this indicated a return rate of only 5%. In 2005, 93 more fish were tagged, but tags were not read the following year to minimize handling.

Previous problems with repeated electroshocking of fish inside and outside of the trap, excessive handling, and subsequent mortality or fungal lesions, led to changes implemented in 2006. In 2006 only the top portion of the trap was installed (May 31 to June 28), forming an upstream barrier, but allowing full movement of the fish below it. For brood collection, these were electrofished from the stream on five different days and held in cages only for the day that spawning activities were conducted. A total of 186,546 eggs were obtained. From 2004 to 2006, eggs were both eyed and reared at Mantua Hatchery. In 2007, it was decided that eggs from cutthroat trout from Little Dell would be collected only every other year, due to declining demand for eggs and to help maintain the existing run. Kamas Hatchery staff helped with the spawn, which occurred on 4 dates between June 5 and 26th, 2007. A total of 74 females provided 19,050 eggs (mean of 1,744 eggs/female). Unripe females were placed into a live cage

in the reservoir between takes, but 30% (*n* =9) died. From 2008 to present, eggs were shipped to Fountain Green Hatchery for isolation and incubation until eye-up. In 2008, there were 3 takes (June 2, 18, and 25th); corresponding eye-up percentages were 81, 56, and 46%. Reductions in egg survival that year were attributed to treatment of eggs with hydrogen peroxide instead of iodine; the hydrogen peroxide treatment was based on research by Wagner et al. (2008) that indicated incomplete disinfection of eggs treated with iodine. Iodine was used in subsequent years for disinfection after water hardening. In 2009, the 3 takes were on June 17, 24, and July 1; corresponding eye-up percentages were 60, 97, and 63%. A total of 62 females were spawned; mean fecundity was 1,046 egg/female. In 2010, the egg takes were on June 16, 22, and 30; corresponding eye-up percentages were 79, 67, and 85%. In 2011 the spring was cooler and wetter, so the egg takes were delayed (June 28, July 6 and 13); corresponding eye-up percentages were poorer (15, 40, 39%, respectively) than in previous years. The average fecundity was 1,722 eggs/female (*n* =70). Of the 189 females captured, only 37% were ripe.

The dates for the egg take vary by year, ranging from late May to the first or second week of July. Water temperatures in the creek at the time of the first spawn ranged from 9.5 to 12.2°C (49-54 F) between 2003 and 2007; water temperatures at the last spawn ranged from 10 to 16.7°C (50-62 F; Slater and Wiley 2008).

Methods.— Currently the trap (Figure 18) consists of a single barrier to upstream movement installed above either Mountain Dell or Little Dell Reservoir. Cutthroat trout are caught by electrofishing a day or two prior to spawning and held in pens in the creek near the stream or in the reservoir. The pens are made from cloth netting stretched over a square frame of PVC. The frames are fastened into a cubical cage shape with zip-ties. For spawning, the fish are sorted into ripe males and females that are held in pens, then transferred to containers near the fish culturist assigned to the egg take. Green females are released back into the reservoir. On Parley's Creek, green females may be held in cages between takes (Chad Hill, Midway Hatchery, pers. comm.). Fish are anesthetized with a low dose of tricaine methanesulfonate prior to spawning. The fish culturist dips the female in a bucket of clean water to rinse off the anesthetic, then hand strips the ripe female's eggs onto a cloth mesh screen. Ovarian fluid is collected in a pan below the eggs for disease inspection. Eggs are transferred to a bowl until a total of five females have been stripped. The ovarian fluid is then transferred to a 50 mL centrifuge tube and placed into a cooler. The bowl is wiped out with paper towels and reused for the next five. The pooled eggs are fertilized by stripping sperm from at least five males directly on the eggs. A fine mesh wire screen is used to keep feces out of the eggs. Occasionally more males are needed due to poor aim

Figure 18. Aluminum conduit barrier on Parley's Creek, 2012.

or poor sperm production. Males are gently wiped with a towel to remove excess water, so the water doesn't prematurely activate the sperm. Spent brood are placed into a bucket of water and carried back to the stream and released. A saline (about 1% NaCl) solution is used to initiate fertilization, eggs are gently mixed a few seconds by hand, and later rinsed after 2-5 min with hatchery well water. Eggs are left to water harden in hatchery well water in a covered container for at least 60 min prior to egg treatment with 100 mg/L iodine (Argentyne®) for 10 min. Usually all the eggs taken in a location will be collected and pooled before doing the iodine treatment, so the time post-fertilization will vary accordingly. A study by Wagner et al. (2012) indicated that this is not an issue as far as egg survival is concerned. At Mountain Dell, egg collection occurs both at the junction of the reservoir (Figure 19) and Parley's Creek and upstream of the Highway 65 culvert about 100 m, just below the installed barrier. A portable canopy provides shade during the egg collection (Figure 19).

Figure 19. Utah Division of Wildlife biologists conducting the 2012 egg take at Mountain Dell Reservoir.

Fish Production Data.—Total egg production by year and survival to eye-up and to stocking are compared among years in Table 12. Average monthly (Figure 20) and monthly peak flows (Figure 21) for the spring spawning period are provided for 2002-2006. The spawning operation typically occurs on the descending limb of the hydrograph. In 2008, 2009, and 2011 average fecundity was 1,674, 1,069, and 1,722 eggs/female, respectively (Wiley 2011). Among the three egg takes in 2009, the fecundity ranged from 825 to 1,497 eggs/female.

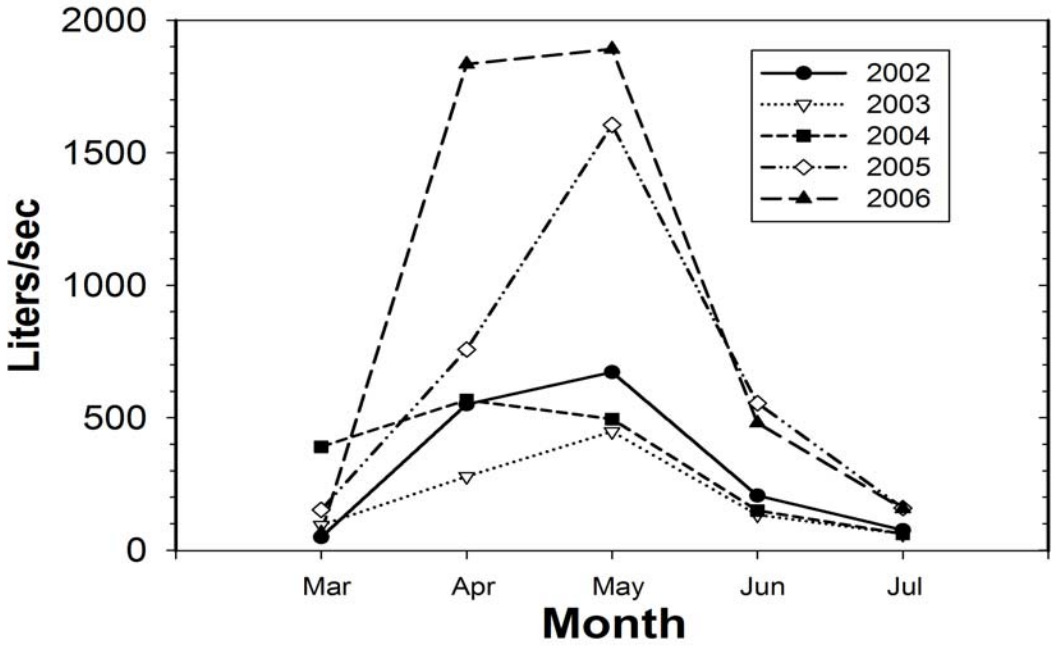

Figure 20. Average monthly flows in Mountain Dell Creek above Little Dell Reservoir between 2002 and 2006.

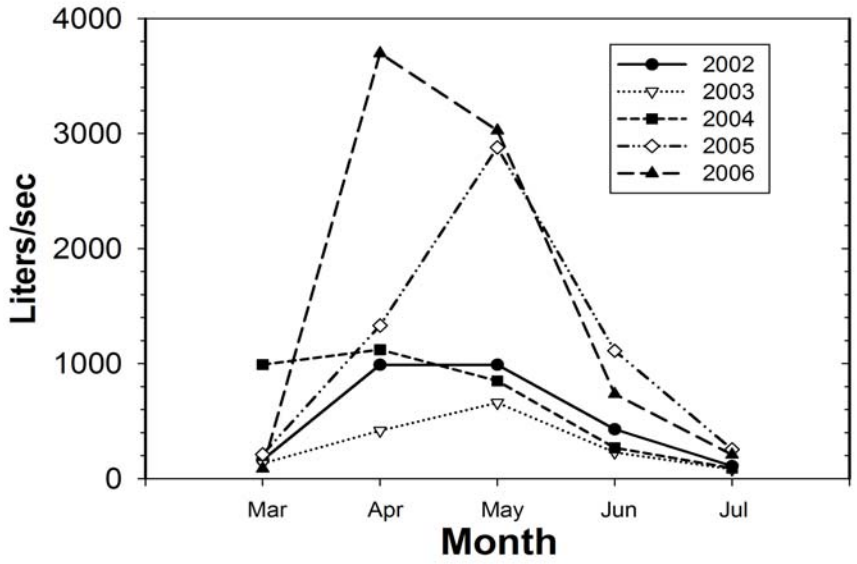

Figure 21. Monthly peak flows (cubic feet/sec) in Mountain Dell Creek above Little Dell Reservoir during 2002-2006.

Table 12. Summary of annual egg collection totals and survival to eye-up and stocking for Bonneville cutthroat trout from Mountain Dell (MD) and Little Dell (LD) reservoirs. Hatchery abbreviations: FE = Fisheries Experiment Station, Logan; MT = Mantua Hatchery; MW = Midway Hatchery; FG = Fountain Green. Data are from Slater and Wiley (2008), Wiley (2011), and FG hatchery records.

Year	Site	Total Green Eggs	Receiving Hatchery	Number of Eyed Eggs	Eye-Up (%)	Fish Stocked (N)	Survival from Eyed Egg to Stock (%)	Survival from Green Egg to Stock (%)
1996	MD	~25,500		2,400		2,313	96	9
1997	MD	45,000		N/A	N/A	5,000		11
2001	LD	17,134	FE	N/A	N/A	15,504		90
2002	LD	36,554	FE	28,822	79	21,456	86	68
2003	LD	36,015	MT	32,468	90	24,845	77	70
2004	LD	59,440	MT	34,919	59	29,519	85	50
2005	LD	51,283	MT	33,949	66	26,116	77	51
2006	LD,MD	186,546	MT	120,278	65	120,054	99	64
2007	MD	129,050	MW	108,546	84	87,750	82	68
2008	MD	176,580	FG	103,359	58	32,259	31	19
2009	LD, MD	64,827	FG	48,564	75	38,500	79	59
2010	LD	181,600	FG	140,980	78	114,300	81	63
2011	LD	149,648	FG	50,838	34	32,922	65	22
2012	MD	130,641	FG	86,115	61			

The size distribution (total length) of spawning fish is compared among years in Figure 22. In 2007 there was a noticeable shift in size towards larger fish compared to other years; other years with higher average lengths were 2002 and 2003. Interestingly, these years also had better than average egg survival. The mean length and weight of spawners is provided in Table 13. In 2011, three size classes appeared to be spawning (Wiley 2011).

Table 13. Average size and condition factor of Bonneville cutthroat trout collected at Little Dell and Mountain Dell reservoirs during annual wild egg take operations (Slater and Wiley 2008; Nielson and Slater 2009).

Year	Sample Size (n)	Total Length (mm)	Weight (g)	Condition Factor (K)
Mountain Dell				
1996	34	446		
1997	75	447[a]		
2006	309	466	1,069	0.96
2007	295	473	1,141	1.06
2008	400	453	960	1.04
2009				
2012				
Little Dell				
1998	102			
2001				
2002	98	523	1,549	1.08
2003	72	504	1,269	0.96
2004	208	423	780	1.00
2005	207	415	730	1.00
2006	445	405	660	0.99
2009				
2010				
2011		444	964	
Mean		454	1,014	1.01

[a]females only

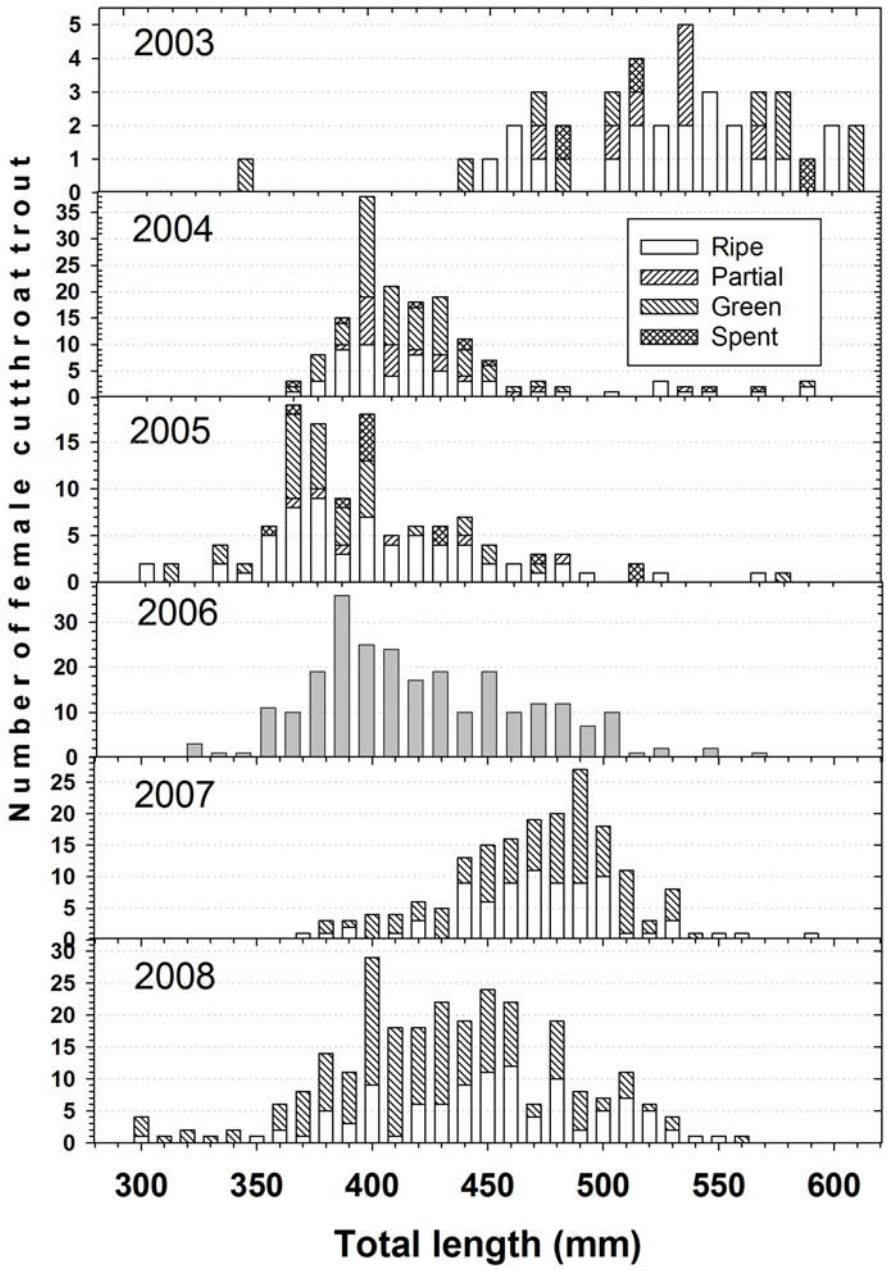

Figure 22. Comparison among years of the size distribution (number of fish within a 10-mm length category) of trapped female cutthroat trout from Little Dell and Mountain Dell trap operations. For 2006, all females are pooled, but graphs for other years indicate the numbers of ripe, partially spent, spent, and green females.

Manning Meadow Reservoir

Bonneville cutthroat trout

Oncorhynchus clarkii utah

Managers.— Fisheries biologists of the Southern Region UDWR Office; Glenwood Hatchery

Location.— Manning Meadow Reservoir is in the Fishlake National Forest, east of Marysvale, Piute County, Utah at 2,973 m elevation (9,750 ft; Judd 1997). It is in the Sevier River drainage of the Great Basin at the headwaters of Manning Creek (Hepworth et al. 2000). It has a total capacity of 1,230,000 m^3 (1,000 acre-ft) and surface area of 23.8 ha (59 ac; Judd 1997). Maximum depth is 20 m. The trap is located in Timber Creek, the principal tributary on the west side the reservoir .

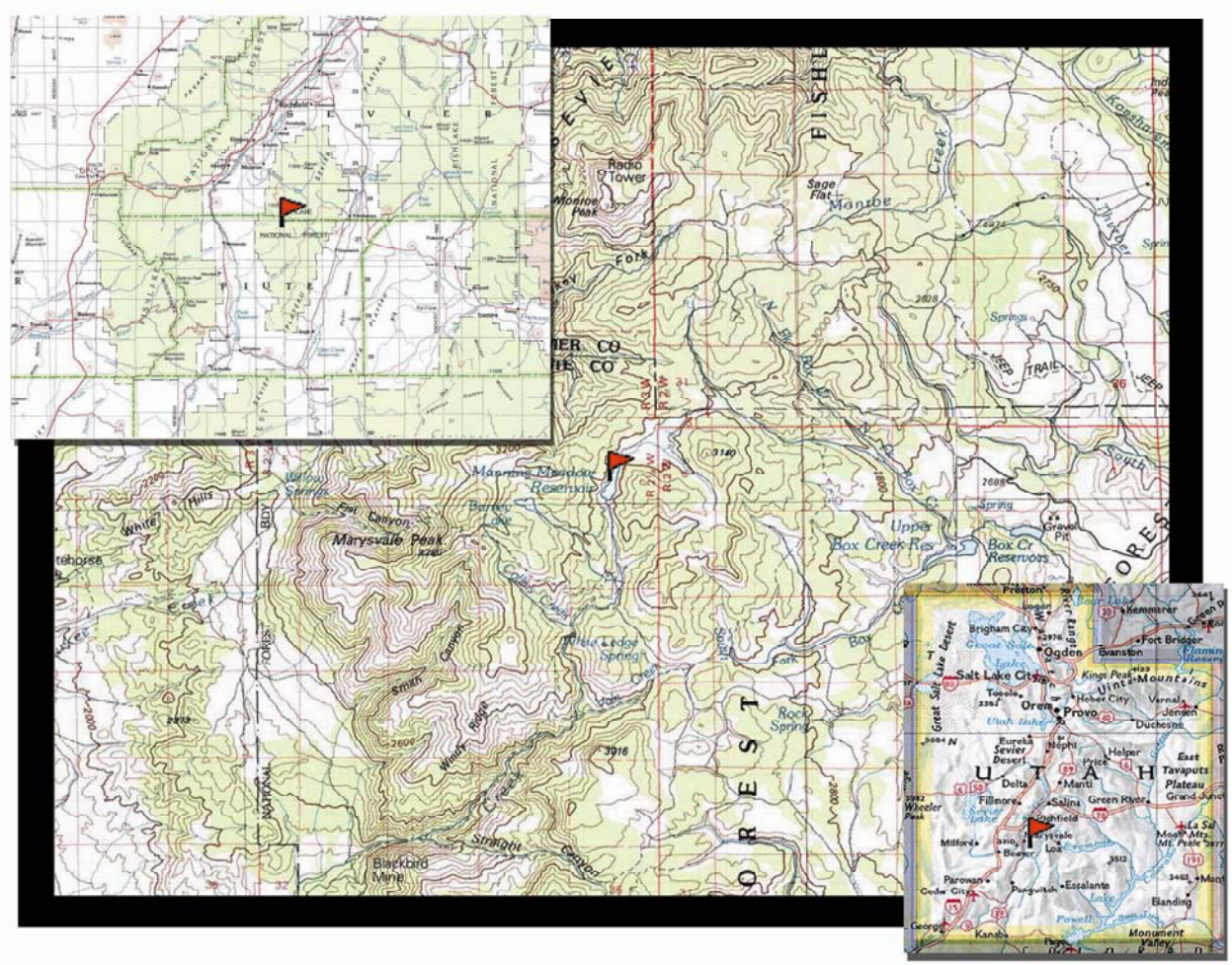

Figure 23. Location of Manning Meadow Reservoir (see red flag).

History.— Manning Meadow Reservoir was built in 1969 (Rawley 1975). It is classified as a eutrophic reservoir with a capacity of 1,230,000 m^3 (996 ac-ft), a mean depth of 5.5 m, and is at 2,973 m elevation (9,750 ft)(Judd 1997).

In 1990 and 1991, following rotenone treatment (1989), Bonneville cutthroat trout from Pine Creek (in Beaver County) were transplanted to the reservoir (Hepworth et al. 2000). The fish in Pine Creek were a mix of cutthroat trout from Reservoir Canyon Creek (Santa Clara River drainage), Water Canyon Creek (Santa Clara River drainage), and Birch Creek (Beaver River drainage), Utah. These populations were the only known pure cutthroat trout in that region at that time (Behnke 1976, cited in Behnke 1992; Hepworth et al. 1997). Fishing regulations subsequent to the introduction have included year-round closure (1990), seasonal closure to protect spawning fish (1990 to present), fly and lure gear restrictions (1991 to present), no harvest of cutthroat trout (1991-1994, 1999-2002), limited harvest of two fish (1995-1998) and one fish over 22 inches in length (2003 to present). A portion of the progeny from the egg takes are typically restocked in the reservoir as age 0, although some age 1 fish have been stocked.

The Bonneville cutthroat trout egg take operation began in 1992 (Hepworth et al. 2000). Fish were trapped annually since then in Timber Creek. Fish have also been trapped at the reservoir spillway where a permanent screen and weir board were installed in 1997 to control water levels in the spillway channel (Hepworth et al. 2000). The initial trap at the mouth of Timber Creek consisted of aluminum frames with removable rods that funneled fish into an excavated channel and maintained fish in holding compartments. Redwood planks were later added to prevent bank sloughing. In 1997, a concrete structure featuring 3 compartments was built. Poaching and vandalism have been a problem, so personnel are needed on site '24-7' during the trap operation.

Initially eggs were sent to the Fish Lake installation for incubation until eye-up, which took about 31-32 days. In 1995, Loa Hatchery received the eggs, but there was poor survival of eggs to first feeding. In 1998 and 1999, eggs went to both Fish Lake and the Fisheries Experiment Station. In 1999, the first take, which went to FES had an eye-up of 71%. The 2nd and 3rd takes went to Fish Lake for incubation, but had lower survival to eye-up (39.6, 30.6%, respectively). Since 2008, Fountain Green Hatchery has incubated the eggs until eye-up. In 1992, there were problems with air bubbles in the hatching jars at Fish Lake, which were fixed for the subsequent years (memo from Patrick Brown to Dale Hepworth, 1993). Formalin treatment of eggs daily with 1667 mg/L for 15 min during incubation was done each year. In 1994, fish were reared at Fountain Green Hatchery, although 16,700 eyed eggs were sent to FES for rearing for a strain comparison study in the Southern Region; the cutthroat trout at Fountain Green Hatchery suffered about 6.7% loss due to bird and raccoon predation, as well as gill disease. Coldwater disease has been a problem with Manning Meadow stocks from about 2006 to present (Ottenbacher et al. 2007, 2011).

Methods.— Most of the following data is from Hepworth et al. (2000) and a conversation with Darin Sampson, Glenwood Hatchery, in October 2012. Spawning typically occurs between mid-June and mid-July, with peak activity in late June and early July. Captured fish are held in the traps (cooler temperatures) or in cages (warmer temperatures) in the reservoir. Fish are sorted so that 'green' females are held in a reservoir cage until the next take, ripe females are left in the trap, and males are put in a separate cage. Spent females are held in a compartment of the trap until the operation is completed for the year, then returned to the reservoir. Spawning usually begins when the water temperature reaches 13-15°C . Eggs were taken on 2-3 dates each year at weekly intervals. Prior to 1995, eggs and sperm were taken from 2-10 fish at a time. Pairing varied each year, depending on available fish, but at least 20 paired matings were made. In subsequent years, eggs retained on cloth screens were pooled in groups of 5-10 females. The male-to-female ratio is usually 1:1. For fertilization, sperm is expressed directly onto the eggs and salt diluent is added to the mixture. In recent years, the sperm is pooled first before pouring on the eggs (Michael Hadley, fisheries biologist, pers. comm.). Eggs are rinsed after about 10 min and water hardened with water from the site. After water hardening for ≥1 h, the eggs are treated with 100 mg/L iodine and transferred to a cooler with well water from Glenwood Hatchery. Eggs are then transported to Fountain Green Hatchery for isolation and incubation.

Fish Production Data.— Female cutthroat trout in Manning Meadow Reservoir mature at age 3 (Hepworth et al 2000). Spawning dates and trap operation dates ranged from June 2 to July 13 between 1992 and 2012. These dates are shown in the table below for each year; lake temperatures for the first and last egg take are provided as well. A graph showing green egg numbers per take in relation to the time of the year (for the years that data was available) is given in Figure 24. There was no significant correlation between the number of green eggs taken per take and the egg survival to hatch (r^2 = 0.01, p = 0.58). A comparison of the percent hatch between the first-take eggs and the second-take eggs (paired t-test) indicated that there was no significant difference between the two (p = 0.39). Fecundity varied (Figure 25), but did not trend any direction. The number of females spawned each year, their mean length, and other production data are provided in Table 15. The size distribution of spawners (total length) is provided for a few years for which there were data (Figure 26).

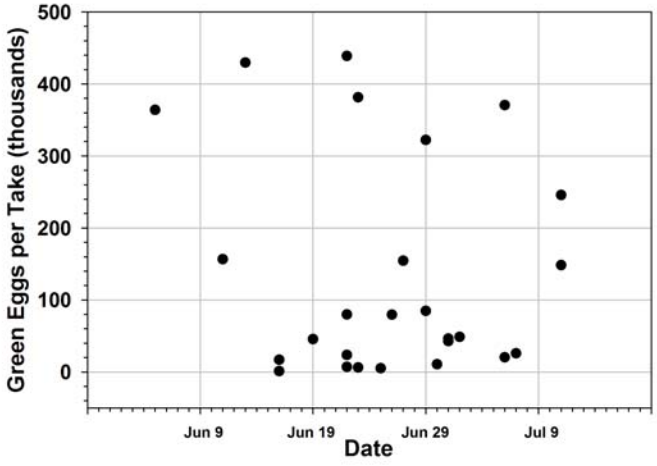

Figure 24. Relationship between total eggs taken and time of year at Manning Meadow Reservoir wild fish trap.

Table 14. Comparison of dates of Manning Meadow Reservoir trap operations among years for the egg take from Bonneville cutthroat trout (Hepworth et al. 2000; Ottenbacher et al. 2011).

Year	Trap Operation Start	First Spawn Date	Last Spawn Date	Number of Takes	Lake water temperature °C (°F)	
					First spawn	Last spawn
1992	2 June	16 June	30 June	3	12.8(55)	16.7(62)
1993	21 June	22 June	6 July	3	16.7(62)	16.7(62)
1994	14 June	16 June	22 June	2	13.3(56)	15.6(60)
1995	3 July	5 July	11 July	2	15.6(60)	16.7(62)
1996	24 June	26 June	2 July	3	14.4(58)	15.6(60)
1997	23 June	25 June	8 July	3	15.0(59)	16.7(62)
1998	29 June	1 July	13 July	3	14.4(58)	17.2(63)
1999	18 June	22 June	6 July	3	14.4(58)	16.7(62)
2000	5 June	6 June	13 June	3	14.4(58)	15.0(59)
2001	12 June	14 June	20 June	2	14.4(58)	16.1(61)
2002	7 June	11 June	18 June	2	14.4(58)	16.1(61)
2003	13 June	18 June	25 June	2	12.8(55)	13.9(57)
2004	10 June	16 June	23 June	2	15.0(59)	15.0(59)
2005	18 June	21 June	5 July	3	11.7(53)	17.8(64)
2006	9 June	13 June	23 June	3	15.6(60)	17.8(64)
2007	8 June	13 June	19 June	2	16.7(62)	18.3(65)
2008	18 June	23 June	27 June	2	15.6(60)	18.3(65)
2009	18 June	22 June	29 June	2	13.3(56)	17.8(64)
2010	17 June	22 June	29 June	2	13.3(56)	16.7(62)
2011	5 July	6 July	11 July	2	15.6(60)	18.9(66)
2012	31 May	5 June	11 June	2		

Table 15. Number of cutthroat trout females spawned, mean length of fish used for fertilization, total eggs collected, egg size, and fecundity are presented for each year of trap operation at Manning Meadow Reservoir (Hepworth et al. 2000). Also shown are survival to the eyed stage, to hatch, and to stocking, expressed as a percentage of green eggs. The number of fish stocked (all sites) from the resulting progeny is given for the year of stocking for both Age-0 and Age-1 stocking sizes. Hatchery abbreviations: FES = Fisheries Experiment Station; FL= Fish Lake; FG = Fountain Green; LO = Loa Hatchery.

Year	Number of Females Spawned	Mean Length (mm)		Total Green Eggs	Eye-up Hatchery, Mean Eye-Up (%)	Mean Hatch (%)	Survival from Green Egg to Stocking (%)	Number of Fish Stocked[1]	Total Number in trap
		Fe-male	Male						
1992	27	340.4		19,218	FL, 47.0	42.1	29	Y: 5,523 F: 0	
1993	61	386.1		61,148	FL, 100	69.6	53	Y: 18,499 F: 13,973	
1994	45	401.3		57,000	FL, 100	45.3	54	Y: 6,869 F: 16,498	
1995	218	342.9	365.8	176,896	LO, 14.8	10.1*	15	Y: 0 F: 25,750	
1996	198	342.9	360.7	136,980	FL, 63.5	60.6	55	Y: 8,895 F: 63,601	485
1997	141	365.8	375.9	92,603	FL, 82.9	55.0	37	Y: 16,214 F: 17,211	271
1998	116	363.2	322.6	80,514	FL + FES	74.9*	52	Y: 10,503 F: 31,204	330
1999	296	315.0	332.7	198,895	FL+ FES, 59.1	20.5	41	Y: 33,291 F: 47,501	744
2000	265	322.6	335.3	173,484	FL, 66.4	62.6*	59	Y: 18,893 F: 79,757	1,099
2001	516	327.7	342.9	330,139	FL, 75.8	74.1*	64	Y: 25,063 F: 161,374	1,809
2002	560	340.4	358.1	368,688	FL, 78.9	72.4*	68	Y: 27,745 F: 214,411	1,310
2003	270	358.1	368.3	223,614	FL, 82.2	73.8*	69	Y: 11,832 F: 141,985	753
2004	223	391.2	393.7	256,984	FL, 71.5	59.6*	41	Y: 9,346 F: 96,805	546
2005	154	426.7	414.0	216,438	FL, 80.6	69.9*	63	Y: 8,719 F: 128,011	352
2006	114	416.6	378.5	139,104	FL, 76.2	67.8*	36	Y: 0 F: 50,667	339
2007	466	350.5	363.2	475,488	FL, 78.3	74.0	58	Y: 3,637 F: 273,727	1,076
2008	540	355.6	370.8	536,112	FG, 57.8	49.1[a]	35	Y: 5,045 F: 182,847	1,451
2009	580	368.3	386.1	523,776	FG, 86.3	79.1	43	Y: 3,275 F: 225,326	1,681

2010	338	378.5	391.2	402,254	FG, 72.8	64.2	62	Y: 5,996 F:244,705	1,299
2011	516	388.6	401.3	616,512	FG, 35.4	27.8	15	Y: 5,500 F: 87,358	1,166
2012	433	442.5	401.4	525,764	FG, 73.3	68.7		Y: 5,500 F: 328,228	1,214
Mean		367.9	370.1	267,219		58.2	47.4		936.8

[1]Age-0 (fish stocked the same year it hatched)=F, Y= age-1 (stocked the year following hatch);* survival to initial feeding (hatch data not available); [a]hydrogen peroxide was used for egg disinfection

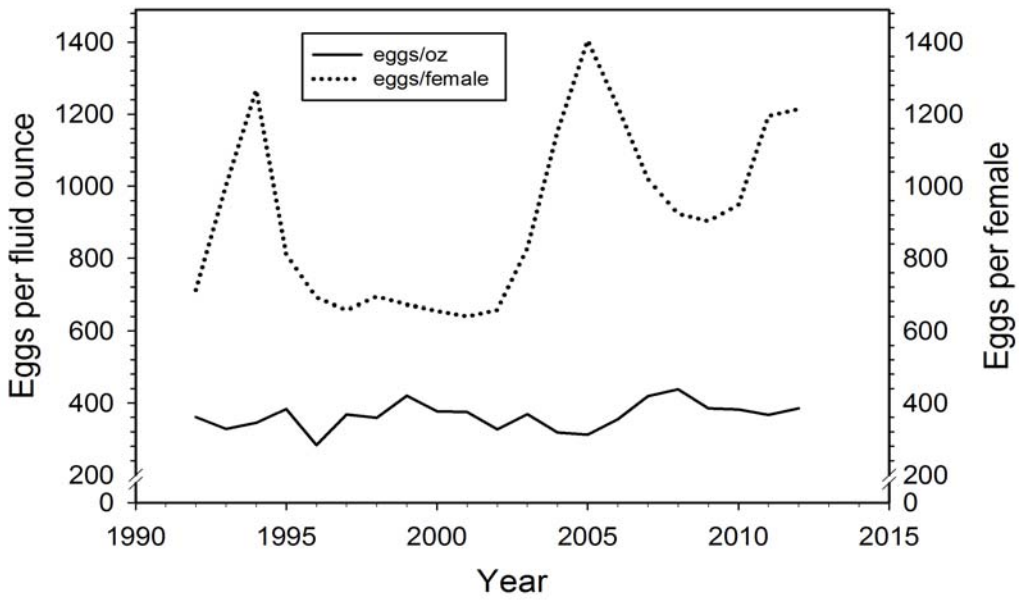

Figure 25. Comparison among years of fecundity (eggs/female) and egg size (eggs/oz) of cutthroat trout at the Manning Meadow Reservoir trap**.**

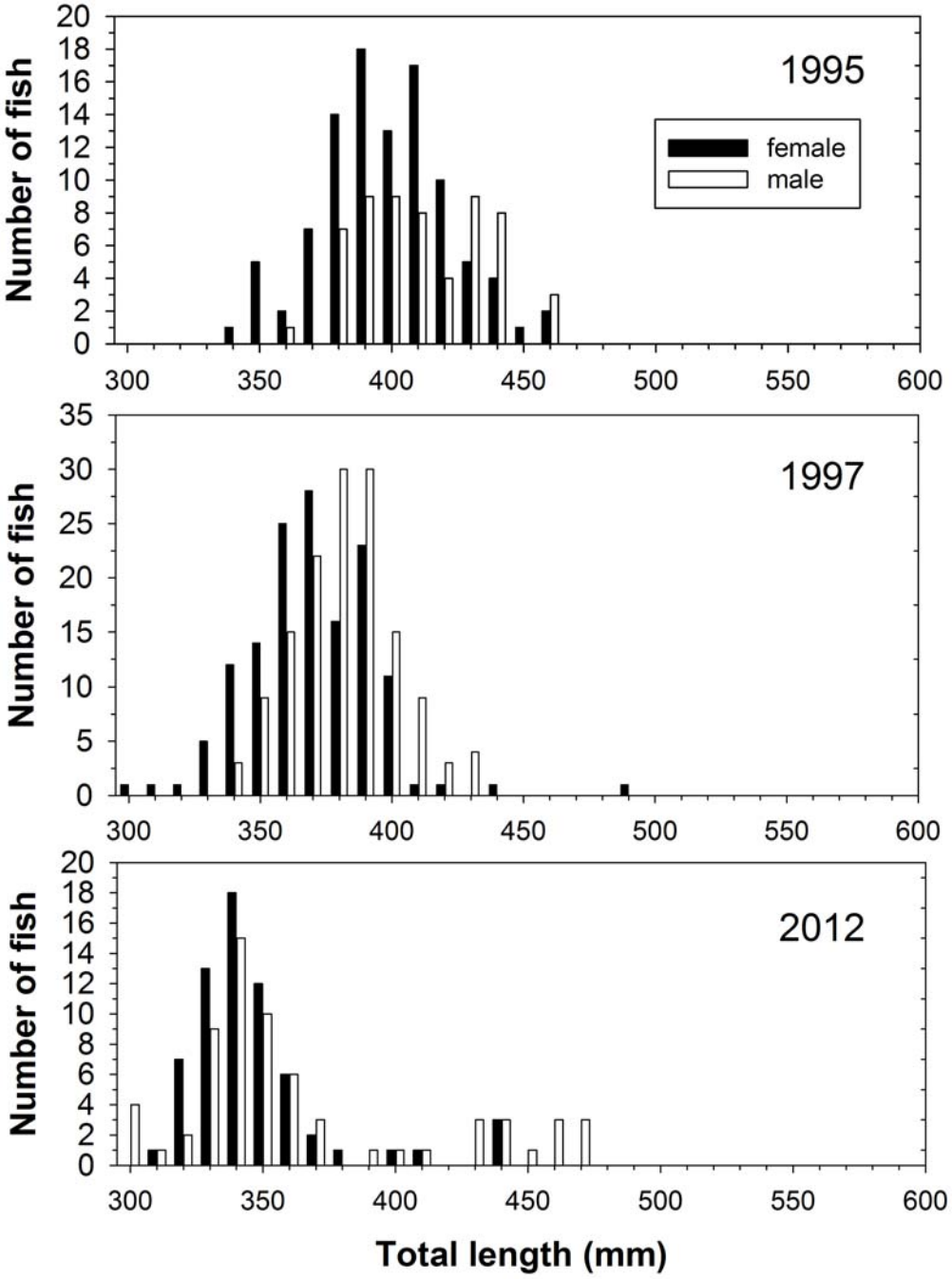

Figure 26. Length frequencies for cutthroat trout from Manning Meadow Reservoir used in the egg-taking operation in 1995, 1997, and 2012**.**

Sheep Creek Lake

Colorado River cutthroat trout

Oncorhynchus clarkii pleuriticus

Managers.— Fisheries biologists of the Northeastern Region UDWR, Whiterocks Hatchery

Location.— Sheep Creek Lake is situated in the Ashley National Forest, approximately 35 km southeast of the town of Manila. From Manila, travel 21.5 km south on Utah Highway 44 and turn right onto Forest Service Road 221. Travel along this road for 14 km and then turn right onto Forest Service Road 009. The lake is a short distance along this road. Water for Sheep Creek Lake comes from the Sheep Creek Lake Canal, which is diverted from Beaver Creek in the Carter Creek Drainage. The canal is approximately 4.8 km long and runs through mostly alpine meadow habitat. Water that leaves Sheep Creek Lake runs back into Beaver Creek above Brownie Lake and ultimately into Flaming Gorge Reservoir via Carter Creek. The lake sits at an elevation of 2,261 m and has a surface area of 34.8 ha (Judd 1997). The maximum depth of the lake is 5.2 m with an average depth of 3.1 m (Judd 1997). The lake has a maximum storage capacity of 1,130,000 m^3 (Judd 1997).

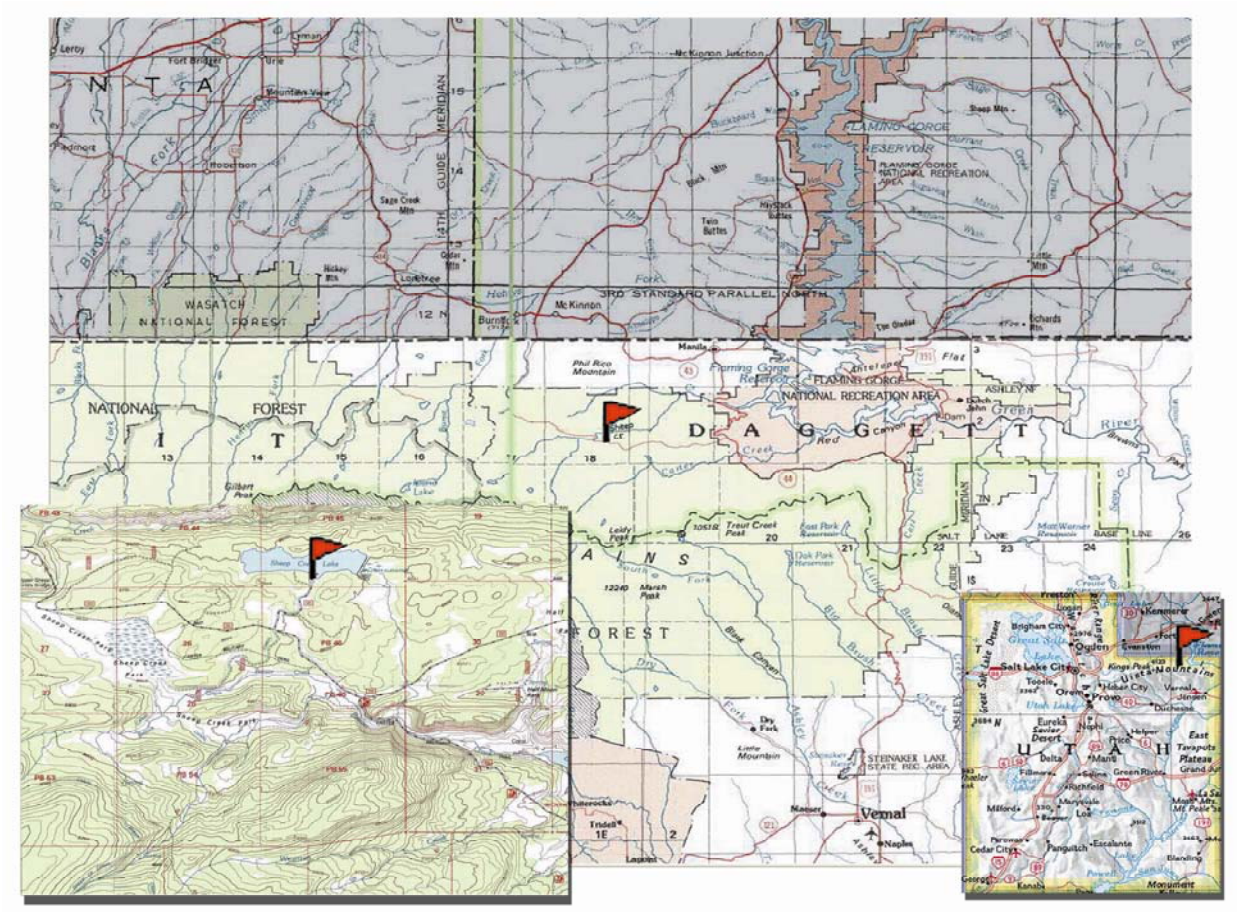

Figure 27. Location of Sheep Creek Lake (see red flag).

History.— Shortly after construction in the early 1960's, Sheep Creek Lake was stocked with Yellowstone strain cutthroat trout. The lake quickly became a productive source of eggs from these fish. In the 36th biennial report (UFG 1964), it is noted that 2.5 million cutthroat trout eggs were obtained from 'the newly constructed Sheep Creek Lake' and that it was being managed as a wild brood stock lake. From 1965 to 1971, one to three million eggs were taken each year (Table 14). In the 1974 biennial report (UDWR 1974), it was noted that the Sheep Creek Lake trap would be closed due to Strawberry Reservoir producing enough cutthroat trout eggs to meet demand. In 1995, an intense gill netting effort was initiated at Sheep Creek Lake. The goal of this gill netting operation was to remove Yellowstone strain cutthroat trout from the lake (Mullins and Crosby 2000). Approximately 500 south slope strain Colorado River strain cutthroat trout were transplanted from the West Fork of the Duchesne River annually from 1995 to 1997 (Mullins and Crosby 2000). The purpose of the gill netting/fish transplant project was to establish a south slope Uinta Mountain Colorado River cutthroat trout brood population in Sheep Creek Lake. The transplanted fish were fin-clipped to differentiate them from any resident cutthroat trout. The transplanted fish were treated with praziquantel (5 mg/L for 4 h) to rid the fish of tapeworms. No tapeworms have been found in the lake indicating successful treatment of the transplants. The first attempt to collect eggs from the transplanted Colorado River cutthroat trout occurred in 1998 one year before the disease certification process was completed for the lake (1999). On 9 June 1998 a stream-side incubator with 200,000 eggs was set up in the canal below the trap. However, fungal growth and high water temperatures in the canal resulted in the loss of most of the eggs, so the effort was aborted. Since 1999, when disease certification was completed, eggs collected from Sheep Creek Lake have been hatched at facilities in Logan, Whiterocks, Fountain Green and Big Springs (Ute Tribe Hatchery).

Figure 28. Sheep Creek Lake trap, old (late 1960s?) undated photo from Northeast Regional DWR Office archives**.**

Figure 29. Sheep Creek Lake Trap viewed from the lake (undated photo from Northeast Regional DWR Office archives, late 1960s?).

Recently, there was an effort to develop a North Slope Uinta Mountains brood population of Colorado River cutthroat trout in the lake as well. Genetic testing of fish from W. Fork Smith's Fork indicated no rainbow trout introgression, so 589 fish were transferred between 2003 and 2006 (106 to 180 fish/year; Garn Birchell, unpublished data; 2004 Performance Report, F-44-R Segment 24). The transferred fish were differentiated from the South Slope brood by different fin clips or by PIT tagging: adipose clip for South-Slope and a pelvic clip and/or PIT tag for the North-Slope brood. No fish were spawned unless they had been fin clipped or had a PIT tag. Progeny restocked in the lake were similarly clipped or PIT tagged to maintain the broodstock. In 2009, genetic analyses indicated that there was Yellowstone cutthroat trout introgression in the North-Slope Colorado River cutthroat trout source population (W. Fork Smith's Fork) that had been overlooked. As a result, egg takes from the North-Slope brood were discontinued (2009 Federal Aid Performance Report, F-44-R, Utah) until a genetically pure source population was located that satisfied disease certification requirements. A genetically pure population was located in the Little West Fork of the Black's Fork and disease certification was completed in 2011. In 2010, 200 Colorado River cutthroat trout from the Little West Fork of the Black's Fork (North Slope, Uinta Mountains) were transferred to the lake. Additional transplants from the Little West Fork of the Black's Fork to Sheep Creek Lake did not occur in 2011 or 2012 because an evaluation of the population size indicated it was not large enough to sustain large annual transplants. None of the 2010 transplanted fish entered the trap in 2011, but a few of them did in 2012 and a small number of eggs were collected. Efforts continue to be made by fisheries managers and fish health personnel to find additional source populations for developing the North-Slope Colorado River cutthroat trout brood population. Elk Creek harbors another genetically pure population and disease certification was started in 2012.

Methods.— The trap at Sheep Creek Lake is a permanent concrete structure with slots where welded aluminum screens and a funnel are slid into place to form the trap during spawning operations (Figure 30). The screens are used to keep the fish in the trap and to section the trap into separate compartments for fish sorting. The trap sits on the canal adjacent to the lake and water runs through it whenever there is water diverted into the canal. In preparation for the egg take, biologists turn off the water in the canal early in the spring to prevent fish from prematurely running up the canal and through the concrete structure that forms the trap.

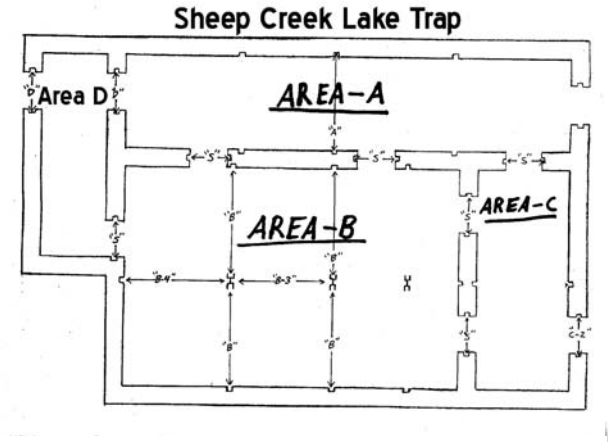

Figure 30. Top view schematic drawing of Sheep Creek Lake trap. Walls are concrete with numerous points for screen placement (arrows). Water enters the trap from the top right opening into Area A.

In mid June when the fish are ready to spawn, the aluminum screens and funnel are placed in the trap and the water is diverted back into the canal to

encourage spawning trout to run up the canal and into the trap. Personnel from the UDWR Northeastern Region camp on site and care for the trap. A canopy is erected over the trap for the duration of the operation and another portable canopy is set up for the day of the spawning operation. As fish enter the trap they are sorted morning and night; south slope green females, ripe females, and males are each assigned to separate compartments. Presently male and female North-Slope cutthroat trout are all placed into one cage because of low fish numbers entering the trap. Fish must have a fin clip to be spawned (adipose fin clip =CTCR South Slope; pelvic fin clip for North Slope) or a PIT tag. Untagged or unclipped fish are placed in a separate compartment and used for disease certification. Total lengths and weights are recorded at the time of sorting until 100 fish are measured. After ripe female fish are stripped they are returned to the lake. Green females are held in the trap for stripping on later spawn dates. Males that are stripped are also placed back into the trap for possible use during later spawn dates. Eggs from 5 females are pooled, collecting ovarian fluid for disease testing. The eggs are fertilized by 5 males, expressing the sperm directly on eggs, though a screen is used to keep feces off the eggs. A salt diluent solution is used to initiate fertilization. After 3-5 min, Whiterocks Hatchery water is used to rinse the eggs, which are put in a cooler with hatchery water to water harden. After 1 h the eggs are treated with 100 mg/L iodine for 10-15 min and then are transported to Fountain Green Hatchery.

Fish Production Data.— Egg production records for the early years using Yellowstone strain cutthroat trout are given in Table 16. In 1999, annual egg collections were reinitiated using south slope Colorado River strain cutthroat trout (Table 17). The progeny from the egg takes have been stocked into South Slope Uinta lakes for sport fishing and in several streams for establishment of conservation populations. Fish were also given to the Ute tribe for south-slope stocking and for maintaining the brood population at Sheep Creek Lake. In 2000, about 125,000 CTCR eggs were collected and sent to Whiterocks Hatchery; 5,000 went to the Ute tribe. In 2001, 124,000 eggs were taken.

Figure 31. Biologists Calvin Black and Pat Lakin spawn Colorado River cutthroat trout at Sheep Creek Lake, 2010 (photo by Garn Birchell).

Table 16. Comparison among years (1965-1974) of the total number of Yellowstone strain cutthroat trout eggs taken from the Sheep Creek Lake trap (UFG 1966, UFG 1968, UFG 1970, UDWR 1972; UDWR 1974).

Year	Number of Eggs Collected	Year	Number of Eggs Collected
1965	3,023,664	1970	1,624,054
1966	1,902,720	1971	1,364,580
1967	1,203,873	1972	905,018
1968	2,680,300	1973	376,084
1969	1,585,575	1974	126,054

In 2002 and 2003, eggs were transferred after eye-up to the Fisheries Experiment Station, but hatched in transit, leading to high mortality in 2002. In 2003, 221,000 green eggs were taken of which 125,000 eyed up. Eventually Uinta Lakes were stocked with 64,956 and 1,200 were put into Sheep Creek Lake (Trap set June 6, spawned June 10th, eggs went to FES). The survivors were stocked back into the lake. In 2005 and 2006, about 243,000 and 300,000 eggs were collected, respectively, from cutthroat trout there (2005 and 2006 federal aid reports, F-44-R, Utah). In June 2008, 403,560 eggs were collected which resulted in 85,719 fingerlings (21.2% survival; 2008 Federal Aid Annual Report, F-44-R, Utah). After 2008, the number of eggs collected from the lake decreased (37,128-220,632 eggs collected, average = 121,644 eggs). It is not known why the numbers of eggs collected has decreased.

Fewer eggs have been collected from North-Slope Colorado River cutthroat trout than south slope cutthroat trout because a sufficient number of brood fish have never been transplanted into the lake. Eggs were collected from North-Slope fish in 2005-2008, and 2012. The numbers of females spawned during those years has ranged between one and seven. A total of 10,881 eggs were collected in 2008 and 512 eggs were collected in 2012. The number of eggs collected in 2005-2007 is not known. In 2008, 26% of the collected North-Slope eggs eyed. The eye-up rate of the eggs collected in 2012 was 0%. The eye-up rates of north slope eggs collected in 2005-2007 is not known, however, it is known that approximately 150 north slope fingerling were stocked back into the lake in 2005. In 2006, 211 fingerling were re-stocked into the lake and in 2007, approximately 100 fingerling were stocked.

Table 17. Annual number of spawners, total green eggs, and their survival to eye-up or to stocking (as a percentage of green eggs), for south slope Colorado River cutthroat trout from Sheep Creek Lake. Abbreviations: FES = Fisheries Experiment Station, FG = Fountain Green, WR = Whiterocks. (Data from hatchery records, Mullins and Crosby 1999, 2000, 2003, 2004, unpublished data of Garn Birchell).

Year	Date	Number Trapped	Number Spawned	Total Green Eggs	Fingerlings Stocked	Eye-up Hatchery	Survival to Eye-Up (%)	Survival to Stock (%)
1999				198,420	78,246	FES	89.3	39.4
2000		290		125,000	26,611		Poor[1]	21.3
2001	5-Jun			44,222		WR		
	15-Jun			79,778	23,648		76.1	29.6
	Total	736		124,000				
2002	1st take			117,696	109,945	FES	85.6	93.4
	2nd take			206,180	29,618		84.8	14.4
	Total	2,366		323,876				
2003	10-Jun			221,079	68,733	FES	66.5	31.1
2004		846		249,823	31,685	FES	77.8	12.7[2]
2005	21-Jun		153	163,216		FES	67.7	
	24-Jun		75	80,028			62.4	
	Total	1,270	228	243,244	78,758			32.4
2006	13-Jun		42	32,113	12,016	FES	50	37.4
	16-Jun		19	74,816	39,313		71.9	52.5
	21-Jun		200	196,261	16,432		49.2	8.4
	Total	921	261	303,190	67,761			32.3
2007	20-Jun	483	115	164,960	12,924			7.8
	27-Jun		30					
	Total		145					
2008	26-Jun	428	233	403,560	85,719	FG	55	21
2009	26-Jun	418	121	173,628	27288[3]	FG	53	
2010	29-Jun		50	32,412		FG	49	
	7-Jul		27	22,776				
	Total	212	77	55,188	616[4]			1.1
2011	28-Jun		25	33,456		FG	17	
	6-Jul		?	3,672			0	0
	Total	110	25	37,128	498[5]			1.3
2012	18-Jun		113	140,160		FG	34	
	26-Jun		58	80,472			0	0
	Total	218	171	220,632				

[1]Poor eye-up thought to be due to warm water temperature in canal where fish were held prior to spawning (Mullin and Crosby 2000). [2]16,417 sac-fry culled (excess), so survival would have been higher (Wagner et al. 2007).
[3] From online stocking history database:22,823 stocked into high lakes and Sheep Creek. Sheep Creek stock from

2009 of 1,655 subtracted because these fish would have been spawned in 2008. Fish from the 2009 egg take that were held over and stocked in 2010 include 3,060 for Sheep Creek Lake (the database shows these fish as CTCRNSSL, but this has to be an error because no north-slope fish were spawned in 2009), 2004 for Broken Arrow Creek, and 1,056 for Jackson Lake. [4]from 2011 stocking report; [5] from 2012 stocking report.

Strawberry Reservoir

Strawberry Reservoir cutthroat trout and Bear Lake cutthroat trout
Oncorhynchus clarkii bouvieri x *O. clarkii utah* and *O. clarkii utah*

Managers.—Strawberry Project fisheries biologists; Midway and Kamas hatcheries

Location.— Strawberry Reservoir is in Wasatch County, about 23 miles south of Heber City, just south of U.S. Route 40. It is an impoundment of the Strawberry River, an upper Colorado River tributary. The reservoir is at 2,317 m elevation, has a surface area of 3,994 ha (17,000 ac) and a volume of about 1,364,314,500 m^3 (1,106,500 ac-ft) (Judd 1997). The trap is located on the Strawberry River near the Forest Service Visitor Center, about 6 river-km upstream of the reservoir.

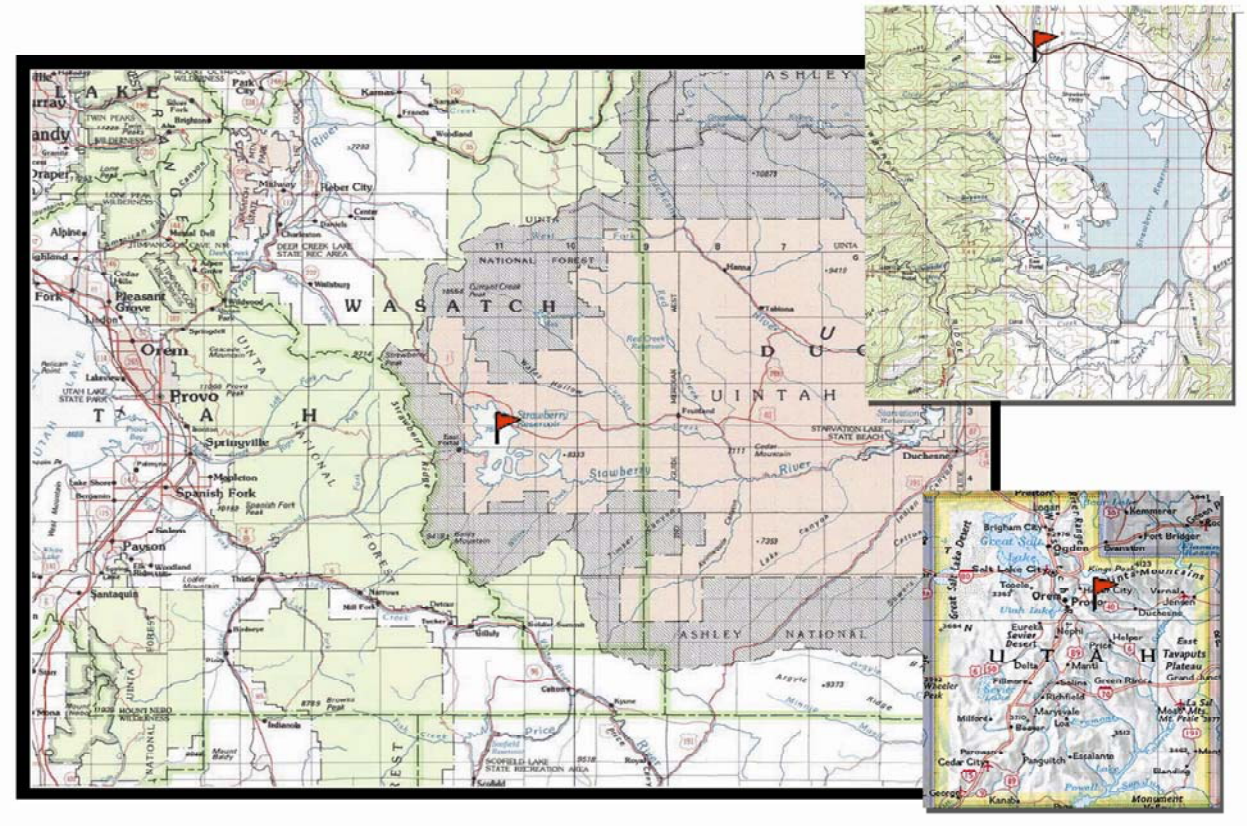

Figure 32. Location of Strawberry Reservoir (see red flag).

History.— Strawberry Reservoir was initially built in 1906 and was the first Bureau of Reclamation project in Utah (Judd 1997). The Soldier Creek Dam on the Strawberry River was completed in 1973, increasing the capacity of Strawberry Reservoir to 1,106,500 acre-ft (17,160 surface acres)(UDWR 1972). In a 1922 biennial report (UFG 1922), the initial trap installation at Strawberry Reservoir was mentioned: " *Great quantities of spawning fish, in passing up the streams during the flood waters, have*

year after year become stranded in the upper tributaries of the Strawberry River and the receding waters have left them in pools to die before the spawning season is over. In order to overcome this loss it was necessary to construct a dam which would obstruct the passage of fish above a certain point, and this work, which was completed this year, will not alone prevent the loss of a great number of fish, but will also furnish a place where the fish may be held and great quantities of eggs for hatching purposes can be collected."

Cutthroat trout have been taken from the Strawberry Reservoir trap for many years, as well as kokanee and rainbow trout (see Table 14). The 1940 biennial report (UFG 1940) noted that 10 million eggs were taken from native trout (i.e., cutthroat trout) from Strawberry Reservoir and Schofield Reservoir during each of the last two years and "*…represents the first egg take from native trout in Utah since 1931*". In 1944, the construction of a 'new cement fish trap' at the junction of Co-op Creek and Strawberry River was noted (UFG 1944; see photo). A 'spawning house' was constructed on Clyde Creek (Strawberry River tributary) in 1954

Figure 33. Wild trap on Strawberry River (UFG 1944).

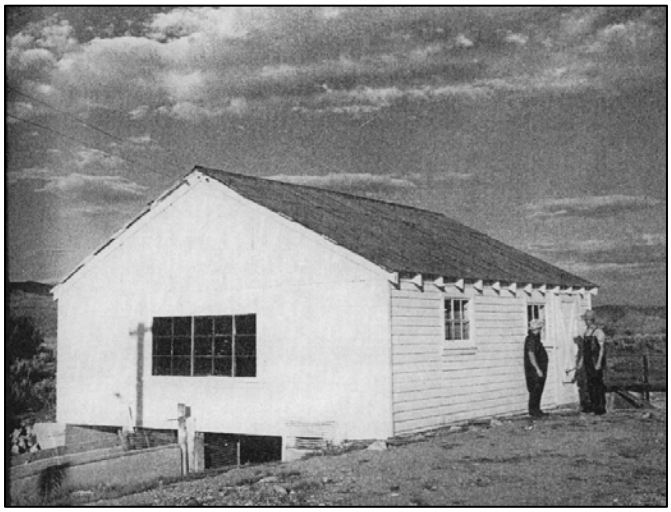

Figure 34. Clyde Creek spawning house, 1954 (UDWR 1954)

(Figure 34, UFG 1954). On Indian Creek, a spawn taking station was built circa 1956 (UFG 1956). The station included a fish ladder from the reservoir to the Indian Creek Canal and a holding pen and trap on the canal. The first two years of this station yielded 3.1 million cutthroat trout eggs.

In 1986, the Strawberry Project was initiated, providing permanent staff dedicated solely to management of the fisheries in the reservoir (Lentsch and Spateholts 1989). The Strawberry Reservoir trap is managed by the Northeastern Regional Office of the UDWR, principally through the Strawberry Reservoir special project personnel.

Cutthroat trout in Strawberry Reservoir were a mix of Yellowstone and Bonneville genotypes (Martin et al. 1985) prior to the massive rotenone treatment project completed in 1990. The reservoir was previously treated with piscicide in 1961 (Rawley 1975) and the drainage inundated by Soldier Creek Dam was also treated with rotenone and explosives in 1973 to remove 'rough fish'(Tate et al. 1973). After the 1990 treatment, which was the largest rotenone treatment project in the world, Bear Lake cutthroat trout were used for restocking (Knight et al. 1994; Knight et al. 1999).

In 1978, Charlie Thompson reported that about 6,979,211 cutthroat trout eggs were taken from fish at the trap and distributed to Springville, Whiterocks, Kamas, Loa, Panguitch (Mammoth Creek), Jones Hole, Fountain Green, and Logan hatcheries (Thompson 1978c). At that time, the usual technique was to express eggs and sperm into a pan, pooling about 10 females at a time (Thompson 1978c). Therefore, ovarian fluid was part the milieu. Tests that year by Ron Goede, Fisheries Experiment Station director, compared that standard method with eggs collected on a screen, so all the ovarian fluid drained off. A third treatment evaluated air spawning. Survival to eye-up was 88.7% for eggs collected by air spawning, 82.8% for eggs collected on a screen, and 58.6% using the conventional method (Thompson 1978c). From 1986 to 1989, trap operation was used to collect biological data (species, sex, reproductive status, total length) in addition to egg collection (Lentsch and Spateholts 1989). In 1989, 2,870 unmarked Strawberry cutthroat trout, 688 fluorescent-dye marked Strawberry cutthroat trout, 15 Bear Lake cutthroat trout, 3 rainbow trout, 36 mountain sucker, 2 speckled dace, 1 redside shiner, and 1 Utah chub were captured in the trap (Lentsch and Spateholts 1989). After the 1990 rotenone treatment, cutthroat trout egg collection was reinitiated in 1997. However, although biological data was obtained from trapped fish, egg collection did not occur every year, depending on demand and the egg take at Bear Lake and from the captive brood population at Mantua Hatchery.

Methods.— An electric barrier is used in the Strawberry River (see photo at right) to prevent fish from going any further upstream than the trap during trap operation times. Currently, no cutthroat trout trapping occurs at Strawberry Reservoir since production from Bear Lake and Mantua Hatchery is sufficient to meet the current needs. See the kokanee section for additional details on spawning methods and trap design.

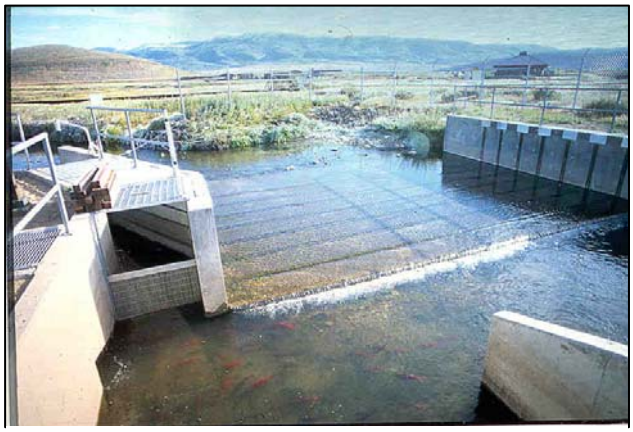

Figure 35. Electric weir on the Strawberry River.

Fish Production Data.— After the rotenone treatment in 1990, Some biological information was collected by Knight et al. (1994). Fecundity of Bear Lake cutthroat trout sampled in 1994 averaged 2,545 eggs for fish ranging in size from 360 to 570 mm. The relationship with size was expressed as: Fecundity = $0.008 \times TL^{2.412}$, where TL = total length in mm (Knight et al. 1994). Egg retention averaged 74 eggs/fish (SD = 141, *n* = 14). In 1994, only 162 cutthroat trout were captured at the Strawberry River trap.

The timing of runs was similar among the tributaries, with peaks around late May to early June (Knight et al. 1994). Daily cutthroat trout numbers entering into the traps on Indian Creek, Strawberry River, and Trout Creek is shown in Figure 36 (Knight et al. 1994). In 1997, 312 cutthroat trout (162 females) entered the Strawberry River trap from May 23 to June 26; the run peaked in mid-June (Wilson and Spateholts 1998). The mean total lengths of cutthroat trout entering the trap that year were 454 mm for males (range, 200-570 mm) and 471 mm for females (330-590 mm). The length frequency distributions for cutthroat trout entering the trap from 1999-2009 are shown in Figure 37 (Ward and Robinson, unpublished data).

In 1997, ages of spawning females were estimated to be principally 5-year olds, with some 4- and 6-year olds as well. Spawning males were principally 4- and 5-year olds, though some 3- and 6-year olds were present too. In 1997, 45 females gave 76,000 eggs (1,688 eggs/female) on 18 June (Strawberry River trap) and 98 females gave 143,100 eggs (1,460 eggs/female) on 24 June (Aspen boat ramp netting). Eye-up of the latter lot was poor (28%) compared to the first (89%), which was attributed to poor sperm production and over-ripe condition of the eggs at the Aspen site (Wilson and Spateholts 1998).

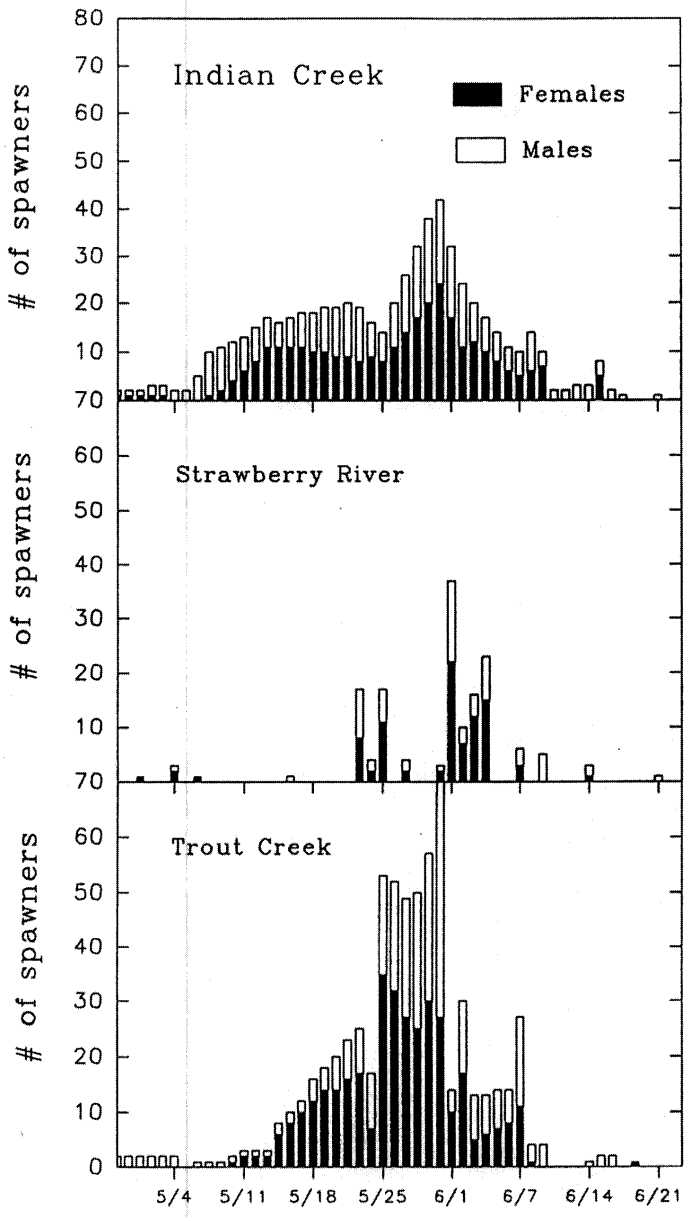

Figure 36. Numbers of spawning cutthroat trout entering three Strawberry Reservoir tributaries daily in 1994 (Knight et al. 1994). Trout Creek and Indian Creek numbers were interpolated between alternate days.

Table 18. Comparison among years of the total number of green eggs obtained from wild rainbow and cutthroat trout in the Strawberry Reservoir trap (UFG 1964; UFG 1966; UFG 1968; UDWR 1972; UDWR 1974). The survival of eggs to the eyed stage is given in parentheses for a few years where data exists (Annual Statewide Fish Production Reports, 1981 to 1991).

Year	Cutthroat Trout Eggs	Rainbow Trout eggs
1957	2,076,152	339,456
1958	1,312,322	None
1959	1,311,362	None
1960	1,223,154	59,778
1961	1,717,594	None
1962*	None	None
1963	587,844	
1964	698,922	
1965	638,723	None
1966	2,002,554	234,952
1967	4,748,921	750,428
1968	5,952,816	199,716
1969	6,198,071	None
1970	6,495,124	445,116
1971	9,941,046	None
1972	6,850,710	183,521
1973	7,530,620	None
1974	6,227,712	17,952
1981	3,115,446 (86.8%)	33,345 (80.3%)
1982	2,746,080 (90.3%)	None
1983	2,415,000 (79.0%)	None
1984	1,086,797 (95.5%)	None
1990	914,784 (78.4%)	None

*Rotenone treatment in 1961

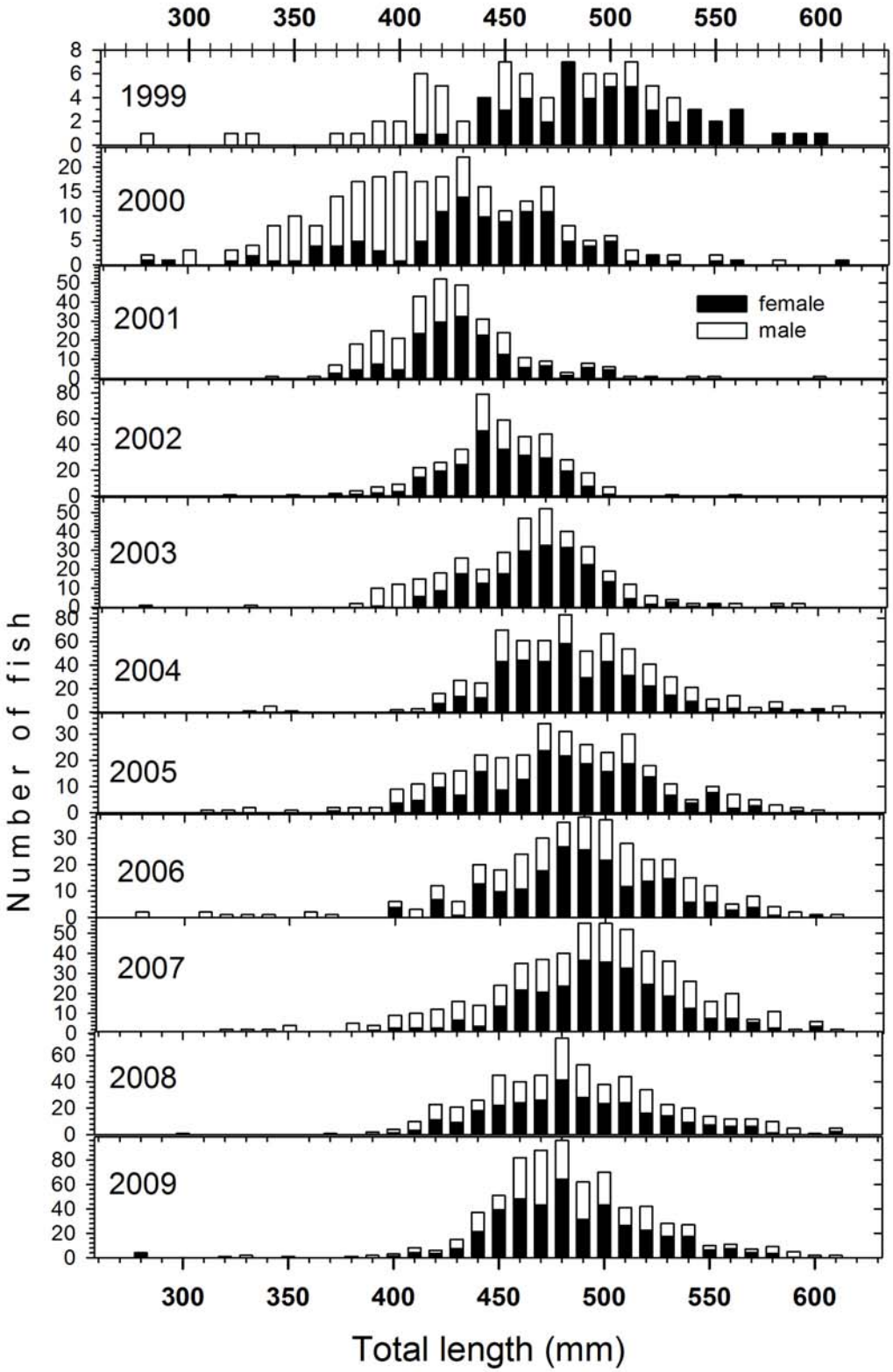

Figure 37. Comparison of the size distribution among years (numbers within a 10-cm total length class) of Bear Lake cutthroat trout captured in the Strawberry River trap.

Table 19. Bear Lake cutthroat trout egg collection data for Strawberry Reservoir, 1997-2012*.

Date	Total Green Eggs Collected	Eye-Up (%)
6-18-97	76,000	28
6-24-97	143,100	89
1998	508,716	72
1999	231,346	72
2000	441,101	ND
2002	849,112	ND
2004	620,375	81
6-12-08	71,136	67
6-17-08	94,180	94
6-26-08	422,820	38

* No eggs were collected in 2001, 2003, 2005-2007, 2009-2012

Trout Creek, West Desert

Bonneville cutthroat trout

Oncorhynchus clarkii utah

Location.— Trout creek is located in the Deep Creek Mountain Range, approximately 27 km south of Callao, Utah. From Callao, one can access the creek by traveling south on the Snake Valley Road. The headwaters of the creek sit at an elevation of approximately 3,000 m. The elevation where the creek crosses the Snake Valley Road is 1,600 m. The distance from the headwaters to the Snake Valley Road is 10 km. Trout Creek is classified as a first order stream. Several trap sites and fish rearing locations have been used by the Utah Division of Wildlife Resources in the Deep Creek Mountain Range. All of the creeks in the mountain range are first order and travel approximately 10 km before reaching the Snake Valley. The changes in elevation of these creeks from their headwaters to where they reach the floor of the valley are similar to that of Trout Creek. During the late 1990's and early 2000's fish were reared at a ranch owned by Buck Douglass. The Douglass Ranch is near where Granite Creek crosses the Snake Valley Road (18 km south of Callao) and sits at an elevation of approximately 1,600 m.

History.— In 1974, a pure population of Snake Valley Bonneville cutthroat trout was identified in upper Trout Creek (in the west Desert, near Callao). The next year, another pure population was discovered in nearby Birch Creek. To preserve the genetic purity of these populations, a series of fish removals and transplants occurred in the late 1970's. The first removal of rainbow trout occurred in lower Trout Creek in October 1977. Birch Creek was treated with rotenone in spring 1978. During the fall of 1978, 90 adult Snake Valley Bonneville cutthroat trout were transplanted from the upper reaches of Trout Creek into the lower reaches. An additional 60 fish were transplanted into Birch Creek. By 1982, rainbow trout had re-colonized the lower portions of Trout Creek (below a natural barrier). The lower portions of Birch Creek had no fish, but, a healthy population of pure strain cutthroat trout was established in the upper portions of the creek. Both in fall 1991 and spring 1992, rotenone treatments were carried out to remove rainbow trout and rainbow x cutthroat hybrids from the lower portions of Trout Creek.

In addition to fish transplants, the UDWR operated an egg take program using Trout Creek fish. The intention of this egg take program was to expand the population of Snake Valley Bonneville cutthroat trout into at least five additional streams in the watershed. Apparently this egg take began in 1978. A UDWR memorandum notes that during this year 349 eggs were collected and transported to the Springville Hatchery for incubation. Approximately 100 of the eggs hatched. The fate of these hatched eggs is not known. The same memorandum noted that in the future that the UDWR intended on incubating eggs within Trout Creek. Whether or not this was done and the success of this program is not known. The history of the egg take program at Trout Creek during the 1980's is not known. Renewed interest in the program was expressed during the early 1990's. In 1991, 450 eggs were collected from Trout Creek fish. These eggs were incubated in streamside incubators and approximately 165 fish were released into the stream at swim-up. Starting in 1992, the location of where eggs were incubated was

moved from Trout Creek to nearby Granite Ranch. This was done to facilitate the monitoring of the eggs. The eggs were incubated in a streamside incubator that utilized Red Cedar Creek as a water supply. After hatch, the fry were transferred to a circular tank that was held in a shed on the Granite Ranch property. The manager of the ranch raised the fish to 2.0-2.5 inches in length. They were then stocked into nearby streams. In 1992, 700 eggs were collected and incubated in this facility. The survival of these eggs was low and only 19 fish were ultimately stocked (into lower Birch Creek). In 1993, 1,000 eggs were collected and 142 were stocked into lower Birch Creek.

In 1997, another shift in the collection of eggs from Trout Creek fish occurred. During this year, a refuge population of Snake Valley Bonneville cutthroat trout was established in a pond owned by Buck Douglass. Fish culture operations were moved from Granite Ranch to the Douglass property. Eggs were collected from both Trout Creek fish and fish from the refuge population pond. These fish were reared on the Douglass property. Similar operations occurred through 2008.

Methods.— The methods used to collect eggs from this trap operation are not known. It is assumed that the eggs are reared using normal culture methods.

Fish Production Data.— Little data from this trap is still available. A timeline of known fish culture operations using Trout Creek fish is presented in Table 16. Data from 2003-2005 is available and is presented in Table 17.

Table 20. Timeline of known fish culture activities in the Deep Creek Mountain Range, Utah.

Year	What Occurred
1974	Pure strain Snake Valley Bonneville cutthroat trout discovered in upper Trout Creek
1975	Pure strain Snake Valley Bonneville cutthroat trout discovered in Birch Creek
1977	Rotenone treatment of lower Trout Creek; subsequent transfer of 90 adult cutthroat from the upper to the lower section of Trout Creek
1978	349 eggs taken from fish at Trout Creek, eggs incubated at Springville, 100 hatched; Birch Creek treated with rotenone, 60 adults moved from Trout Creek into Birch Creek
1982	Rainbow trout re-discovered in lower Trout Creek, another rotenone treatment occurred in this section
1989	Rainbow trout re-discovered in lower 3/4 of Birch Creek
1991	450 eggs collected from Trout Creek fish, eggs incubated in stream and 165 hatched and released back into Trout creek; Lower 3/4 of Birch Creek treated with rotenone
1992	700 eggs collected from Trout Creek fish, eggs incubated in stream-side incubator at Granite Ranch, 41 eggs hatched and reared in troughs at Granite Ranch, ulimately all fish died prior to stocking
1993	1,000 eggs collected from Trout Creek fish, eggs were incubated and raised at Granite Ranch, ultimately 142 fish survived and were stocked into Birch Creek
1995	No cutthroat eggs taken, instead, rainbow x cutthroat eggs taken from Granite Creek; this was done to work on culture techniques
1997	Refuge population established at ranch owned by Buck Douglass, three ponds and primative culture facilities established; fish transplated from Trout Creek to ponds at ranch

2001	Douglass Ranch fish started on artificial feed
2002	300 eggs stripped at Douglass Ranch, incubated streamside, reared in ponds; 21 fish transplanted from Trout Creek to Douglass Ranch; 4th pond constructed
2003	1,300 eggs stripped and reared as in 2002; 35 fish transplanted from Trout Creek to 4th pond
2004	3,200 eggs stripped and reared as before; 20 fish from rearing pond placed into Indian Farms Creek
2005	6,000 eggs stripped, 2,200 of which hatched, reared at Midway, stocked into various Deep Creek streams at 3 inches in fall; 1,400 fish from Douglass Ranch stocked into Toms Creek, 300 into Basin Creek
2006	6,500 eggs stripped, 3,400 of which hatched, reared at Midway; 3,000 fish from Douglass Ranch split and stocked into Red Cedar, Indian Farms, and Toms Creek
2007	Die-off of brood fish in pond
2008	Program officially ended

Table 21. Numbers and total lengths of female and male fish collected from Douglass Pond in 2003, 2004, and 2005. When available, the numbers of eggs collected and the number of eggs/oz is presented.

Year	Date	# of Females Collected	# of Males Collected	Average Female TL (mm)	Average Male TL (mm)	# of Females Spawned	# of Eggs Collected	Eggs/oz
2003	5/12	11	8	375	392	6		
	5/19	4	2	368	292	1		
2004	5/7	15	22	294	303	9	3180	354
2005	5/6	13	17	309	280		3000	
	5/17	17	10	278	295	6		

Kokanee Salmon

Porcupine Reservoir

Porcupine Reservoir, near Avon, Utah, on the Little Bear River drainage, was built circa 1963 and kokanee were stocked soon after. Egg takes were initiated at Porcupine Reservoir in 1991 (Wilson 1991, 1992), when Strawberry Reservoir kokanee were not available due to the rotenone treatment. The eye-up for 1991 and 1992 was about 55-56% for both years (Wilson and Spateholts 1998). The egg take was discontinued in 1993 due to poor egg numbers and the discovery of *Myxobolus cerebralis*, the cause of whirling disease (Wilson 1994).

Sheep Creek

Sheep Creek is a tributary to Flaming Gorge Reservoir on the Green River in Daggett County. See the map for the Sheep Creek Lake trap (Figure 27) to find the site. The trap is managed by the special project staff at Flaming Gorge Reservoir. Whiterocks Hatchery personnel assist with the spawning operation (Figure 36).

Figure 36. Mike McCarty, Assistant Superintendent, Whiterocks State Fish Hatchery, holding a Sheep Creek kokanee salmon, September 2012 (photo by Ryan Moseley).

History— Flaming Gorge dam impounded the Green River in 1962, creating a 17,000 ha reservoir that is 145 km long (Schmidt et al. 1983). The reservoir has a capacity of 4.6 billion cubic meters (Judd 1997) and maximum depth of 134 m. In 1963, 450,000 kokanee were stocked and 707,984 more were stocked the following year (Schmidt et al. 1983). There are two genetically distinct populations of kokanee in the reservoir, one spawning primarily near shore within the reservoir and the other spawning in tributaries such as Sheep Creek and the Green River (Canning 1996). The shore spawners are much more abundant (93%) than the tributary spawning stock (7%; Canning 1996). The shore spawners originated from Granby Lake, Colorado and the Sheep Creek stock originated from British Columbia (Eiserman et al. 1966), with some additional stocking from Granby Reservoir (Canning 1996). The Granby Lake stock originated from Flathead Lake, Montana, which was stocked with kokanee from Whatcom Lake, near Bellingham, Washington (Wagner 1996). In Sheep Creek, there are currently both early (September) and late (October to early November) kokanee runs.

Egg takes have been intermittent over the years. When Strawberry Reservoir was being treated with rotenone, the kokanee egg take shifted to Porcupine Reservoir and Sheep Creek. In 1991 at Sheep Creek, 624,012 kokanee eggs were obtained of which 39.2% eyed (problems with the water supply to eggs suffocated one take that year). The following year, 151,358 green eggs were obtained and 90.2% eyed (1992 and 1993 Fish Production reports). The mean length of spawning kokanee salmon in Sheep Creek in 1995 was 432.8 mm for males and 390.6 mm for females (Leucke and Canning 1996).

Kokanee egg takes did not resume until 2008, but have been attempted annually since then.

Fish health inspections and surveys have been conducted in coordination with the egg take or as part of a survey. In 1989, 30 spawning kokanee from Sheep Creek were tested for 'erythrocytic inclusion body syndrome' (EIBS) and found negative. In addition, kidneys from 150 kokanee sampled that same year were negative for *Ichthyophonus hoferi* and three bacterial species: *Aeromonas salmonicida*, *Yersinia ruckeri*, and *Renibacterium salmoninarum*. In 1989, as well in annual inspections between 1990 and 2000, plus 2008 and 2009, the fish were also negative for the myxozoan parasite *Myxobolus cerebralis.* However in 2010, *M. cerebralis* was found in kokanee near the mouth of Sheep Creek. In 2011, the parasite was found in other kokanee captured in Flaming Gorge Reservoir.

Methods— For the kokanee capture, early run fish are captured by electrofishing and late-run fish are captured by trap, supplemented with electrofishing. For the trap, weirs block the stream and funnel fish into an aluminum bar trap. Fish that are electrofished are transferred to hatchery trucks or holding cages (Figure 37). There is no sorting into separate cages; instead, females are selected directly from the cage or truck tank. Non-ripe females are released (or held for a later egg take) and ripe females are stripped onto cloth mesh screens over a bowl. Eggs from 5 females are pooled to get ovarian fluid samples for disease testing. Two pools are combined and fertilized by 10 males (1:1 ratio) stripped directly onto the eggs. The remainder of the process is the same as that

Figure 37. Sheep Creek kokanee salmon egg collection scene, 2012. Photo by Ryan Mosley.

Figure 38. Cages in Sheep Creek for holding kokanee salmon (photo by Ryan Mosley).

at Sheep Creek Lake. For late kokanee runs, cages are used to hold fish in the stream until an egg take is performed (Figure 38).

Fish Production—A summary of the recent information on the Sheep Creek kokanee egg take is presented in Table 22. In 2008 and 2009, late-run kokanee eggs were taken (Table 22). No early run eggs were taken in 2009 due to a good take at Strawberry Reservoir. Additional trapping for late run kokanee was conducted from 14 October to 4 November, 2010 but only 5 females and 11 males were caught during this period and no eggs were taken. In 2011, 43 of 120 females captured by electrofishing on September 14 provided 38,226 eggs. Trapping between 13 October 2011 and 11 November 2011 provided additional eggs for a total of 153,698 green eggs taken that fall. The eggs from the first take that year were shipped to Fountain Green Hatchery for isolation and incubation; Survival to eye-up was 88%; the number of green eggs/oz was 277. In 2008 the eggs/oz for green kokanee eggs was 253.

Table 22. Comparison among years (2008-2012) of the total kokanee salmon egg take, egg survival to eye-up, and other production data from Sheep Creek, Daggett County. The capture method, either trap [T]or electofishing [E], is noted in parentheses within the 'number of females spawned' column. Data was provided by Ryan Mosley, Flaming Gorge project biologist; Eddie Hanson and Brandon Ivory, Fountain Green Hatchery (unpublished data); Michael McCarty, Whiterocks Hatchery; and Statewide Fish Production Reports for 1992 and 1993.

Date	Number of Females Spawned (Capture Method)	Total Green Eggs	Eggs/Female	Eye-Up (%)	Stream Temperature °C
1991	.	624,012	.	39.2[a]	.
1992	.	151,358	.	90.2	.
10-23-2008	(E)	165,968	1,551	98	10.0
10-22-2009	(E)	166,000	.	.	5.0
9-20-2010	30 (E)	27,700	923	77	9.5
9-14-2011	43 (E)	38,226	889	88	13.3
10-17-2011	15 (T)	31,024	2,068	80	10.0
10-20-2011	13 (T)	18,088	1,391	78	6.1
10-26-2011	30 (T)	48,576	1,619	86	3.9
11-11-2011	12 (T)	17,784	1,482	81	5.6
9-18-2012	140 (E)	126,192	901	67	11.1
9-24-2012	83 (E)	87,360	1,052	42	11.1
10-15-2012	84 (T)	96,152	1,145	74	8.3
10-18-2012	104 (T)	116,144	1,117	82	4.4
10-23-2012	74 (T)	89,488	1,209	77	6.7
Means (2008-2012):		79,131	1,254	77.5	

[a]problem with water supply to an egg jar that suffocated 1 egg take

Strawberry Reservoir

History— Kokanee were stocked into Strawberry Reservoir as fry in 1937 (98,000 from the U.S. Bureau of Fisheries; source unknown), in 1939 (244,000 eggs from Pend Oreille Lake, Idaho were hatched at Springville Federal Hatchery; a portion of the resultant fry also went to Bear Lake), and in 1948 (208,000; Popov and Low 1950). In 1947, 40,000 fingerlings, raised from eggs from Idaho, were stocked (Popov and Low 1950). After the 1990 rotenone treatment, kokanee were stocked directly into the reservoir. Since 1998, most of the kokanee have been stocked into the tributaries instead (Strawberry River, Indian Creek, and Trout Creek; Figure 39); This has improved the runs, increasing the average number of spawners from 1,257 during the 1993-1997 period to 4,561 (1988-2007; Ward and Robinson 2009). There is currently an early run (September) and a late run (fall/winter). The source for the early run fish was a combination of Sheep Creek and Porcupine Reservoir, which were stocked during the early to mid-1990's (R. Wilson, pers. comm.). Late spawning kokanee came from Roaring Judy Hatchery, Altmont, Colorado. Early efforts attempted to keep the runs separate, but since 1999, all fish have been spawned regardless of marking or phenotype. As a result, the November runs have diminished, indicating the kokanee populations at Strawberry Reservoir are principally maintained by hatchery stocks (Ward and Robinson 2009). However, in a 2004 report (Federal Aid Annual Performance Report, F-44-R, Segment 24 for Utah), it was noted that 72% of kokanee spawners returning to Strawberry River were from natural recruitment.

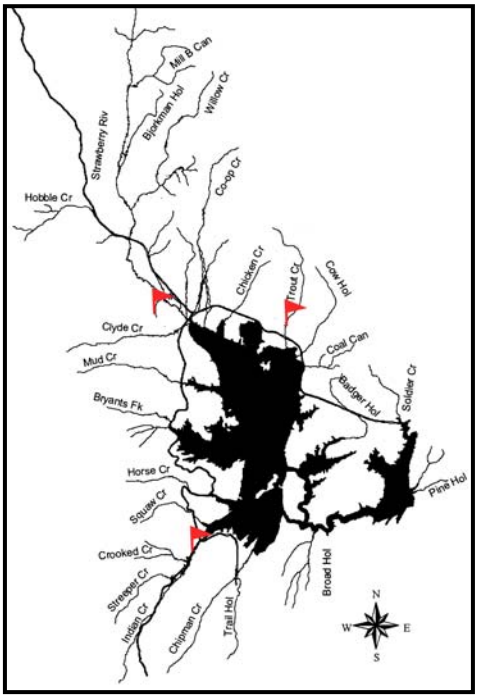

Figure 39. Red flag shows tributaries of Strawberry Reservoir stocked with kokanee salmon.

Kokanee salmon runs in 1993 and 1994 were bimodal, with 2-year-olds outnumbering 3-year-olds. In 1995-1996, the runs were dominated by 3-year-olds. Kokanee growth rate reductions were largely the reason for the trend towards an increase in age at spawning (Wilson and Spateholts 1998). An electric fish barrier has been used in the Strawberry River to discourage upstream movement during trapping season for hours that the trap is not in operation; the barrier was turned off during weekends. A morpholine drip was used to attract kokanee in 1996.

In 1996, kokanee eggs were collected from four trap sites: Strawberry River, Central Utah Project Tunnel ('Ladders'), Indian Creek, and a floating Merwin trap on Soldier Creek near the marina. The Indian Creek trap consisted of an aluminum panel weir and portable trap pens, operated between mid-September and mid October. The protocol was to pass a third of Strawberry River spawners upstream of the trap and ½ of Indian Creek spawners, but this was adjusted as the runs developed (Wilson and Spateholts 1998). In 1996, 27% of spawners at Indian Creek were passed of the 1,158

(482 female, 676 male) captured. In 1995, an estimated run of 17,838 kokanee used Indian Creek between 1 September and 15 October. Only 9 kokanee were caught in the Merwin trap in 1996, probably due to stocking fish by barge instead of one particular site. Currently only Strawberry River kokanee are trapped, although Indian Creek kokanee are occasionally trapped as well, depending on the strength of the run up the Strawberry River. The Indian Creek fish are transported to the Strawberry River trap to spawn. They are held separately to obtain biological data on that population.

Kokanee salmon runs have become an annual spectacle, attracting thousands of visitors each year, including children from many local schools, for which tours are organized (Figure 40; Ward and Robinson 2009). An annual Wildlife Festival is scheduled around the kokanee run, providing an opportunity to educate the public.

Figure 40. DWR biologist Alan Ward explains the trap operation to visitors of the Strawberry River trap.

Methods— An electric barrier is used to prevent upstream passage during the trap operation. The barrier and trap operation are started about late August, and usually runs to about the first week of October. Kokanee are crowded into the trap (Figure 41), where they are presorted by gender, daily as they enter. On spawning day, which is usually twice a week, the females are sorted by ripeness. For this process, the females are netted out of the raceway and dumped into a shallow sorting net which is out of the water. Non-ripe females are held until the next spawning date(s). Ripe females are transferred into a separate area for spawning. For spawning, the females are anesthetized, then the tails are cut, bleeding the fish out. In the dry well area of the trap, where personnel stand and handle fish, the eggs are stripped onto a cloth screen over a bowl. The stainless steel bowl is used to collect ovarian fluid, pooling fluid from five females for disease testing. After stripping the eggs out, the abdomen is cut open to remove the remaining eggs from the body cavity. Eggs from 2 groups of five are combined, and fertilized by about 10 males (1:1 ratio). For males, they are

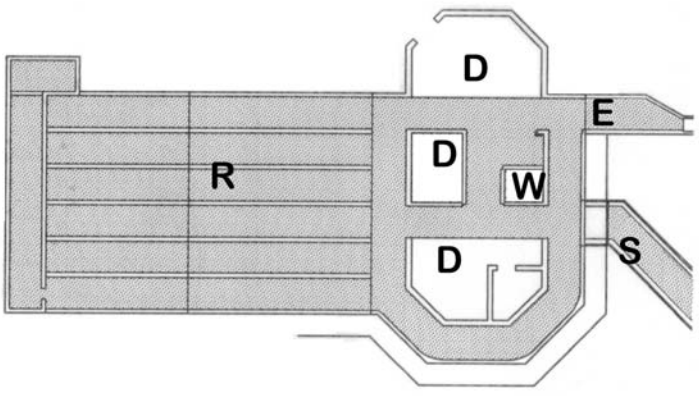

Figure 41. Schematic drawing of the Strawberry River trap. D= dry areas for personnel, W= storage for wet equipment, E = Entry point for fish and water outflow, R = raceways, S = spent fish raceway and outflow.

dried off, and milt is stripped through a sieve, directly on the egg pool. Salt diluent is added, eggs and milt are gently mixed and left undisturbed. After a few minutes, eggs are rinsed with hatchery well water (Kamas or Midway) from a hose run from a hatchery truck. Eggs are left to water harden in a cooler for 1 h, taking care to only fill the cooler 1/3 to ½ full with eggs. After water hardening, eggs are treated with 100 mg/L iodine for 10-15 min, and rinsed with hatchery well water. Egg volume is measured at this time, as well as eggs per unit volume, to calculate the total number of eggs collected. The cooler is then transported to Fountain Green Hatchery for incubation and isolation.

Fish Production data— Fecundity was determined in 1994 by counting all the eggs from 31 females sacrificed for study. Mean fecundity was 1,320 (± 494 SD), and ranged from 700 to 2,550 eggs. The relationship with size was expressed as: Fecundity = 0.47 x $TL^{1.326}$, where TL = total length in mm. Mean egg retention determined in 12 spent females was 292 (SD = 332 eggs), and was not correlated with size (r^2 = 0.009; Knight et al. 1994). Additional fecundity data for kokanee from 1994-2011 indicated an average of 1,190 eggs/female and a range of 629 to 1,555 eggs/female; Table 23).

The number of kokanee trapped each year since 1993 is provided in Figure 42. There was considerable variation among years. The spike in run numbers in 1999 and 2000 were the most noticeable. This may have been a result of stocking fish into the stream rather than directly in the reservoir (1991-1997), beginning in 1998. In subsequent years, the abundance of kokanee could have been affected by increasing numbers of non-game species and stocking of cutthroat trout at a larger size (Ward and Robinson 2009). The number of eggs produced by the egg-take operation and their survival is provided in Table 23, along with fecundity data. Egg survival to eye-up has generally been above 70%, although poor survival due to unknown factors was noted in 1994 and 1995 (Table 23). In more recent years, the gap between egg takes has been reduced to 3-4 days, which could have a favorable effect on egg survival.

In 2007, the Strawberry River trap operation (28 August through 9 October) captured 676 males and 577 females which were used for egg takes. In 2009, there were six egg takes, 3-4 days apart, between 10 September and 28 September on the Strawberry River. In 2010, there were 8 egg takes between 13 September and 11 October; The green eggs/oz ranged from 249 to 309 among takes. In 2011, there were 7 takes between 19 September and 11 October. The green eggs/oz ranged from 299 to 329 and survival to eye-up ranged from 55 to 90%. A comparison among years of the size (total length) of kokanee females is presented in figures for both Strawberry River (Figure 44) and Indian Creek (Figure 43).

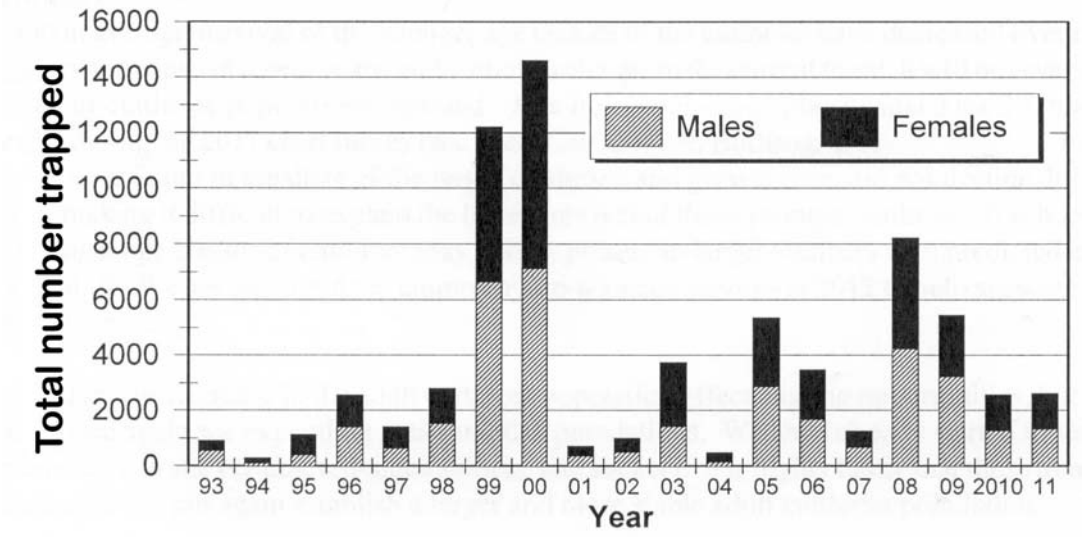

Figure 42. Total number of kokanee salmon trapped in the Strawberry River trap between 1993 and 2011 (females, dark shading; males, light shading; Ward and Robinson, F-44-R, Federal Aid Report for 2012).

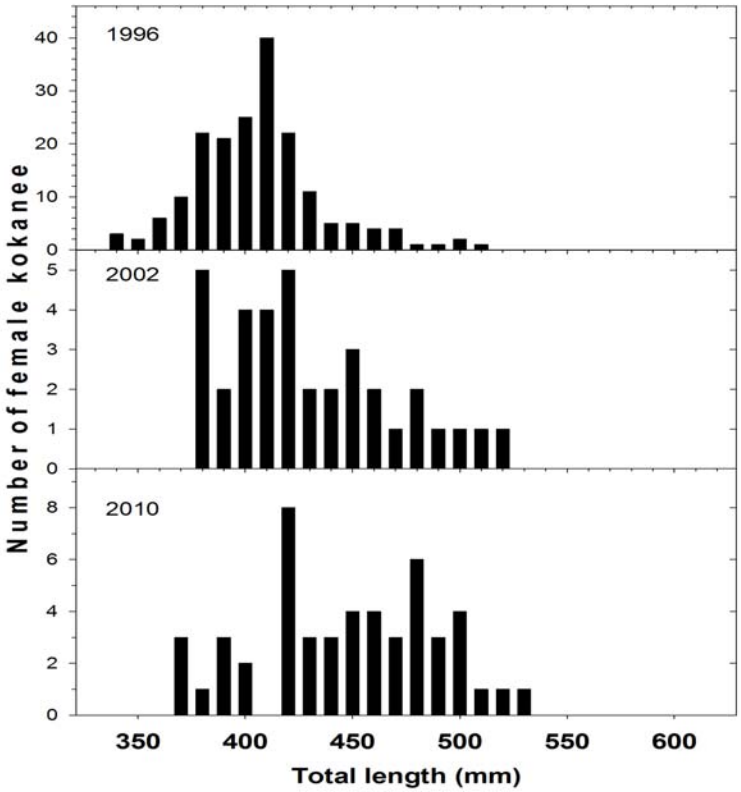

Figure 43. Comparison among years of the number of female kokanee from Indian Creek in various size classes (10 mm interval) (unpublished data, Ward and Robinson).

Table 23. Kokanee egg collection data for Strawberry Reservoir, 1993-2012 (Ward and Robinson 2009; Fountain Green Hatchery data).

Year	Total Green Eggs Collected	Number of Females Spawned	Mean Eggs per Female	Eye-Up (%)	Green-Egg- to-Stock Survival (%)
1993	239,933	Unknown		70	
1994	1,019,544	1,020	1,000	33	
1995	1,717,637	1,865	921	45	
1996	978,442	1,146	854	69*	
1997	540,870	540	1,002	62	
1998	1,436,281	1,357	1,058	89	
1999	2,094,262	1,938	1,081	77	
2000	2,472,724	1,861	1,329	85	62.8
2001	436,968	390	1,120	72	33.6
2002	435,764	399	1,092	73	30.4
2003	1,430,694	1,094	1,308	Unknown	56.2
2004	483,555	311	1,555	73	46.5
2005	1,821,456	1,299	1,402	85	51.4
2006	2,036,752	1,501	1,357	83	36.2
2007	786,957	508	1,549	unknown	61.5
2008	2,746,300				14.5
2009	1,785,666	1,594	1,120	75.8	28.0
2010	1,432,084	1,175	629	83.0	63.5
2011	1,017,712	710	1,433	73.9	44.0
2012	1,368,973				48.0
Mean	**1,314,129**	**1,094**	**1,190**	**71**	**44.0**

*includes two late-run (Nov 14 and 19) takes that had poor (45,47%) egg survival.

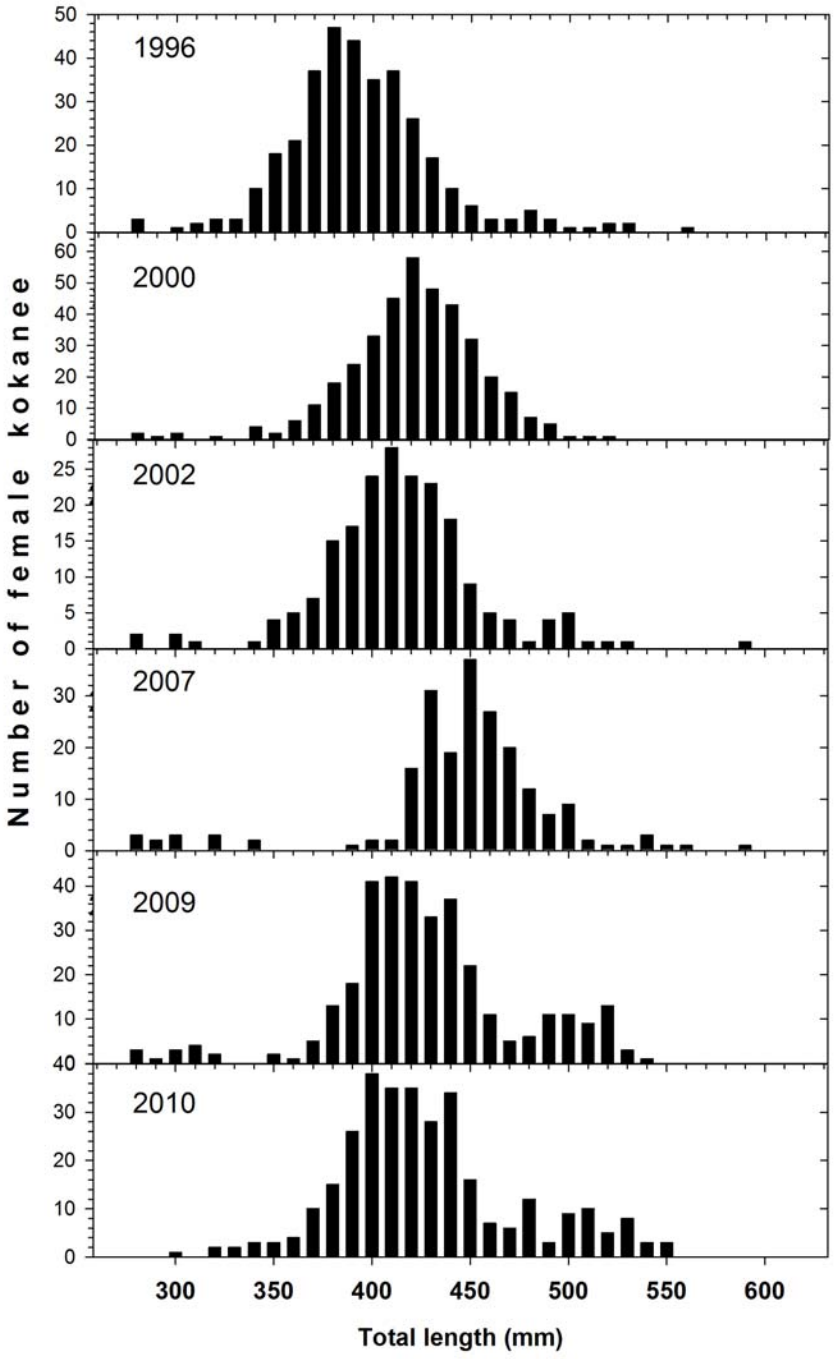

Figure 44. Comparison among years of the number of kokanee females from Strawberry River in various size classes (10 mm increments) (unpublished data, Ward and Robinson).

Other Miscellaneous Wild Egg Take Activities

In 1912, in addition to Fish Lake, cutthroat trout eggs were obtained from fish in the Provo River at the dam of the Telluride Power Company as well as at Puffer Lake, Piute County (UFG 1912). A trap on Fish Creek above Scofield Reservoir was used to take cutthroat trout eggs for several years (UFG 1940; UFG 1942). In the 24th biennial report (UFG 1942), it was noted that the trap '..*has been repaired and is now producing several millions of native trout eggs each season. Two new traps have been built on tributaries to Panguitch Lake*." However, Panguitch Creek was noted as a temporary spawning station in 1914 (UFG 1914). According to Ron Goede (pers. comm.), former director of the Fisheries Experiment Station, the Fish Creek trap was discontinued circa 1967 due to problems with infectious pancreatic necrosis virus in that population.

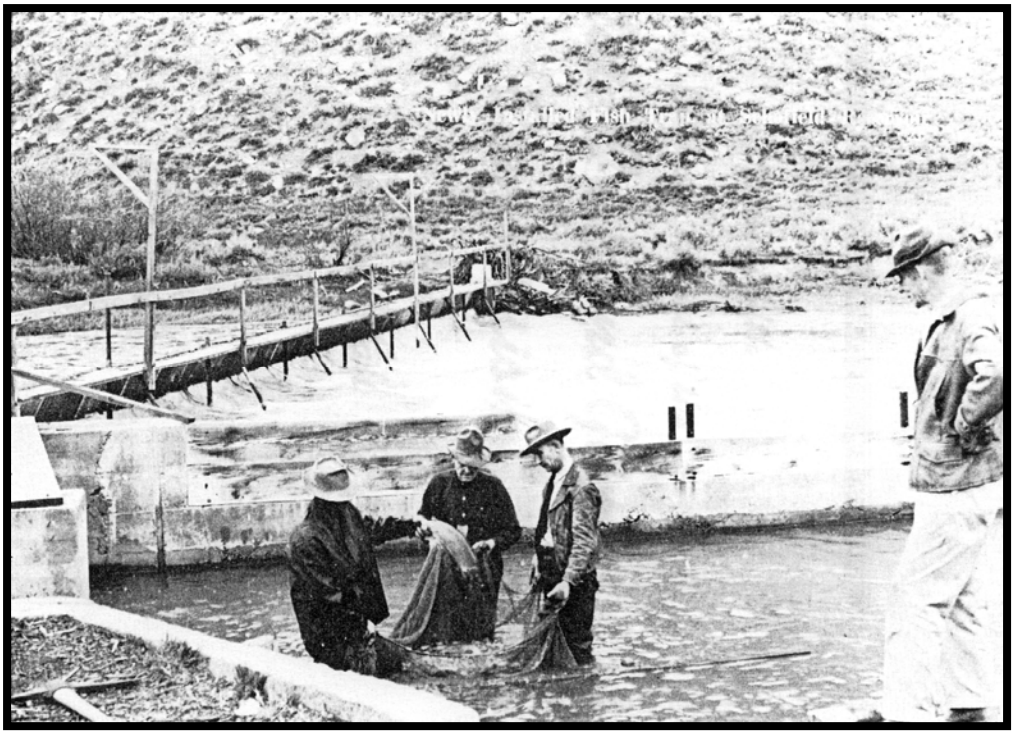

Figure 45. Wild trap at Schofield Reservoir (UFG 1944).

From 1981 to 1983, Bonneville cisco eggs were taken near Cisco Beach, Bear Lake (Annual Statewide Fish Production Reports, Utah Division of Wildlife). These were stocked as fry, e.g., (3.3 million in 1982, into Flaming Gorge Reservoir (Schmidt et al. 1983). Survival to the eyed stage was comparable to salmonids (in 1981, 1982, and 1983, the percentage that eyed up was 60.8, 66.0, and 56.9% of 5.86 million, 6.94 million, and 6.63 million green eggs, respectively).

For several years cutthroat trout eggs were also taken from Electric Lake. The reservoir was built in 1973 by Utah Power and Light Co. for power generation (Thomas 1984). The reservoir dams the Right Fork Huntington Creek, east of Huntington, Utah, in the San Rafael River drainage (Rawley

1975). The reservoir is at 2,592 m (8,500 ft) elevation, has a maximum depth of 62.8 m , a surface area of 193 ha , and maximum volume of 38,574,012 m^3 (Janssen 1987). In 1976 a barrier was established annually for at least 3 years above the lake to prevent brown trout from spawning (Wilson 1978). Because of dam seepage and drought (1977), the reservoir did not fill until 1980 (Janssen 1987). No mention of the wild egg take was made in Janssen's (1987) federal aid proposal. The cutthroat trout in the reservoir were considered to be mostly *O. clarkii bouvieri*. Based on fish health inspection records, it appeared that the trap operation started about 1990 and ended in 2000. In 1991 and 1992, 114,122 and 667,589 green cutthroat eggs were obtained, respectively, of which 66.8% and 56.9% survived to eye-up (Annual Statewide Fish Production Reports). Eggs per female averaged 597 in 1991 and 509 in 1992. In 1991, there were 6 takes between June 24 and July 10th, with the peak number taken on June 24th. In 1992, there were 8 takes between May 18 and June 22, with peak numbers of eggs taken June 15th. In 1994, 32,045 eggs from Electric Lake cutthroat trout were incubated at Fish Lake (memo from P. Brown to T. Miles, 15 August 1994), then sent to the FES for rearing; Of these, 81.3% hatched. In 1999, 7,296 eggs from a single take were transferred to the Fisheries Experiment Station where 85.3% eyed, 82.0% hatched, and 67.0% (of green eggs) survived to first feeding.

Red Butte Creek, near the University of Utah in Salt Lake City, was stocked with 60 Bonneville cutthroat trout from North Fork Little North Willow Creek in October 1987 (2005 Federal Aid Annual Report, F-44-R, Utah). The reservoir on the creek was used one year for an egg take for Bonneville cutthroat trout. In 2000, 8,693 eggs were taken, of which 63.1% hatched, and 61.8% survived to first feeding at the Fisheries Experiment Station. In 2005, the reservoir was drained for repairs.

Brown trout and golden trout have also been taken from wild sources. In addition to Fish Lake (egg take in 1971), brown trout eggs (*n* = 117,706) were obtained from Flaming Gorge Reservoir (UDWR 1972). The Egan Hatchery brood program started soon after, so wild brown trout eggs were no longer needed. Golden trout eggs were obtained in 1974 from mature fish in Daggett Lake, on the north side of the Uintah Mountains (UDWR 1974), and reared at Whiterocks Hatchery.

In 1972, walleye eggs were taken from fish in Willard Bay (1,097,000 eggs) and Utah Lake (10,990,000 eggs; UDWR 1972). In the springs of 1973 and 1974, 35 million walleye eggs were taken from fish captured by electrofishing in the Provo River near Utah Lake (UDWR 1974). In March 1978, just over 31,000,000 walleye eggs were taken from wild fish (483 females, 754 males) by Charlie Thompson, Central Regional Office fisheries biologist (Thompson 1978a). This was 'the highest number of females taken since 1975 (348 females, 554 males; Thompson 1978a). These were hatched at Springville Hatchery and stocked into Utah Lake, Yuba Reservoir, and Starvation Reservoir as 5-day-old fry; some were also sent to Nevada Fish and Game (Thompson 1978b).

In June 1977 and 1978, Dale Hepworth (1978) reported collecting eggs from threadfin shad from Lake Powell using excelsior mats. The eggs (about 1 million) as well as an estimated 6,000 adult threadfin shad were transferred to Gunlock Reservoir (Hepworth 1978).

Fish Health

Each year, samples are taken from wild fish to certify that the population is free of prohibited pathogens. The samples include ovarian fluid from spawned females (all females if <60 or 12 pools of 5 fish each) and samples from kidney and spleen (up to 60 fish per year, usually from excess males). Standard testing of these samples (USFWS and AFS-FHS 2005) by the Fisheries Experiment Station personnel checks for the presence of *Renibacterium salmoninarum*, *Myxobolus cerebralis*, infectious pancreatic necrosis virus, viral hemorrhagic septicemia virus, and infectious hematopoietic necrosis virus.

Results have been negative for all wild salmonids tested over the years for the prohibited pathogens noted above, with a few exceptions noted in Table 24. *Myxobolus cerebralis*, the myxosporean parasite that causes whirling disease, has been discovered in a few locations. Fortunately, since the disease is not egg-transmissible, the egg taking operations can still be conducted.

Table 24. Summary of positive findings for fish health testing of wild brood stocks. PCR+ denotes a result that was positive with the use of a polymerase chain reaction.

Location	Pathogen	Date found	Notes
Bear Lake	*Myxobolus cerebralis*	2006	Myxospores found in 1 brown trout (also PCR+); all cutthroat trout were negative (Cavender 2006)
Little Dell Reservoir	*Myxobolus cerebralis*	2003	Wagner et al. (2007)
Porcupine Reservoir	*Myxobolus cerebralis*	1993	Wilson (1994)
Sheep Creek Lake	*Myxobolus cerebralis*	2007	Wilson et al. (2011)
Sheep Creek/Flaming Gorge Reservoir	*Myxobolus cerebralis*	2010, 2011	4 of 60 positive in Sheep Creek near the reservoir in 2010; in 2011, 3 or 38 kokanee from the reservoir were infected (W. Cavender, pers. comm.).
Strawberry Reservoir	*Myxobolus cerebralis*	2011	2 of 60 kokanee infected (F-44-R Segment 32, Federal Aid Report)

Meta-Analysis

Two overlapping datasets were used for the meta-analysis. One was comprised of data from tables in this report that included all the cutthroat trout traps over all years, except for Kolob Reservoir, which was excluded since it only had 2 years of data. The data were primarily averages for each year. The average eye-up and eggs per female across all years for each trap for cutthroat trout from these data (Table 25) were also analyzed. The effects of cutthroat trout strain, reservoir surface area, and trap elevation on eye-up and the average number of eggs produced by each female was analyzed using this dataset. The second data set used cutthroat trout data from Fountain Green Hatchery from 2008 to 2012, and had data at the egg-take level. Percent eye-up was available at least for some years for all traps. However, survival to stocking from green egg was lacking for the Strawberry and Bear Lake traps, since these sources could not be isolated from the Mantua Hatchery stocks in the records. Fecundity (eggs per female) data was available for all but two traps. The metric 'eggs per ounce for eyed eggs' was analyzed from the Fountain Green Hatchery dataset to examine egg size differences among trap sites. Larger fish generally have larger eggs and fewer eggs per ounce.

For the first dataset, analysis of variance on percent eye-up indicated significant differences among traps ($p < 0.001$, df = 7, F= 10.7; Table 25). The lowest average eye-up was from Lake Canyon Reservoir and the highest was from the Swan Creek trap at Bear Lake. Percent eye-up was significantly different among cutthroat trout strains as well; eye-up was significantly higher for CTBL (83.3%), than for CTCR (54.0%) or CTBV (69.8%), which significantly differed from each other ($p < 0.001$, df = 2, F = 25.0). A box plot graph in Figure 47 compares the eye-up among traps and strains of cutthroat trout and demonstrates the high annual variability in egg survival.

There was a weak (r = 0.35), but significant (p = <0.001), positive correlation between the number of green eggs taken (log scale) and the resulting eye-up (Figure 46). This was likely influenced by the Swan Creek trap data, where larger fish are spawned and the eye-ups are significantly higher. However, even with the one data point from the far upper right removed, the regression was still significant ($P < 0.001$, r =

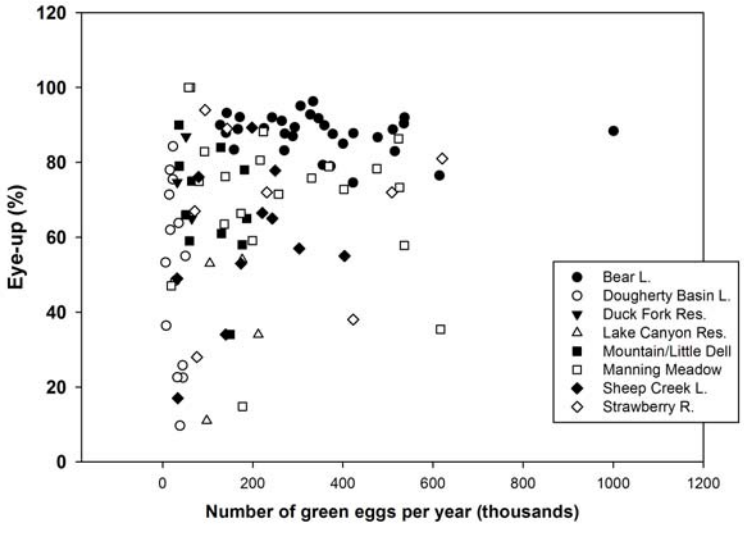

Figure 46. Relationship between the number of green eggs taken per year and egg survival to eye-up.

0.35). More eggs in a take could also buffer egg shock effects within a cooler or diminish effects of sunlight, air temperature, dessication, etc. on the outside of a pile of eggs waiting to be fertilized.

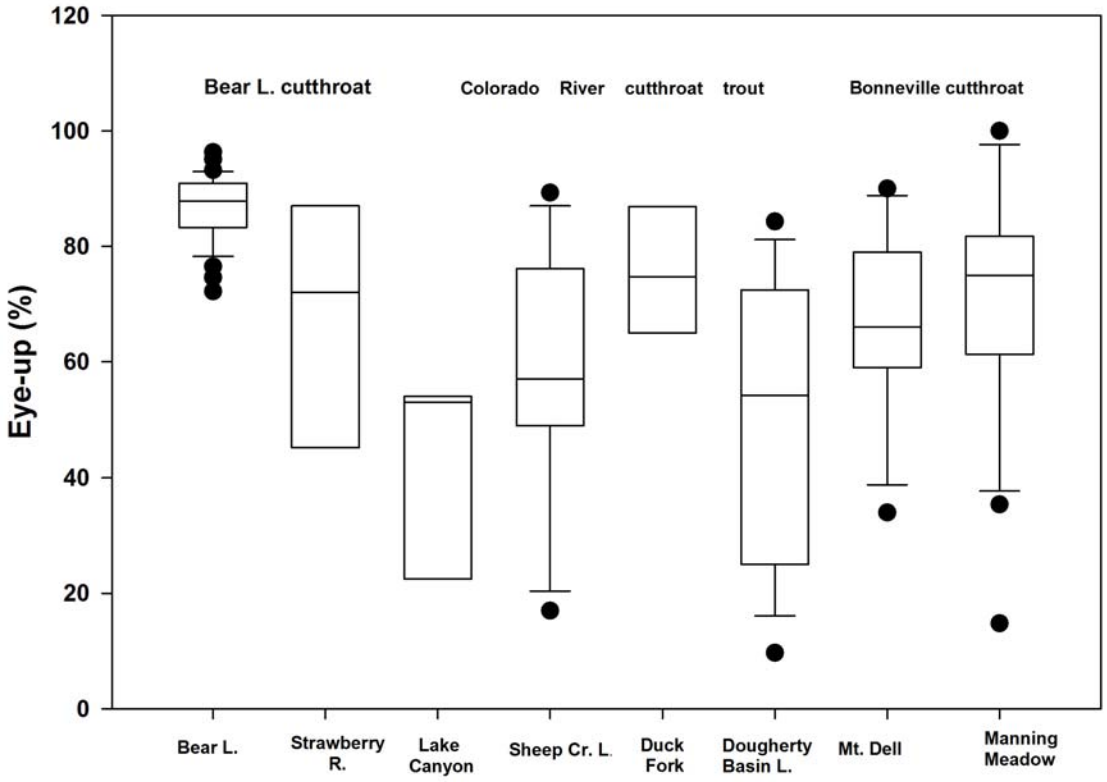

Figure 47. Comparison of the percent eye-up among traps and cutthroat trout strains. Box plots show the median, 25th and 75th percentile, minimum and maximum values that are not outliers (error bar), and outliers (filled circles) that are more than 1.5 box-lengths from edge of box.

The influence of trap elevation and reservoir area on eye-up and fecundity was analyzed by multiple and linear regression. Trap elevation represents several different variables that could affect egg survival, such as changes in gas saturation due to elevation, duration of winter ice cover (reducing feeding opportunities on terrestrials or limiting distribution due to low dissolved oxygen resulting from prolonged stratification), maximum summer reservoir temperatures, air temperatures during the egg take, remoteness, etc. Reservoir area represents a similar suite of variables such as maximum summer temperature, probability of capture by angling, overwintering conditions, and the likelihood of larger size classes. Percent eye-up was not significantly influenced by elevation or reservoir area (R = 0.65, p = 0.25, F = 1.83, total df = 7) or travel distance

(r = 0.22, p = 0.59). However, fecundity (eggs/female) was negatively correlated with elevation (r = 0.87, p = 0.024, F = 12.5, total df = 5; Figure 48) and positively correlated with reservoir area (r = 0.89, p = 0.016, F = 16.0, total df = 5). This is not too surprising since larger waters produce larger fish which produce more eggs and higher elevations are generally cooler, reducing growth. Water body size is generally smaller too.

Table 25. Comparison among trap locations of the percent survival to the eyed egg stage (eye-up) and to stocking based on the initial number of green eggs taken. Fecundity (eggs/female) is also provided for traps which had the data. Abbreviations: CTBL = Bear Lake cutthroat trout, CTBV = Bonneville cutthroat trout, CTCR = Colorado River cutthroat trout, ND= no data. Significant differences among means within a column are noted with a different subscript letter (p > 0.05).

Trap location	Cutthroat strain	Mean Eye-up (%± SD, n)	Survival Green egg to stocking (%± SD, n)	Mean eggs per female (± SD, n)
Bear Lake-Swan Creek	CTBL	86.8 ± 5.6, 36 c	ND	2,253 ± 843, 39 a
Strawberry River	CTBL	67.6 ± 23.5, 8 abc	ND	ND
Dougherty Basin Lake	CTCR	50.6 ± 23.8, 14 ab	32.5 ± 19.3, 12 ab	582 ± 95, 12 b
Duck Fork Reservoir	CTCR	75.5 ± 11.0, 3 bc	34.7 ± 6.3, 3 ab	1,336 ± 184, 3 ab
Lake Canyon Reservoir	CTCR	38.0 ± 20.2, 4 a	26.3 ± 34.1, 2 ab	1,557 ± 220, 5 ab
Sheep Creek Lake	CTCR	58.1 ± 20.5, 11 abc	21.8 ± 12.8, 7 a	1,253 ± 307, 8 ab
Mountain/Little Dell reservoirs	CTBV	68.1 ± 15.5, 11 abc	56.7 ± 20.8, 11 b	ND
Manning Meadow Reservoir	CTBV	70.7 ± 20.0, 21 abc	50.8 ± 14.2, 20 b	932 ± 252, 21 b

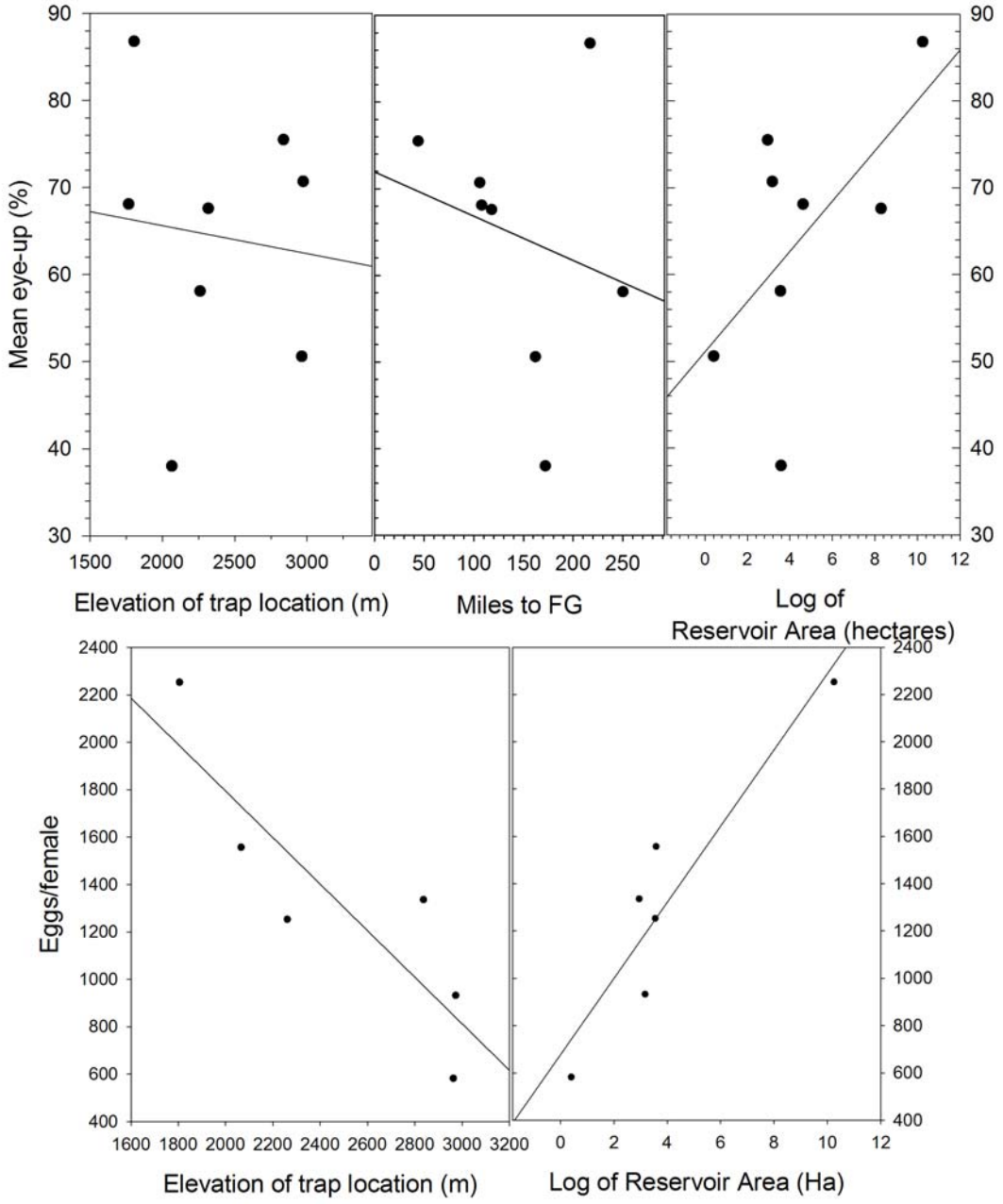

Figure 48. Correlation between trap elevation, distance from trap to Fountain Green State Fish Hatchery (FG), or trap reservoir area and fecundity (eggs/female) and egg survival to the eyed stage (percent eye-up).

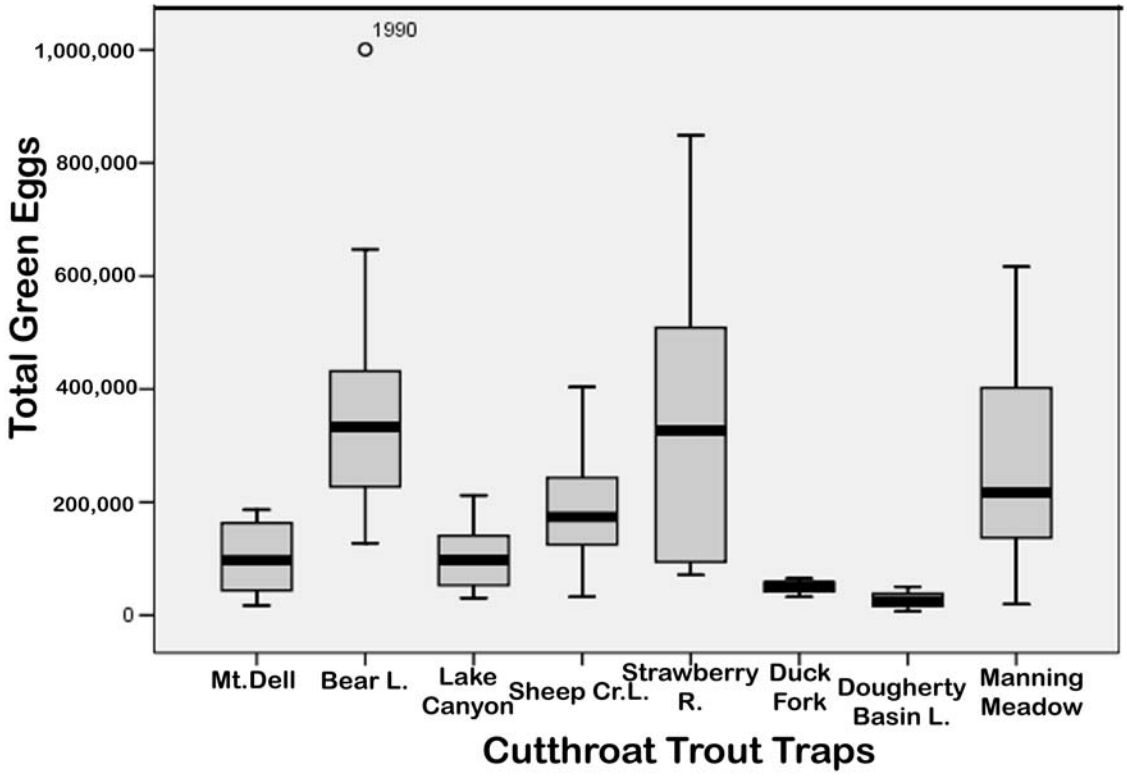

Figure 49. Comparison among cutthroat trout traps of the annual variation in the total number of total green eggs taken each year (see Figure 46 for box plot explanation). Traps are ordered left to right by lowest (1,767 m) to highest elevation (2,973 m).

The percent survival of green eggs to stocking was not compared between traps because this metric may be biased by culling during early rearing to trim numbers to target a stocking quota. So, survival may be artificially low. Hatchery variables would also play a large role in survival, making trap related influences on survival more difficult to discern.

Fecundity was significantly higher at the Swan Creek trap (2,253 eggs/female) than at the Dougherty Basin Lake (582 eggs/female) or Manning Meadow (932 eggs/female) traps ($p < 0.01$, df = 5, F=23.6; Table 25). The number of eggs per female also differed significantly among cutthroat trout strains ($p < 0.01$, df = 2, F = 46.3). Fecundity was higher in Bear Lake cutthroat trout (2,253 egg/female) than for either Bonneville cutthroat trout (932 eggs/female) or Colorado River cutthroat trout (999 eggs/female), which did not significantly differ from each other. This difference may be biased for the Bear Lake cutthroat trout, since this strain is produced using fish from Bear Lake. These fish have the benefit of growing to a larger size in a larger body of water. The mean size of spawning females at Swan Creek (520 mm, across years) is larger than that for most of the other traps (308 to 489 mm). How this strain would perform in a smaller reservoir is not known, but it is well established that larger fish produce more eggs (Piper et al. 1982). Older

females (e.g., 3 year-old vs. 2) may also provide eggs that have a higher egg survival to eye-up (Piper et al. 1982). This may help explain why eye-up is significantly higher for cutthroat trout from the Swan Creek trap than other sites, where fewer older fish make up the population.

For the Fountain Green Hatchery data set that only included egg-takes between 2008 and 2012, there were significant differences among traps as well. The percent survival to eye-up was significantly higher at Bear Lake (87.5%) than at Dougherty Basin Lake (33.2%; $p < 0.001$, df = 8, F = 7.9). The percent eye-up at the other sites (38.9 to 67.6%) did not significantly differ among any of the trap sites (Table 26). Eggs per ounce significantly differed among traps ($p < 0.001$, df = 8, F = 16.9; Table 26). Values ranged from 245 eggs/oz at Bear Lake to 406 eggs/oz at Dougherty Basin Lake and Lake Canyon Reservoir. There was wide variation in the number of eggs obtained at each egg take; mean values ranged from about 11,000 at Kolob Reservoir to over 260,000 eggs/take at Manning Meadow Reservoir (Table 26).

As with the other data set, there were significant differences related to strain of cutthroat trout. Percent eye-up was significantly higher for Bear Lake cutthroat trout (85.3%) than for Bonneville cutthroat trout, which had significantly higher survival to eye-up (63.7%) than Colorado River cutthroat trout (44.1%; Table 26). Egg size also varied significantly among strains ($p < 0.001$, df = 2, F = 52.3); Bear Lake cutthroat trout had significantly larger eggs (249 eggs/oz) than the other two strains (365-391 eggs/oz), which did not significantly differ from each other. This is likely due to the larger size of the waters where the Bear Lake cutthroat trout reside. Both Bear Lake and Strawberry traps are more permanent structures where staff have had years of experience and workers work in more comfortable settings than at the other traps. This may have a bearing on egg survival as well.

A stepwise multiple regression analysis evaluated the relationship between percent eye-up and six variables: 1) reservoir size (natural log of area), 2) travel distance between the trap site and egg rearing hatchery, 3) use of electrofishing to capture fish (yes/no), 4) travel on dirt road from site to get to paved road (yes/no), 5) Julian date, and 6) site elevation. Reservoir size was a significant predictor of survival to eye-up (R = 0.55, $p < 0.001$, df = 1, F = 42.0). When travel distance was added to the model, this combination was also significant (R = 0.62, $p < 0.001$, df = 2, F = 28.9). However, when site elevation, electrofishing, dirt road travel, and Julian day were added to the model, these variables were excluded from the model since they were poor predictors of egg survival to eye-up. When data were pooled across traps, the relationship between Julian date and eye-up was not significant (p =0.95). Scatter plots of some of these variables correlated with percent eye-up are presented in Figure 50.

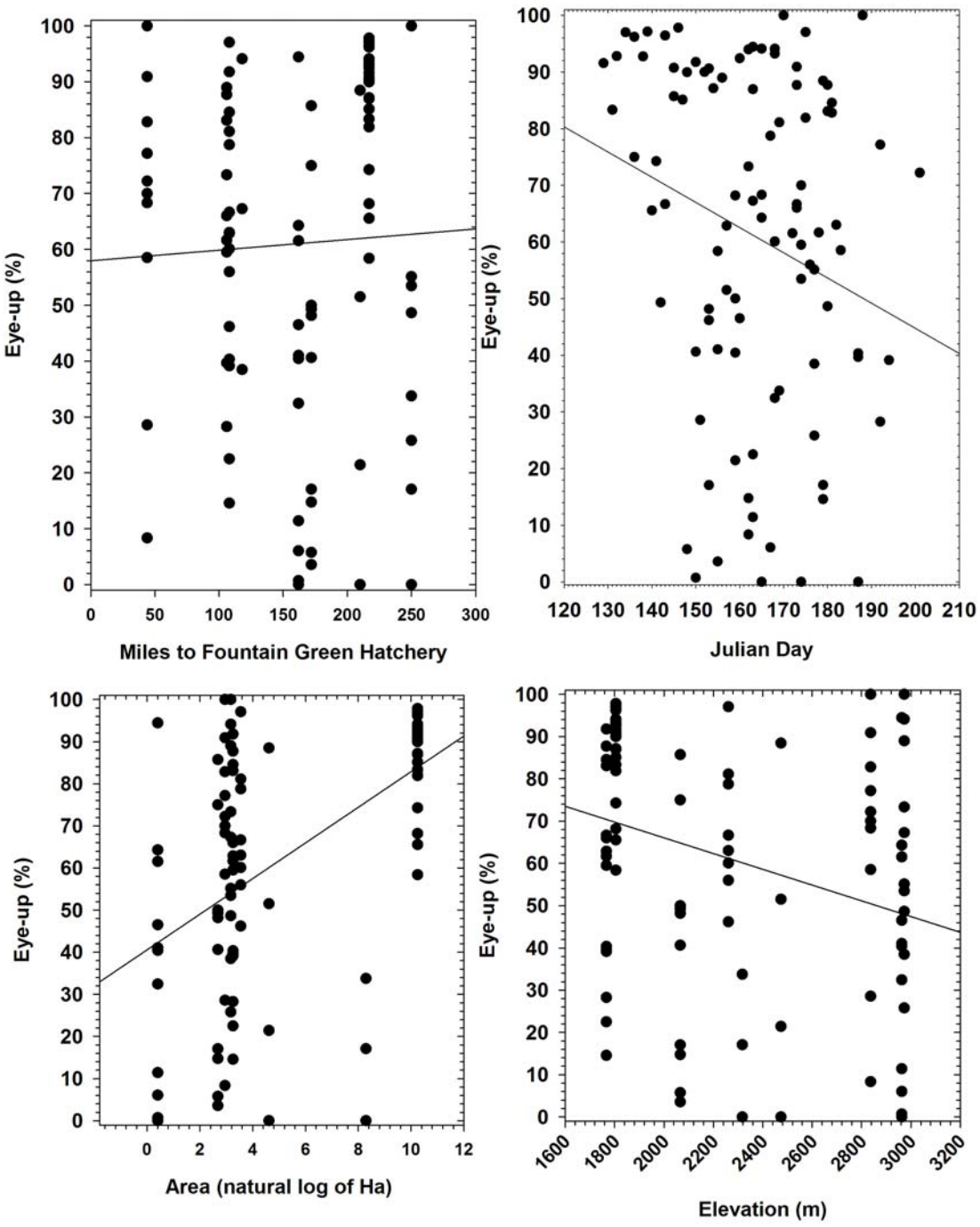

Figure 50. Scatter plots showing the relationship between cutthroat trout egg survival to eye-up and wild trap site elevation (r = 0.30), reservoir area (r = 0.52), travel distance to the egg-rearing hatchery (r = 0.04), and time of year (r = 0.23; Julian date 152 = June 1).

Table 26. Comparison of total green eggs taken per egg take, percent survival to eye-up, and eggs per ounce (eyed eggs) among wild trap sites for cutthroat trout of three different strains. Data are from Fountain Green Hatchery records from 2008 to 2012. Significant differences among means within a column are noted by a different letter following the mean ($p < 0.05$). Significant differences among cutthroat trout strains are similarly noted, using letters at the end of the alphabet.

Trap	Strain of Cutthroat Trout	Eye-Up (% ± SD)	Eyed Eggs Per Ounce (Mean ± SD)	Total Green Eggs per Take (Mean ± SD)
Bear Lake	Bear Lake	87.5 ± 10.5 a	245 ± 24 a	83,920 ± 46,215
Strawberry River	Bear Lake	66.6 ± 27.8 ab	286 ± 8 ab	196,045 ± 196,730
Strain means (*n* = 28)		85.3 ± 14.1 z	249 ± 26 z	95,934 ± 77,541
Manning Meadow Reservoir	Bonneville	67.6 ± 21.0 ab	397 ± 29 bc	260,442 ± 133,286
Mountain Dell Reservoir	Bonneville	60.7 ± 23.6 ab	345 ± 26 abc	43,956 ± 21,295
Strain means (*n* = 25)		63.7 ± 22.5 y	357 ± 43 y	134,340 ± 139,545
Dougherty Basin Lake	Colorado River	33.2 ± 30.6 b	406 ± 34 c	16,226 ± 9,630
Duck Fork Reservoir	Colorado River	65.7 ± 27.9 ab	400 ± 21 bc	17,099 ± 8,947
Kolob Reservoir	Colorado River	40.3 ± 38.4 ab	378 ± 33 bc	11,011 ± 7,621
Lake Canyon Reservoir	Colorado River	39.0 ± 28.3 ab	406 ± 84 c	54,725 ± 33,760
Sheep Creek Lake	Colorado River	41.7 ± 30.3 ab	331 ± 152 abc	102,568 ± 136,962
Strain means (*n* =44-47)		44.1 ± 31.2 x	391 ± 80 y	41,021 ± 65,832

When percent survival to eye-up was compared among years (2008-2012) within each trap site, no significant differences were noted for Bear Lake ($p = 0.23$), Dougherty Basin Lake ($p = 0.86$), Duck Fork ($p = 0.47$), Kolob Reservoir ($p = 0.32$), Mountain Dell Reservoir ($p = 0.12$), and Sheep Creek Lake ($p = 0.33$). However, Lake Canyon Reservoir had significantly lower survival to eye-up in 2008 (8%; $p = 0.04$) than in the other years (33.5 to 66.9%). There were also significant differences among years for Manning Meadow Reservoir, where eye-up in 2011 (34.0%) was lower than in all the other years except 2008 (60.6%). The low survival in 2008 was likely due to the use of hydrogen peroxide for disinfection that year. 2011 was a year in which there was a prolonged cool wet spring, but other years at Manning Meadow with high snowpack and wet springs had acceptable survival (2003: 74%, 2005: 70%). If data from all traps were pooled, there was a significant difference among years ($p = 0.01$): eye-up in 2008 (51.0%) and 2011 (49.5%) was less than in 2010 (77.0%).

To evaluate the effects on survival to eye-up of holding fish over in cages between takes, an analysis of differences among takes within a trap site was made using one-way ANOVA. There were no significant differences among takes for any of the cutthroat trap sites (Table 27).

Table 27. Comparison of the mean percent egg survival to eye-up for cutthroat trout among egg takes for each wild trap site. Data is from Fountain Green Hatchery from 2008-2012. There were no significant differences among takes for each trap (One-way ANOVA, all $p > 0.05$).

Trap	First Take	Second Take	Third Take	Fourth Take
	Eye-up (% ± SD)	Eye-up (% ± SD)	Eye-up (% ± SD)	Eye-up (% ± SD)
Bear Lake[1]	87.8 ± 9.0	88.3 ± 13.0	85.7 ± 16.1	89.7 ± 2.9
Strawberry River[2]	67.2	94.1	38.5	
Manning Meadow Reservoir	71.5 ± 15.5	72.7 ± 10.7	63.7 ± 34.0	58.0 ± 42.0
Mountain Dell Reservoir	61.3 ± 26.3	62.6 ± 22.2	58.1 ± 26.8	
Dougherty Basin Lake	32.7 ± 26.1	45.9 ± 35.0	3.0 ± 4.3	
Duck Fork Reservoir	66.2 ± 26.8	58.3 ± 33.8	79.3 ± 29.3	
Kolob Reservoir	46.6 ± 44.4	21.4		
Lake Canyon Reservoir	45.9 ± 40.3	37.8 ± 22.8	27.7 ± 18.3	
Sheep Creek Lake	39.0 ± 15.8	50.0 ± 70.7		

[1]Bear Lake trap had additional takes each year (take 5 = 80.3%, take 6 = 93.7%) [2]Strawberry River trap only operated in 2008 for cutthroat trout, so $n = 1$ per take)

The lack of significant differences among egg-takes indicated that holding fish in cages between egg collection dates did not reduce survival relative to previous takes. Examination of the data in Table 27 shows that declines in the latter takes may be site specific and may be prove significant with larger sample sizes. For example, as described under the Dougherty Basin Lake summary, there was a significant decrease in eye-up from the second to third take when all years were analyzed for that site.

Water Quality

Water quality varies dramatically across the state of Utah, and has a profound impact on aquatic ecosystems and fish that live in them. For comparison among the wild trap sites, the following table compiles data from Judd (1997; Table 28). No data were available for Dougherty Basin Lake,

Mountain Dell Reservoir, Sheep Creek, Trout Creek, or Lake Canyon Lake. The pH levels were comparable across sites and tended to be basic. This is likely driven by phytoplankton, which consume carbon dioxide, which forms a weak acid in saturated solutions (Boyd 1979). Total hardness as $CaCO_3$ and total alkalinity varies about four-fold among sites, but does not appear to be related to egg survival differences among sites (Table 27).

Table 28. Comparison of water quality among wild fish trap sites (Judd 1997).

Site	Total alkalinity (mg/L)	Total hardness (mg/L)	Conductivity (µmhos/cm)	pH
Bear Lake	375	268	579	8.8
Duck Fork Reservoir	206	242	433	8.5
Electric Lake	94-112	103-119	199-202	8.2-8.8
Fish Lake	55-58	43-49	113-151	8.6
Kolob Reservoir	134-140	152-160	207-302	8.3-8.5
Little Dell Reservoir	33-176	31-176	41-340	8.3-8.7
Manning Meadow Reservoir	33	31	41	8.7
Sheep Creek Lake	44	41	57	8.2
Strawberry Reservoir	114-142	125-153	262-274	8.1-8.7

Recommendations

Based on the analyses summarized above, it appears that there are several factors that help explain variation in survival to eye-up among traps. The most influential of these variables are reservoir area (fish size), and travel distance. However, as figures 47 and 50 demonstrate, there is still wide variation among years and takes within a trap that is not related to the trap per se. This indicates that there are variables that are not being measured that have a great influence on survival to eye-up. Variables related to fertilization may be particularly relevant. For example, Scott and Baynes (1980) noted that diluent to sperm ratios for rainbow trout that led to complete activation varied depending on type of diluent; for isotonic solutions, a ≥2:1 ratio is recommended.
Data should be collected on additional variables such as:

1) stream and reservoir water temperatures during the trap operation (some trap managers are already collecting these data) and during the peak of summer. Deployment of temperature loggers could assist in the collection of these data
2) general weather patterns (e.g., air temperatures during the take, wind speed, cloud cover, rain/sun),
3) sperm handling notes (pooling, number/pool, sperm quantity diluent temperature and water source, ratio of diluent to sperm or egg volume),
4) egg rinse details (e.g., minutes elapsed after fertilization, number of rinses, presence and relative amount of observed dead eggs or bad eggs, rinse water source),
5) elapsed time between collection of first females eggs and the fifth female's eggs,
6) use of anesthetic ,
7) notes on ease of stripping eggs,
8) personnel doing the spawning, transport (Fountain Green Hatchery is collecting this data already), electrofishing, etc.,
9) Transport notes (e.g., dirt road rougher than usual, precautions made to reduce jarring of cooler, transport time, percentage of cooler occupied by eggs, air pocket in cooler?, water source).

The trap where the best eye-up percentages and lowest variances were achieved was Swan Creek. While this success could be attributed to the larger size of the brood and more consistent water quality in Bear Lake, one confounding difference is also the sperm collection method. Sperm is collected in a Styrofoam cup with a small dip screen over it to prevent feces from mixing with the sperm. The sperm is pooled before fertilization. This process may reduce the likelihood of water dripping into the mixture, providing a better fertilization rate. Trap managers are encouraged to try the cup collection method and see if eye-up rates become more consistent. To determine if fertilization success is a problem, we recommend sampling of eggs at Fountain Green Hatchery (e.g., random sample of 100-200 eggs from the lot) at 24-48 h after fertilization. These eggs would be fixed in formalin, stained with alizarin (calcium stain), and examined to determine if a blastula was initiated or not. Similar sampling prior to bumping at eye-up may also give an indication of the percentage of 'blanks' (unfertilized eggs).

An additional consideration with egg survival is genetics. Based on studies by Kincaid (1976a) and Bridges (1973), inbreeding has been shown to reduce egg hatchability, formalin tolerance, and fry survival and growth. The effect can be large, e.g., hatchability was reduced by 53% in inbred rainbow trout (Kincaid 1976a). Increases in deformities can also occur; 11-18% higher rates have been observed in inbred rainbow trout (Kincaid 1976b). Research has indicated that salmonids are able to recognize 'kin' and prefer to mate with fish that are not kin (Quinn and Busack 1985; Brown and Brown 1992). When conducting crosses in the field, trap managers may increase the probability of inbreeding since they do not have the same ability to discriminate among 'kin'. This is especially problematic at sites where few to no fish reach beyond the first or second age class at which they spawn. If anglers or other sources of mortality crop off the larger fish, the probability of

a full-sib mating increases. Further reductions in heterozygozity (variety in the gene pool) are also a consequence of pooling gametes (e.g., five fish pools instead of paired matings). Research has shown that differences in the fertilizing ability (potency) of sperm can vary among males, so the relative contribution of each male is disproportional when pooled sperm is added to eggs (Gharrett and Shirley 1985; Gile and Ferguson 1990). Sequential stripping of males onto eggs also reduces the equitable allocation of genetic material (Gharrett and Shirley 1985). Withler and Beacham (1994) found that serial stripping of three males onto eggs from one female led to individual males siring between 0 and 94% of the progeny. Stocking of hatchery fish resulting from these crosses leads to further reductions in heterozygozity because of swamping of the wild genotypes by the hatchery genotype and interbreeding between the two groups (Wang et al. 2002).

Given the potential for inbreeding and reductions in heterozygosity with pooling of gametes, we recommend doing paired matings for wild traps where fewer than 200 fish are spawned during the egg take. Sites such as Manning Meadow Reservoir and Bear Lake have enough fish entering the traps that genetics is less of a concern. Paired mating may have other benefits too, such as reduced exposure time of eggs to the air and/or more consistent sequencing of egg stripping, fertilization, rinsing, etc. An examination of the stocks for signs of inbreeding may be worth conducting as well. Allozyme variation has been used to document inbreeding between hatchery and wild stocks of Atlantic salmon (Wang et al. 2002) and cutthroat trout (Allendorf and Phelps 1980). Fluctuating asymmetry (amount of asymmetry between characters on the left and right side of a fish) has also been used to measure inbreeding (Leary et al. 1985; Wagner 1996). The greater the degree of inbreeding, the more frequently asymmetry is observed (Vrijenhoek and Lerman 1982).

Travel time was a significant factor related to egg survival, and although presence or absence of dirt road travel did not prove significant in the meta-analysis, the wide variation in the data may have masked the effect. A controlled study is needed to examine this potential effect on egg survival. Efforts by egg cooler transporters to minimize the shock during transport may improve survival. Purchase mat cushions to use under the coolers or buckle coolers on a car seat. Research into the effects of air pockets in transport coolers on egg survival may be beneficial too.

Reductions in handling may be possible too. Eggs are counted twice, once at the site and again on receipt at the hatchery. This seems unnecessarily redundant. Eggs should be counted at the site after water hardening and iodine treatment and this data shared with the receiving hatchery. The hatchery can get its own estimate at eye-up, when the lot is picked to remove dead eggs.

Use of anesthetic can be helpful in reducing stress of wild fish, possibly leading to better survival of the brood for future spawns. Care must be taken to rinse the fish prior to spawning to minimize any chance of anesthetic dripping into the eggs. At present, the withdrawal time for MS-222 is 21 d, so this would require closure to harvest for the spawning period, if this is not already in place. An alternative with 0 d withdrawal time is available for use under a federal INAD (investigational

new animal drug) permit—Aqui-S®, a clove oil derivative. More information on the percentage of repeat spawners at each trap would be helpful in understanding more about the year-to-year survival, bioenergetics, and age distributions of the wild brood.

Acknowledgments

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