Fall 2002 through Spring 2003

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Root River Steelhead Facility
Fall 2002 and Spring 2003

Jim Thompson
Brad Eggold

Wisconsin Department of Natural Resources
Bureau of Fisheries Management and Habitat Protection
Southern Lake Michigan Work Unit
600 E. Greenfield Ave.
Milwaukee, WI 53204

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Abstract – A total of 10,340 chinook salmon, 2,514 coho salmon, 1,361 steelhead and 295 brown trout were examined at the Root River Steelhead Facility during fall, 2002 and spring, 2003. The majority of the chinooks (9,912 or 96%) were passed upstream. The remaining 428 were sacrificed after spawning, for disease testing, or were too weak to pass. A total of 2,076 coho salmon were passed upstream, another 192 were transported to Kettle Moraine Springs Hatchery as broodstock, and the remaining 246 were sacrificed for disease testing, or were too weak to pass. Eight hundred seventy-two coho salmon were spawned at the facility to produce 848,000 eggs. The fall return of 301 steelhead was lower than the previous years' return, but slightly higher than the past 5-year average fall return of 246. Two-hundred fifty skamania-strain steelhead were identified by fin clips and transported to Kettle Moraine Springs Hatchery as broodstock in late summer/early fall. The spring return of 1,060 steelhead was the third lowest since 1994. The majority of the spring steelhead (977, or 92%) were passed upstream. Three hundred sixty-eight were spawned, while another 83 were sacrificed for health assessment after spawning. The 368 spring spawners produced 560,000 eggs. Three brown trout died in the weir and the remaining 291 were passed upstream. The estimated population of chinook salmon above the weir was 12,338 (± 458 SD). Population estimates for the other species were brown trout: 534 (± 147 SD), coho salmon: 5,963 (± 781 SD), fall steelhead: 72 (± 19 SD). Spring population estimates were chambers creek steelhead: 211 (± 28 SD), and ganaraska steelhead: 858 (± 168 SD).

Cover photo: A summer catch of steelhead from the Lake Michigan waters off Door County. Photo by DNR Fisheries Biologist Paul Peeters.

The Root River Steelhead Facility (RRSF) is one of three weirs operated by Wisconsin Department of Natural Resources (WDNR) to collect information and broodstock from Lake Michigan trout and salmon. The Strawberry Creek Weir in Sturgeon Bay targets chinook salmon, while the Besadny Area Fishery Facility (BAFF) on the Kewaunee River targets coho salmon and steelhead and the RRSF contributes primarily steelhead. In addition, BAFF and RRSF function as backup collection sites for the other species. Brown trout do not return well to the weir sites, and are collected in the lower reaches of the rivers with a boat electroshocker. Management of trout and salmon in Lake Michigan brood rivers is intended to ensure adequate egg collections, conserve the genetic diversity of feral trout and salmon stocks and provide fishing opportunities. To accomplish these objectives, weir operations follow strategies outlined by WDNR guiding documents (e.g., Ives 1996, WDNR 1999).

The weirs provide a more efficient and reliable method to collect adult salmonids than the portable weirs and electrofishing efforts employed during past years. The RRSF was constructed in 1994 through a cooperative effort by WDNR, Salmon Unlimited, City of Racine and U.S. Fish & Wildlife Service. In addition to providing a collection and processing site for returning adult salmonids, the RRSF provides a unique educational tool for school groups and other interested publics.

This paper reports the results of data collected at the RRSF during fall, 2002 and spring, 2003. These data contribute to a long-term index of chinook, coho and steelhead populations in the Root River, and are collected to fulfill three objectives: 1) track the abundance of salmonid returns, 2) measure growth and condition of each species and/or strain, and 3) estimate return rate of each species.

METHODS

During operation of the weir, a minimum of 100 fish per targeted species and fin clip were sampled, except that data on skamania broodstock were obtained from Kettle Moraine Springs Hatchery (KMSH). Skamania, which spawn in late winter, are transported to the hatchery where they are allowed to mature in holding ponds. These fish are handled only minimally at the weir to minimize stress. Sampled fish were measured to the nearest millimeter, weighed to the nearest 0.1 pound, examined for fin clips, gender and condition. The remaining fish were tallied by species, gender and fin clip. Gametes were stripped from these fish, if needed. After this initial handling, fish were either passed upstream or sacrificed (fish health or contaminant samples). All fish passed upstream were given an upper caudal clip for population estimates.

All non-target species or fin clips were tallied by species, fin clip and sex, given an upper caudal clip and passed upstream. All coded wire tagged (CWT) fish are marked by an adipose-only clip, and have a tiny microtag implanted in their heads. The CWT fish were measured, weighed and sacrificed; heads were removed from behind the opercular flap, and frozen for later examination. Fish were collected as needed for other studies including disease or contaminant samples.

Size and condition

Trends in size and condition of all species processed at RRSF are calculated. Only fish with both total length and weight data are included in calculations of trophy weight (95^{th} percentile of the weight distribution), and standard weight (predicted weight at a given length based on a length-weight regression). The lengths used for calculation of standard weight are: 30 inches for chinook, 22 inches for coho, 22 inches for steelhead, and 20 inches for brown trout.

Coho salmon growth, age and maturity evaluation

Anadromous Fish Conservation Act funds were awarded for the third year of the growth, age and maturity study of coho salmon. During each of the first two years, one lot of coho salmon yearlings marked with adipose fin clips and uniquely coded wire tags (CWTs) were stocked in the Root River. The coho salmon were stocked just upstream of our weir facility on the river, the Root River Steelhead Facility (RRSF). In order to reach the vision of a Healthy Great Lakes Ecosystem described in the Strategic Vision of the Great Lakes Fishery Commission for the Decade of the 1990s and to more quickly detect changes in the forage base in Lake Michigan, accurate coho salmon data by age is needed. Unlike other salmon and trout that mature in 2-4 years and then return to spawning facilities, coho salmon only spend two summers in the lake prior to returning to their stocking stream. This study will allow Wisconsin to build a database on growth and maturity by age of coho salmon stocked in the Root River. This data will help fisheries biologists

around the lake refine stocking models, growth parameters, forage trends and survival and mortality rates of coho salmon. At the present time (June 2003), three years of stocking have been completed. Coho salmon marked as part of this study are expected to imprint on the Root River and home to the Root River when they mature and attempt to spawn. Most mature at age 2+, with a few showing up at age 1+.

Starting in the fall of 2001 and continuing through the fall of 2005, adipose clipped/CWT coho will be collected at RRSF as part of fall spawning/harvesting operations. Adipose clipped/CWT coho salmon will also be collected through the WDNR contact creel survey, by other states, and during other WDNR surveys, but the primary collection technique will be at RRSF.

During spawning operations at RRSF, coho salmon with an adipose fin clip will be marked with a uniquely numbered jaw tag, weighed, and measured. Heads from all jaw tagged coho salmon will be collected and transported to the WDNR Milwaukee Office for storage and processing. During the winter months, coho salmon heads collected at RRSF and from other sources will be checked for CWTs. Coho salmon heads with a CWT detected will be dissected for CWT recovery. Extracted CWTs will be decoded.

Steelhead strain evaluation

Steelhead stocking targets in the Root River were 35,000 per strain until 1999, when chambers creek and ganaraska targets were reduced to 27,000. All steelhead stocked in the broodstock rivers (Root and Kewaunee Rivers) are marked with a fin clip to identify the strain and yearclass. Each strain is assigned three fin clips (two fin clips prior to 1997), which are rotated annually. The three clips allow much cleaner separation of year-classes than the two-year clip rotation used previously. In addition to their use in identifying fish for breeding purposes, the fin clips allow each strain to be evaluated. This includes age of returning fish, return rates and population estimates by strain.

Population estimates

Fish that are passed by the weir are marked with a caudal (tail) clip, and recaptures of marked fish are noted in the creel survey for a mark-recapture population estimate of the population above the weir. Population estimates for each species or strain are derived from one of two equations. When sample sizes were adequate, the Petersen equation for mark and recapture was used (Ricker 1975):

$$N = \frac{M * C}{R} \quad (1)$$

Where

N = size of population in the river
M = number of marked fish at large in the river
C = number of recaptured fish
R = number of marked fish in the recapture sample

The sample standard deviation was calculated as:

$$S(N) = \sqrt{\frac{M^2 * C * (C - R)}{R^3}} \quad (2)$$

For species or strains with low sample sizes (i.e., 3 or fewer marked recaptures), the Bailey's modified equation was used for the population estimate (Ricker 1975):

$$N = \frac{M * (C + 1)}{R + 1} \quad (3)$$

With sample standard deviation:

$$S(N) = \sqrt{\frac{M^2 * (C + 1) * (C - R)}{(R + 1)^2 * (R + 2)}} \quad (4)$$

RESULTS AND DISCUSSION

The seventh season of operation for RRSF began September 6, 2002 and concluded April 21, 2003. A total of 10,340 chinook, 2,514 coho, 1,361 steelhead and 295 brown trout were examined (Table 1).

Chinook salmon

A record total of 10,340 chinook salmon were examined at RRSF during fall, 2002 (Table 2). A number of chinook were sacrificed for disease testing (120), or died in the weir (308). Eggs for hatchery production were taken at Strawberry Creek near Sturgeon Bay (see Peeters and Royseck 2003). The majority (9,912 or 96%) was passed upstream.

Average weight of chinook salmon was 13.3 pounds, slightly higher than the nine-year average of 12.4 pounds (Table 3).

Coho salmon

A total of 2,514 coho salmon were examined at RRSF (Table 4). Most (83%) were passed upstream. One hundred ninety-two were transferred to KMSH to mature for spawning. One-hundred forty were sacrificed for coded wire tags, 60 for health assessments, 17 for contaminant analysis and 29 died in the weir or were too weak to pass upstream. About 848,000 eggs were taken from 872 coho at the weir. Age composition (based on length-frequencies) indicated that the run was comprised of 16% age 1+ and 84% age 2+ coho salmon (Table 5). Average coho salmon weight and length was down considerably from the previous three years. (Table 3).

Coho salmon growth, age and maturity evaluation

Wisconsin DNR personnel collected data on 198 adipose only fin clipped coho salmon from the Root River Steelhead Facility in the fall of 2002. Each coho salmon was marked with a uniquely numbered jaw tag, weighed, and measured. Heads from all jaw tagged coho salmon were collected and transported to the WDNR Milwaukee Office for storage and processing. CWTs were extracted from 145 coho salmon. Of the 145 CWTs, 24 were lost or non-detectable which left 121 for analysis. Age 1+ coho salmon represented only 1.7% of the decoded salmon with age 2+ representing 98.3% of the sample. Male and female age 1+ coho salmon averaged 402 mm and 622 mm respectively while male and female age 2+ both averaged 609 mm. The majority of male and female coho salmon from the fall 2002 spawning run were larger than 600 mm but both sexes had some smaller fish in the sample (Figures 1 and 2). Subsequent spawning runs will allow comparison between years in both length at age and length frequency of the spawning runs.

Steelhead

Steelhead returns to the weir continued to decline. A total of 1,361 steelhead were examined at RRSF from September 6, 2002 to April 21, 2003. Most fish (1,025 or 75%) were passed upstream (Table 6). Eighty-three steelhead were sacrificed for disease testing, three died in the weir. In addition, 250 skamania-strain steelhead were transported as broodstock to KMSH during late summer and fall. Skamania egg collection totaled 370,655, of which 82,350 were fertilized with milt from Indiana males. The Indiana milt was intended to augment the genetic diversity of Wisconsin's feral skamania population. Egg collection totals for the other two strains were 235,000 chambers creek and 325,000 ganaraska.

During most years, age 3 and 4 fish contribute the bulk of the steelhead run, and this trend continued for fall 2002/spring 2003 (Table 7). Steelhead return rates to the weir prior to 1997, fall and spring combined, averaged slightly over 2% for year-classes followed through Age 7. Although not enough time has passed to follow the year-classes after 1996 to completion, it appears that the trend is toward considerably weaker year-classes with the exception of the 1998 year-class. Each year the 1998 year-class has been strongly represented in the returning population.

Management actions to address the decline in steelhead broodstock that have been implemented include: increased weir operations, collection of additional broodstock by electroshocking when shortfalls are

projected, inoculation of adult skamania against disease, and addition of skamania gametes from other sources to increase genetic diversity. A reduction in angler bag limits either below the weirs or in all Wisconsin waters of Lake Michigan was considered, but was postponed in the hope that other actions will be sufficient. A steelhead research agenda is under development.

Steelhead strain evaluation

The percent age composition of the runs was assigned from age-length keys developed from 242 fall fish and 457 known-age (fin clipped) spring fish. Ages 1 and 2 were not represented in the fall sample, 3 are 26.8%, 4 are 53.9%, 5 are 1.7%, 6 are 2.7%, and 7 are 14.8%. During spring, age 2 represent 13.1% of the return, 3 are 52.9%, 4 are 14.1%, 5 are 19.2%, 6 are 0.8% and 7 are not represented (Table 8). The low fall return of age 5 skamania highlights the poor performance of the 1997 year-class.

Fall skamania tend to have higher average length and weight than spring steelhead of the same age, but are comparable to spring fish one year older (Tables 9, 10, 11, Figures 3, 4). This is probably because a given-age fish in fall will be classified one year older the following spring, but puts on little growth during the winter months. Chambers creek steelhead averaged slightly longer and heavier than ganaraska, especially at younger ages. This could be due to either higher growth rates for chambers creek, or perhaps only relatively large chambers creek steelhead make a spawning run.

Population estimates

The number of chinook handled at the weir during 2002 was a record 10,340 (Table 1), and the population estimate was 12,338 (± 458 SD)(Table 12). The coho estimate of 5,963 (± 781 SD) was the third highest on record behind 1997and 2000. Skamania comprised 83% of the fall steelhead encountered at the weir. If 83% of the fall steelhead population (estimated at 72 ± 19 SD) is combined with 250 removed to KMS hatchery, then about 310 skamania returned during fall, 2002. This is the second lowest estimated return of skamania on record. Chambers creek were estimated at 211 (+ 28 SD), while the ganaraska estimate was 858 (+ 168 SD). The spring steelhead population estimates are lower than optimal, but a strong effort by DNR staff allowed adequate numbers of broodstock to be recovered.

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Table 1. Summary of chinook salmon, coho salmon, steelhead and brown trout captured at the Root River Steelhead Facility during 1994 to 2003.

CHINOOK SALMON

Harvest year	Harvested	Passed upstream	Misc. samples	Total
Fall, 1994	129	1,726	3	1,858
Fall, 1995	300	2,663	16	2,979
Fall, 1996	62	5,440	87	5,589
Fall, 1997	0	3,974	128	4,102
Fall, 1998	67	3,845	65	3,977
Fall, 1999	221	5,381	420	6,022
Spring, 2000	0	7	0	7
Fall, 2000	244	6,965	166	7,375
Fall, 2001	432	9,697	84	10,213
Spring, 2002	0	1	0	1
Fall, 2002	308	9,912	120	10,340

COHO SALMON

Harvest year	Harvested	Passed upstream	Misc. samples	Total
Fall, 1994	285	513	15	813
Fall, 1995	1,191	2,115	15	3,321
Fall, 1996	161	3,940	305	4,406
Fall, 1997	655	6,909	330	7,894
Fall, 1998	328	3,336	336	4,000
Fall, 1999	154	978	18	1,150
Fall, 2000	472	2,921	15	3,408
Fall, 2001	314	942	71	1,327
Fall, 2002	221	2,076	217	2,514

STEELHEAD

Harvest year	Harvested	Passed upstream	Misc. samples	Total
Fall, 1994	218	583	47	848
Spring, 1995	120	2,582	18	2,720
Fall, 1995	330	208	0	538
Spring, 1996	150	2,970	49	3,169
Fall, 1996	248	105	0	353
Spring, 1997	2	2,918	125	3,045
Fall, 1997	408	228	8	644
Spring, 1998	0	382	0	382
Fall, 1998	86	64	1	151
Spring, 1999	0	2,131	132	2,263
Fall, 1999	50	19	1	70
Spring, 2000	0	2,107	64	2,171
Fall, 2000	160	59	0	219
Spring, 2001	63	790	6	859
Fall, 2001	314	176	0	490
Spring, 2002	0	1,180	123	1,303
Fall, 2002	253	48	0	301
Spring, 2003	0	977	83	1,060

BROWN TROUT

Harvest year	Harvested	Passed upstream	Misc. samples	Total
Fall, 1994	0	259	0	259
Fall, 1995	46	645	0	691
Spring, 1996	0	4	0	4
Fall, 1996	70	244	0	314
Spring, 1997	0	2	0	2
Fall, 1997	114	369	3	486
Spring, 1998	0	2	0	2
Fall, 1998	14	202	12	228
Fall, 1999	0	125	0	125
Spring, 2000	0	6	0	6
Fall, 2000	2	241	0	243
Spring, 2001	0	2	0	2
Fall, 2001	1	176	0	177
Fall, 2002	3	291	0	294
Spring, 2003	0	1	0	1

Table 2. Number of chinook salmon harvested, passed upstream and sampled at the Root River Steelhead Facility during fall, 2002.

Date	Number harvested	Number passed upstream	Number of miscellaneous samples	Total number of fish
06-Sep-2002	1	44	0	45
16-Sep-2002	0	22	0	22
20-Sep-2002	0	111	0	111
23-Sep-2002	5	267	0	272
26-Sep-2002	2	104	0	106
30-Sep-2002	13	479	0	492
01-Oct-2002	36	805	0	841
02-Oct-2002	119	745	0	864
03-Oct-2002	17	918	0	935
04-Oct-2002	23	816	0	839
07-Oct-2002	46	1,346	0	1,392
00-Oct-2002	5	919	0	924
10-Oct-2002	3	809	120	932
11-Oct-2002	4	621	0	625
14-Oct-2002	17	448	0	465
17-Oct-2002	6	489	0	495
23-Oct-2002	4	354	0	358
24-Oct-2002	2	245	0	247
28-Oct-2002	3	255	0	258
31-Oct-2002	2	115	0	117
Totals	308	9,912	120	10,340

Table 3. Average weight, average length, standard weight and trophy (95th percentile) weight for the major salmonid species returning to the Root River Steelhead Facility during 1994 to 2003.

Season	Number used in analysis	Average weight (pounds)	Average length (inches)	Standard weight	Trophy weight
CHINOOK SALMON					
1994 – 95	343	8.9 ± 5.3	27.7 ± 5.6	9.7	17.8
1995 – 96	443	12.0 ± 5.9	30.7 ± 5.2	10.1	21.0
1996 – 97	703	11.7 ± 5.7	30.7 ± 5.4	9.8	21.1
1997 – 98	490	12.7 ± 4.9	32.5 ± 4.4	9.5	21.1
1998 – 99	389	12.2 ± 5.0	31.9 ± 4.3	9.5	19.6
1999 – 2000	418	13.2 ± 4.4	32.5 ± 3.8	9.9	19.9
2000 – 01	536	12.3 ± 5.7	31.1 ± 5.7	9.7	20.0
2001– 02	672	15.7 ± 5.2	34.3 ± 4.3	10.3	23.5
2002– 03	538	13.3 ± 4.8	32.8 ± 4.7	9.4	19.9
COHO SALMON					
1994 – 95	208	1.5 ± 1.1	15.9 ± 2.5	3.7	3.0
1995 – 96	594	3.1 ± 2.5	19.6 ± 5.1	3.6	9.0
1996 – 97	1,273	5.1 ± 2.4	23.9 ± 4.7	3.5	8.3
1997 – 98	828	3.8 ± 1.7	21.8 ± 3.5	3.5	6.7
1998 – 99	477	4.3 ± 1.7	23.4 ± 3.1	3.4	7.5
1999 – 2000	338	7.1 ± 4.4	25.5 ± 5.9	4.0	13.5
2000 – 01	472	8.2 ± 2.5	27.3 ± 3.2	3.9	11.6
2001– 02	316	6.8 ± 2.9	25.9 ± 4.9	3.7	10.3
2002– 03	445	4.8 ± 1.7	23.8 ± 3.0	3.5	7.6
STEELHEAD					
1994 – 95	638	5.9 ± 2.8	25.4 ± 4.7	3.5	10.7
1995 – 96	963	6.2 ± 2.7	25.6 ± 4.3	3.7	11.0
1996 – 97	626	7.2 ± 2.4	27.4 ± 3.3	3.6	11.2
1997 – 98	522	5.8 ± 2.9	25.7 ± 4.9	3.4	11.2
1998 – 99	603	6.2 ± 2.0	25.9 ± 3.3	3.9	9.8
1999 – 2000	766	7.3 ± 2.5	27.2 ± 3.9	3.6	11.0
2000 – 01	482	5.0 ± 1.7	24.1 ± 2.7	3.7	8.4
2001– 02	674	6.9 ± 2.4	26.9 ± 3.7	3.6	10.5
2002– 03	526	5.3 ± 2.3	24.5 ± 4.1	3.6	9.4
BROWN TROUT					
1994 – 95	108	4.9 ± 1.5	22.1 ± 2.7	3.4	7.0
1995 – 96	201	5.3 ± 2.2	22.4 ± 3.3	3.6	9.0
1996 – 97	162	4.6 ± 2.1	21.4 ± 4.0	3.4	7.8
1997 – 98	250	6.7 ± 3.4	24.0 ± 3.7	3.8	14.1
1998 – 99	55	6.6 ± 3.2	24.3 ± 3.5	3.5	13.5
1999 – 2000	120	6.7 ± 2.6	23.9 ± 3.7	3.5	10.1
2000 – 01	0				
2001– 02	95	5.2 ± 1.8	21.9 ± 3.1	3.7	8.2
2002– 03	156	5.5 ± 1.6	22.5 ± 2.2	4.0	8.0

Table 4. Number of coho salmon harvested, passed upstream and sampled at the Root River Steelhead Facility during fall, 2002.

Date	Number harvested	Number passed upstream	Number of miscellaneous samples	Total Number of fish
06-Sep-2002	0	1	0	1
16-Sep-2002	0	0	0	0
20-Sep-2002	0	5	0	5
23-Sep-2002	0	57	8	65
26-Sep-2002	0	27	4	31
30-Sep-2002	0	66	29	95
01-Oct-2002	67	57	13	137
02-OCt-2002	3	307	12	342
03-Oct-2002	65	74	20	159
04-Oct-2002	0	107	17	124
07-Oct-2002	0	239	29	268
09-Oct-2002	0	0	0	0
10-Oct-2002	27	20	0	47
11-Oct-2002	0	8	0	8
14-Oct-2002	1	19	0	20
17-Oct-2002	11	74	20	105
23-Oct-2002	28	262	0	290
24-Oct-2002	1	9	0	10
28-Oct-2002	16	655	65	736
31-Oct-2002	2	89	0	91
Totals	221	2,076	217	2,514

Table 5. Estimated age composition of coho salmon (sexes combined) examined at the Root River Steelhead Facility during fall, 1994 through 2002. During 1994 to 1998, age was based on age-length key developed from known-age fin-clipped coho salmon. After 1998, ages were assigned by length-frequency of measured fish.

Year of Return	Percent age composition 1+	2+	Number used in analysis	Total return
1994	53 %	47 %	485	813
1995	24 %	76 %	1,349	3,321
1996	32 %	68 %	4,170	4,406
1997	5 %	95 %	6,978	7,894
1998	12 %	88 %	2,439	4,000
1999	44 %	56 %	341	1,150
2000	7 %	93 %	472	3,408
2001	16 %	84 %	320	1,327
2002	16%	84%	334	2,514

Table 6. Number of steelhead harvested, passed upstream and sampled at the Root River Steelhead Facility during fall, 2002 and spring, 2003.

Date	Number harvested	Number passed upstream	Number of miscellaneous samples	Total Number of fish
06-Sep-2002	90	19	0	109
16-Sep-2002	6	0	0	6
20-Sep-2002	15	2	0	17
23-Sep-2002	32	5	0	37
26-Sep-2002	5	0	0	5
30-Sep-2002	19	2	0	21
01-Oct-2002	28	3	0	31
02-Oct-2002	16	6	0	22
03-Oct-2002	10	2	0	12
04-Oct-2002	0	1	0	1
07-Oct-2002	1	1	0	2
09-Oct-2002	0	0	0	0
10-Oct-2002	24	2	0	26
11-Oct-2002	0	0	0	0
14-Oct-2002	0	1	0	1
17-Oct-2002	7	2	0	9
23-Oct-2002	0	0	0	0
24-Oct-2002	0	0	0	0
28-Oct-2002	0	2	0	2
31-Oct-2002	0	0	0	0
03-Apr-2003	0	164	0	164
09-Apr-2003	0	208	83	291
14-Apr-2003	0	460	0	460
21-Apr-2003	0	145	0	145
Totals	253	1,025	83	1,361

Table 7. Return rate of steelhead to the Root River Weir during 1994 through 2003. Number at age were estimated by expanding the proportion at each age in the aged sample against the return of known-strain steelhead. Fall data include only skamania; spring data combine chambers creek and ganaraska returns.

year	number	return	Number at age								Return
class	stocked	time	age 1	age 2	age 3	age 4	age 5	age 6	age 7	total	Rate
1991	39383	fall	0	0	341	241	109	27	0	719	1.82%
	71229	spring	0	0	0	1151	248	255	1	1655	2.32%
	110,612	**total**	**0**	**0**	**341**	**1392**	**357**	**282**	**1**	**2373**	**2.15%**
1992	35276	fall	0	60	106	16	60	1	0	241	0.68%
	65744	spring	0	0	949	900	544	16	0	2410	3.67%
	101,020	**total**	**0**	**60**	**1055**	**916**	**604**	**17**	**0**	**2651**	**2.62%**
1993	30,417	fall	70	59	125	417	22	4	19	716	2.35%
	69,883	spring	0	222	983	1024	17	0	0	2246	3.21%
	100,300	**total**	**70**	**282**	**1108**	**1440**	**39**	**4**	**19**	**2962**	**2.95%**
1994	37,347	fall	76	78	87	37	3	14	10	306	0.82%
	72,313	spring	0	299	534	116	133	45	1	1129	1.56%
	109,660	**total**	**76**	**377**	**621**	**154**	**136**	**59**	**12**	**1435**	**1.31%**
1995	34,254	fall	0	27	25	31	12	39	0	135	0.39%
	69,983	spring	0	25	111	807	216	19	21	1199	1.71%
	104,237	**total**	**0**	**52**	**136**	**838**	**228**	**59**	**21**	**1334**	**1.28%**
1996	35,262	fall	0	0	18	84	20	0	43	165	0.47%
	70,225	spring	0	47	850	815	10	9	0	1731	2.47%
	105,487	**total**	**0**	**47**	**867**	**899**	**30**	**9**	**43**	**1859**	**1.76%**
1997	37,484	fall	0	0	46	5	0	8		59	0.16%
	66,735	spring	0	38	323	61	18	6		447	0.67%
	104,219	**total**	**0**	**38**	**369**	**66**	**18**	**14**		**505**	**0.48%**
1998	35,528	fall	0	5	231	0	5			241	0.68%
	53,914	spring	0	122	578	723	146			1569	2.9%
	89,442	**total**	**0**	**127**	**809**	**723**	**151**			**1810**	**2.0%**
1999	37,010	fall	0	5	0	156				161	0.44%
	54,405	spring	0	25	245	107				377	0.69%
	91,415	**total**	**0**	**29**	**245**	**263**				**537**	**0.59%**
2000	35,247	fall	8	0	77					85	0.24%
	54,160	spring	0	42	403					445	0.82%
	89,407	**total**	**8**	**42**	**480**					**530**	**0.59%**
2001	33,634	fall	0	0						0	-
	54,189	spring	0	100						100	0.18%
	87,823	**total**	**0**	**100**						**100**	**0.11%**

Table 8. Estimated age composition of steelhead (sexes combined) examined at the Root River Steelhead Facility during 1994 – 2003. Age is based on age-length key developed from known-age fin clipped steelhead. Total number represents the number of steelhead used in the analysis. During 2000, 2001and 2002, data from skamania transported to Kettle Moraine Springs Hatchery are included.

Year of return	Percent age composition							Total Number
	1+	2+	3+	4+	5+	6+	7+	
Fall – 1994	8.9	7.5	43.2	34.2	6.2	-	-	146
Spring – 1995		7.3	31.3	38.0	12.7	10.7	-	450
Fall – 1995	15.6	12.2	21.8	49.7	0.7	-	-	147
Spring – 1996		11.0	36.1	33.1	9.1	10.1	0.6	692
Fall – 1996	-	26.3	36.8	5.3	31.6	-	-	21
Spring – 1997		1.0	22.1	42.5	22.5	10.5	1.4	483
Fall – 1997	-	4.4	14.2	67.2	9.6	4.4	-	135
Spring – 1998		15.3	35.9	37.6	5.6	5.2	0.4	287
Fall – 1998	-	-	29.3	44.0	25.3	1.4	-	75
Spring – 1999		2.1	46.5	44.2	7.3	-	-	385
Fall – 1999	-	-	32.3	54.7	5.2	7.8	-	51
Spring – 2000		8.0	21.3	53.6	14.2	3.0	-	714
Fall – 2000	-	2.7	25.3	46.7	6.7	8.0	10.7	75
Spring – 2001		3.5	83.2	8.9	1.4	2.8	0.2	482
Fall – 2001	2.4	1.4	72.8	1.5	13.3	26.3	7.0	212
Spring – 2002		4.2	23.2	68.3	1.5	0.8	2.0	575
Fall – 2002	-	-	26.8	53.9	1.7	2.7	14.8	278
Spring – 2003	-	13.1	52.9	14.1	19.2	0.8	-	491

Table 9. Average length and weight at age (± 1 SD) of fall-run skamania-strain steelhead at the Root River Steelhead Facility during 1994 to 2002. Data from 2000, 2001and 2002 were taken from fish transported and held at Kettle Moraine Springs Hatchery, so some weight loss likely occurred.

Season	Strain	Age 2+	Age 3+	Age 4+	Age 5+	Age 6+	Age 7+
Fall, 1994	Skamania	23.6 (± 0) 4.5 (± 0) N = 1	26.1 (± 1.8) 5.6 (± 1.1) N = 52 / 43	29.9 (± 1.8) 8.3 (± 1.5) len N = 40 wt N = 31	31.9 (± 2.7) 10.2 (± 2.2) len N = 13 wt N = 12	33.6 (± 1.0) 11.6 (± 1.3) N = 11	
Fall, 1995	Skamania	25.8 (± 1.0) 5.3 (± 0.8) N = 14	27.0 (± 1.5) 6.2 (± 1.1) N = 27	30.5 (± 2.0) 9.1 (± 2.1) N = 70	31.7 (± 1.1) 10.5 (± 1.4) N = 6		
Fall, 1996	Skamania	22.1 (± 0) 4.0 (± 0) N = 1	27.2 (± 1.4) 6.7 (± 0.7) N = 7	28.8 (± 0) 8.0 (± 0) N = 1	32.1 (± 1.7) 10.1 (± 1.8) N = 2		
Fall, 1997	Skamania	28.5 (± 1.0) 7.1 (± 0.9) N = 6	27.1 (± 1.1) 6.0 (± 1.0) len N = 19 wt N = 18	31.1 (± 1.8) 9.1 (± 1.9) N = 91	32.1 (± 1.3) 9.6 (± 1.1) N = 12	34.5 (± 1.7) 12.3 (± 3.3) N = 7	36.0 (± 0) 12.9 (± 0) N = 1
Fall, 1998	Skamania		25.8 (± 1.4) 5.1 (± 0.8) N = 22	30.0 (± 2.1) 8.0 (± 1.6) N = 44	31.9 (± 2.0) 9.5 (± 1.5) N = 19		
Fall, 1999	Skamania		28.3 (± 1.6) 7.3 (± 0.8) N = 14	29.0 (± 1.2) 8.0 (± 1.1) N = 25	31.6 (± 2.1) 10.6 (± 0.4) N = 2	32.2 (± 0.6) 10.0 (± 1.1) N = 4	
Fall, 2000	Skamania	26.4 (± 0) 7.0 (± 1.4) N = 2	27.8 (± 1.2) 7.5 (± 1.0) N = 19	30.2 (± 2.0) 8.5 (± 2.0) len N = 37 wt N = 38	28.9 (± 0.5) 8.6 (± 1.0) N = 8	31.2 (± 1.0) 10.6 (± 1.8) N = 6	32.3 (± 2.3) 10.1 (± 1.8) N = 8
Fall, 2001	Skamania		27.0 (± 1.3) 6.8 (± 1.1) len N = 135 wt N = 53	25.5 (± 0.6) 6.6 (± 0.2) len N = 3 wt N = 2	31.5 (± 1.4) 9.3 (± 1.5) len N = 5 wt N = 3	30.5 (± 1.1) 10.1 (± 1.9) len N = 15 wt N = 10	32.6 (± 1.6) 10.9 (± 1.3) len N = 7 wt N = 5
Fall, 2002	Skamania		26.6 (±1.4) 6.2 (± 1.4) len N = 69 wt N = 11	28.7 (± 1.6) 8.0 (± 1.3) len N = 132 wt N = 41	30.0 (± 0.9) 7.3 len N = 4 wt N = 1	30.3 (± 0.7) 7.8 (± 1.1) len N = 6 wt N = 2	32.2 (± 0.9) 10.4 (± 1.1) len N = 31 wt N = 8

Table 10. Average length and weight at age (± 1 SD) of spring-run chambers creek-strain steelhead at the Root River Steelhead Facility during 1995 to 2003.

Season	Strain	Age 2+	Age 3+	Age 4+	Age 5+	Age 6+	Age 7+
Spring, 1995	Chambers Cr.	20.9 (± 1.1) 4.2 (± 1.1) N = 3	23.9 (± 1.7) 4.6 (± 1.1) N = 73	28.1 (± 1.4) 7.6 (± 1.2) N = 89	28.5 (± 1.4) 7.8 (± 1.3) N = 32	31.3 (± 0.9) 10.0 (± 1.1) N = 25	
Spring, 1996	Chambers Cr.	18.5 (± 0.8) 2.2 (± 0.3) N = 22	25.2 (± 1.4) 5.6 (± 1.1) N = 87	27.9 (± 1.4) 7.4 (± 1.2) N = 90	29.5 (± 1.8) 9.3 (± 1.6) N = 52	31.2 (± 1.3) 10.5 (± 1.5) N = 41	32.0 (± 0.6) 12.0 (± 0.7) N = 3
Spring, 1997	Chambers Cr.		24.8 (± 1.3) 5.3 (± 1.0) N = 33	28.6 (± 1.9) 8.3 (± 1.5) N = 77	27.4 (± 1.6) 6.6 (± 1.5) N = 70	32.2(± 1.1) 11.2 (± 1.6) N = 35	
Spring, 1998	Chambers Cr.		23.8 (± 1.4) 4.3 (± 0.8) N = 42	27.7 (± 2.3) 7.0 (± 2.0) N = 39	28.9 (± 1.8) 7.5 (± 1.2) N = 5	32.1 (± 0.8) 10.2 (± 1.3) N = 7	
Spring, 1999	Chambers Cr.	18.6 (± 0.4) 2.7 (± 0.8) N = 2	23.8 (± 1.6) 4.7 (± 0.8) N = 13	28.3 (± 2.0) 7.6 (± 1.3) N = 96	28.6 (± 2.3) 8.0 (± 1.8) N = 4		
Spring, 2000	Chambers Cr.	17.2 (± 1.1) 1.6 (± 0.3) N = 12	26.2 (± 1.8) 6.3 (± 1.1) N = 26	29.3 (± 1.8) 8.3 (± 1.4) N =90	29.8 (± 2.2) 8.7 (± 1.8) N = 54	30.3 (± 1.5) 8.6 (± 1.9) N = 8	
Spring, 2001	Chambers Cr.		23.9 (± 1.6) 4.7 (± 0.8) N = 62	27.5 (± 3.3) 6.9 (± 2.0) N = 8	31.3 (± 0) 10.7 (± 0) N = 1	27.8 (± 0.4) 7.1 (± 0.5) N = 4	
Spring, 2002	Chambers Cr.		25.5 (± 1.8) 5.4 (± 1.1) N = 17	28.9 (± 1.8) 8.0 (± 1.6) N = 206	30.3 (± 2.4) 9.8 (± 1.4) N = 2	29.9 (± 2.3) 8.7 (± 1.6) N = 2	32.3 (± 1.3) 11.2 (± 1.8) N = 8
Spring, 2003	Chambers Cr.	16.9 (±1.4) 1.8 (± .4) N =20	24.8 (± 1.3) 5.1 (± 1.0) N =72	28.2 (± 1.5) 7.4 (± 1.3) N = 27	28.8 (± 2.2) 7.7 (± 1.5) N = 19	28.6 (± .7) 7.1 (± .4) N = 2	

Table 11. Average length and weight at age (± 1 SD) of spring-run ganaraska-strain steelhead at the Root River Steelhead Facility during 1995 to 2003.

Season	Strain	Age 2+	Age 3+	Age 4+	Age 5+	Age 6+	Age 7+
Spring, 1995	Ganaraska	16.5 (± 1.3) 1.5 (± 0.5) N = 30	21.5 (± 2.3) 3.3 (± 1.0) len N = 68 wt N = 67	24.2 (± 2.2) 5.0 (± 1.4) N = 81	27.5 (± 1.7) 7.2 (± 2.0) N = 24	28.8 (± 1.2) 8.0 (± 1.4) N = 23	32.5 (± 0) 12.5 (± 0) N = 1
Spring, 1996	Ganaraska	16.6 (± 1.9) 1.7 (± 0.5) N = 57	23.5 (± 1.8) 4.7 (± 1.2) N = 167	25.1 (± 2.0) 5.7 (± 1.4) N = 113	26.7(± 1.9) 7.1 (± 1.5) N = 22	28.6 (± 1.5) 8.7 (± 1.5) N = 29	32.2 (± 0) 12.5 (± 0) N = 1
Spring, 1997	Ganaraska	15.1 (± 1.9) 1.2 (± 0.4) N = 3	23.5 (± 2.1) 4.3 (± 1.3) N = 75	28.4 (± 1.9) 7.9 (± 1.6) N = 125	27.7 (± 2.1) 7.4 (± 1.7) N = 30	27.1 (± 0) 6.7 (± 0) N = 1	
Spring, 1998	Ganaraska	16.7 (± 1.3) 1.6 (± 0.3) N = 45	21.4 (± 1.9) 3.3 (± 0.8) N = 66	25.1 (± 2.6) 5.2 (± 1.5) N = 94	27.0 (± 0.8) 5.9 (± 0.6) N = 7	31.2 (± 0.2) 9.3 (± 0.7) N = 3	30.4 (± 0) 4.9 (± 0) N = 1
Spring, 1999	Ganaraska	17.1 (± 1.6) 2.0 (± 0.6) N = 6	23.7 (± 1.4) 4.9 (± 0.9) N = 167	26.2 (± 1.7) 6.6 (± 1.3) N = 79	27.6 (± 2.0) 7.4 (± 1.8) N = 25		
Spring, 2000	Ganaraska	16.8 (± 1.6) 1.6 (± 0.4) N = 37	25.1 (± 2.2) 5.8 (± 1.6) N = 73	28.6 (± 2.1) 8.3 (± 1.9) N = 202	28.3 (± 2.3) 8.2 (± 2.1) N = 18	29.4 (± 1.7) 9.0 (± 1.1) N = 5	
Spring, 2001	Ganaraska	16.9 (± 0.6) 1.6 (± 0.3) N = 14	23.7 (± 1.5) 4.7 (± 0.8) N = 273	27.1 (± 2.4) 7.0 (± 2.1) N = 18	29.3 (± 1.0) 9.0 (± 0.6) N = 3	28.9 (± 1.3) 8.7 (± 1.7) N = 4	32.8 (± 0) 12.5 (± 0) N = 1
Spring, 2002	Ganaraska	16.0 (± 1.6) 1.5 (± 0.4) N = 17	23.2 (± 1.5) 4.2 (± 0.7) N = 86	27.3 (± 1.7) 7.1 (± 1.4) N = 103	28.1 (± 2.4) 8.0 (± 2.5) N = 5	28.9 (± 0.5) 8.1 (± 0.2) N = 2	
Spring, 2003	Ganaraska	17.0 (± 1.3) 1.9 (± .8) N = 39	22.8 (± 1.7) 4.3 (± 1.0) N = 116	27.2 (± 2.0) 6.5 (± 1.3) N = 23	25.4 (± 2.2) 5.8 (± 1.7) N = 48		

Table 12. Population estimates for chinook, coho and steelhead salmon returning to the Root River during fall, 1994 through spring, 2003. Fall steelhead are mostly skamania, but may include other strains.

Year	Species	Number of marked fish	Number of recaptured fish	Number of marked fish in recapture sample	Population size (±) 1 SD
Fall, 1994	Chinook	1,720	143	44	5,590 ± 701
	Coho	513	2	0	-
	Fall steelhead	556	22	6	1,827 ± 539
Spring, 1995	Chambers Creek	1,653	117	45	4,298 ± 503
	Ganaraska	453	74	11	2,718 ± 691
Fall, 1995	Chinook	2,663	36	21	4,478 ± 594
	Coho	1,354	33	13	3,288 ± 651
	Fall steelhead	482	36	6	2,547 ± 811
Spring, 1996	Chambers Creek	1,045	48	28	1,765 ± 206
	Ganaraska	1,457	77	31	3,551 ± 475
Fall, 1996	Chinook	5,440	37	36	5,587 ± 147
	Coho	3,940	9	9	3,940 ± 0
	Fall steelhead	105	29	0	3,150 ± 2,189
Spring, 1997	Chambers Creek	900	38	6	5,014 ± 1,606
	Ganaraska	139	23	5	5,356 ± 1,753
Fall, 1997	Chinook	3,974	40	31	5,127 ± 436
	Coho	6,909	52	45	7,983 ± 436
	Fall steelhead	228	16	2	1,297 ± 509
Spring,1998	Chambers Creek	93	15	2	501 ± 226
	Ganaraska	217	17	1	1,962 ± 1,067
Fall, 1998	Chinook	3,845	55	51	4,146 ± 156
	Coho	3,336	25	19	4,389 ± 493
	Fall steelhead	64	33	1	1,088 ± 609
	Brown	202	31	11	539 ± 118
Spring, 1999	Chambers Creek	678	-	-	-
	Ganaraska	1,043	-	-	-
Fall, 1999	Chinook	5,381	18	7	13,836 ± 4,088
	Coho	978	111	35	3,101 ± 434
	Fall steelhead	19	13	0	266 ± 181
	Brown	125	17	2	750 ± 342
Spring, 2000	Chambers Creek	460	1	0	-
	Ganaraska	1,006	21	13	1,625 ± 278
Fall, 2000	Chinook	6,965	72	13	38,575 ± 9,685
	Coho	2,921	38	11	10,091 ± 2,565
	Fall steelhead	59	16	6	157 ± 51
	Brown	241	22	1	2,771 ± 1,529
Spring, 2001	Chambers Creek	128	8	2	384 ± 157
	Ganaraska	475	27	6	2,137 ± 769
Fall, 2001	Chinook	9,697	142	82	16,792 ± 1,205
	Coho	942	2	1	1,413 ± 471
	Fall steelhead	175	40	3	1,794 ± 762
	Brown	176	71	1	6,336 ± 3,607
Spring, 2002	Chambers Creek	564	15	9	940 ± 198
	Ganaraska	372	14	9	579 ± 115
Fall, 2002	Chinook	9,912	178	143	12,338 ± 458
	Coho	2,079	109	38	5,963 ± 781
	Fall Steelhead	48	5	3	72 ± 19
	Brown	291	11	6	534 ± 147
Spring, 2003	Chambers Creek	185	8	7	211 ± 28
	Ganaraska	497	19	11	858 ± 168

Figure 1.

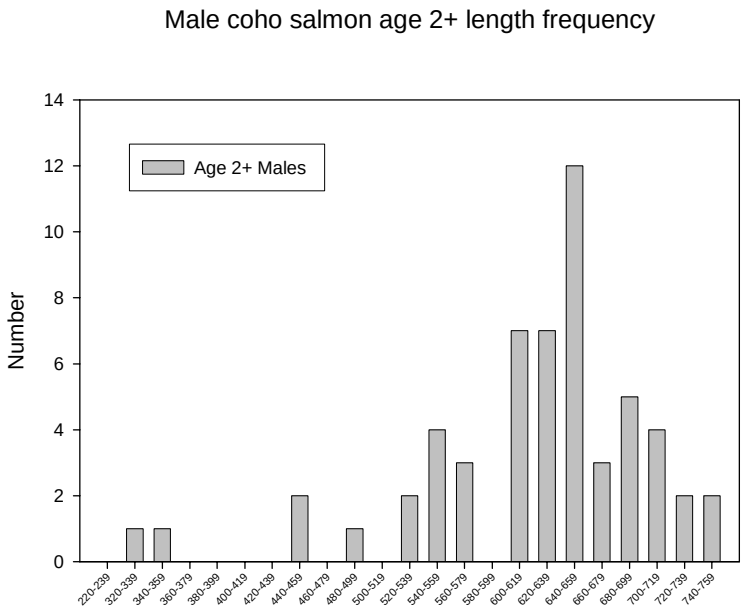


Figure 2.

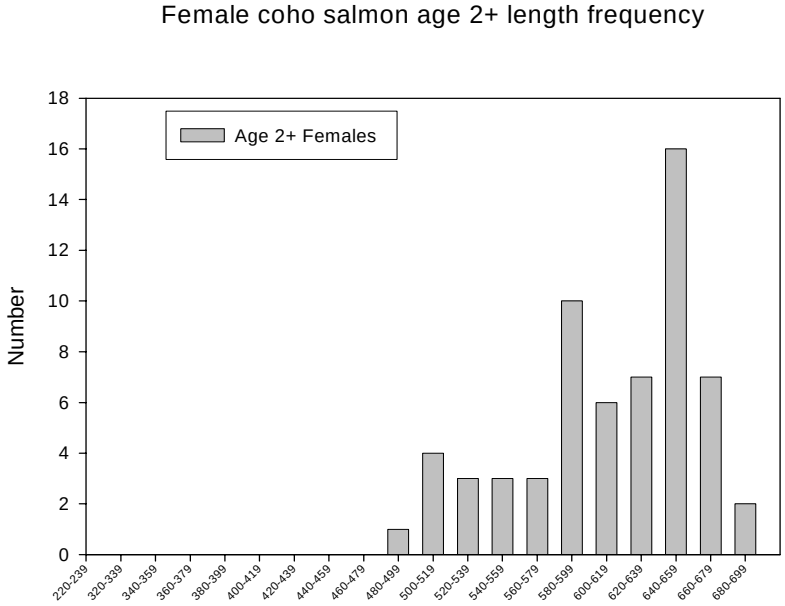


Figure 3. Steelhead mean length-at-age at the Root River Steelhead Facility during 1994 to 2003. Skamania data from 2001 and 2002 were taken from fish transported and held at Kettle Moraine Springs Hatchery.

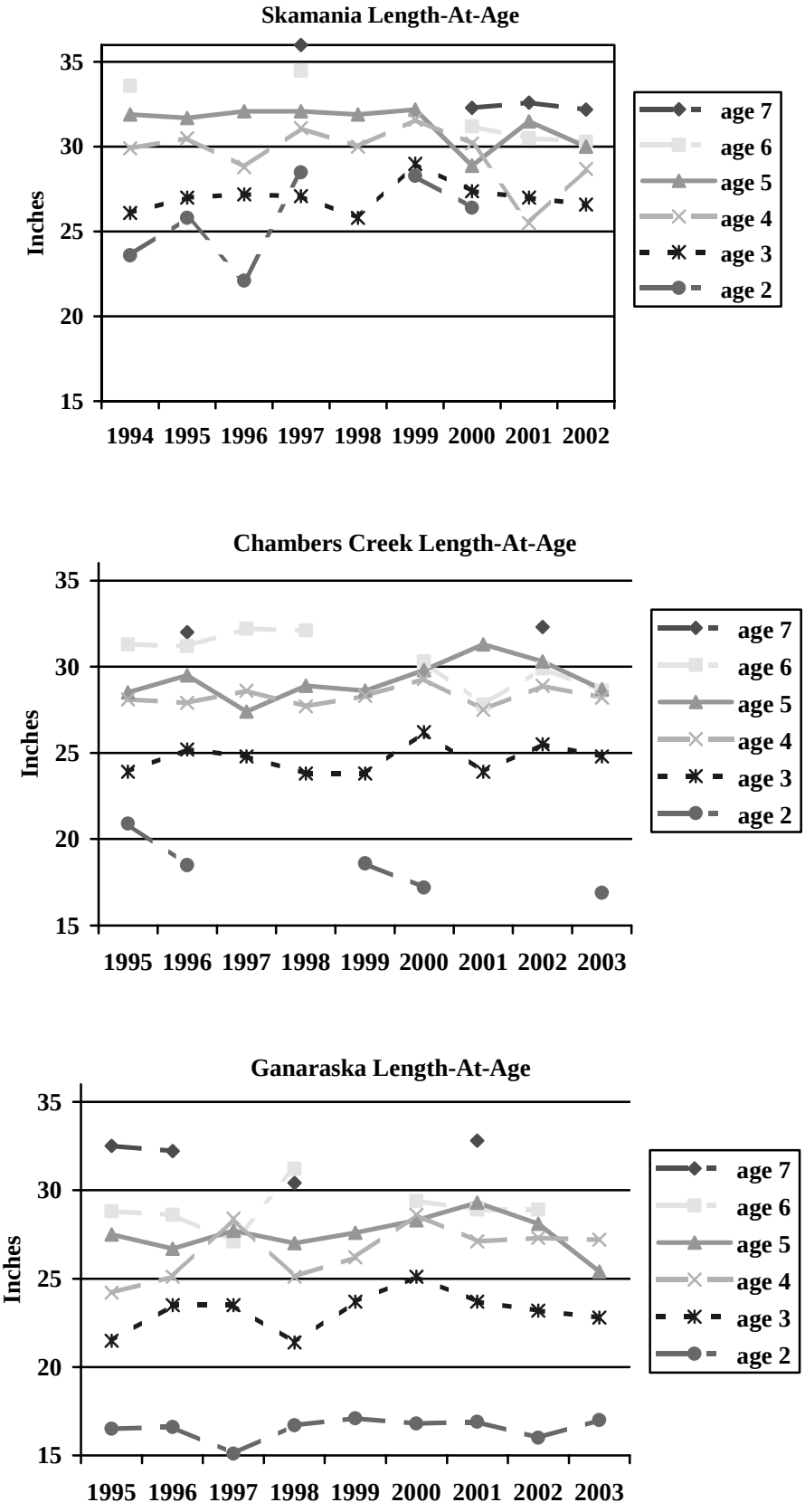
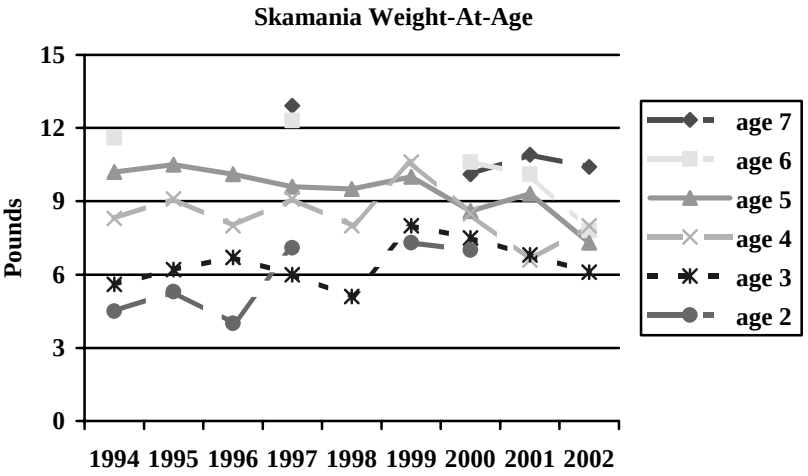
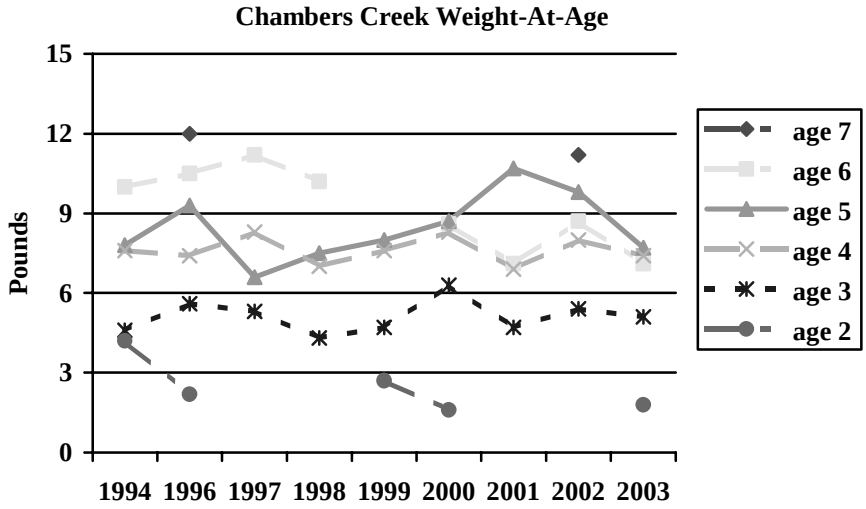
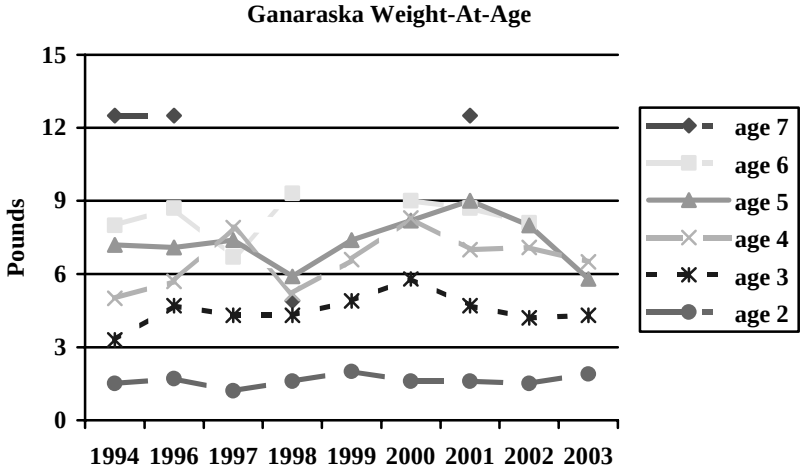


Figure 4. Steelhead mean weight-at-age at the Root River Steelhead Facility during 1994 to 2003. Skamania data from 2001 and 2002 were taken from fish transported and held at Kettle Moraine Springs Hatchery.







APPENDIX A. ROOT RIVER STOCKING NUMBERS

Table A-1. Number of fingerling chinook salmon stocked in the Root River during 1994 - 2002. Targets were 169,500, reduced to 143,900 after 1998. Chinook salmon were marked with an oral dose of Oxytetracycline (OTC) during 2001.

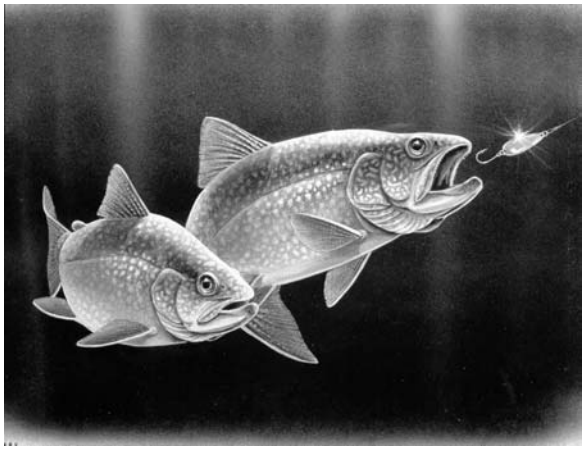
Year stocked	Total number	Strain	Fin clip
1994	75,533	Lake Michigan	LP
	60,000	Lake Michigan	None
1995	99,000	Lake Michigan	RP
	69,250	Lake Michigan	None
1996	158,000	Lake Michigan	None
1997	142,500	Lake Michigan	None
1998	161,500	Lake Michigan	None
1999	143,100	Lake Michigan	None
2000	142,900	Lake Michigan	None
2001	143,973	Lake Michigan	None (OTC)
2002	140,280	Lake Michigan	None

Table A-2. Number of coho salmon stocked in the Root River during 1994 – 2002. Targets were 40,600 spring yearlings and 10,000 fall fingerings.

Year stocked	Total number	Strain	Fin clip	Age
1994	66,080	Lake Ontario	None	Spring yearling 1+
	55,954	Lake Ontario	RMLP	Fall fingerling 0+
	50,389	Lake Michigan	RP	Spring yearling 1+
1995	65,100	Lake Michigan	RMRP	Spring yearling 1+
	54,832	Lake Michigan	RMLV	Fall fingerling 0+
1996	40,590	Lake Michigan	RMRV	Spring yearling 1+
	63,697	Lake Michigan	LP	Fall fingerling 0+
1997	48,107	Lake Michigan	RP	Spring yearling 1+
	6,668	Lake Michigan	REL	Spring yearling 1+
	4,208	Lake Michigan	None	Spring yearling 1+
	20,604	Lake Michigan	None	Fall fingerling 0+
1998	33,666	Lake Michigan	None	Spring yearling 1+
	10,000	Lake Michigan	None	Fall fingerling 0+
1999	45,945	Lake Michigan	None	Spring yearling 1+
	13,824	Lake Michigan	None	Fall fingerling 0+
2000	41,375	Lake Michigan	None	Spring yearling 1+
	10,030	Lake Michigan	None	Fall fingerling 0+
2001	27,970	Lake Michigan	None	Spring yearling 1+
	11,080	Lake Michigan	A-CWT	Spring yearling 1+
	10,260	Lake Michigan	None	Fall fingerling 0+
2002	29,954	Lake Michigan	None	Spring yearling 1+
	10,648	Lake Michigan	A-CWT	Spring yearling 1+
	12,285	Lake Michigan	None	Fall fingerling 0+

Table A-3. Number of steelhead stocked in the Root River during 1994 – 2002. Stocking targets were 35,000 per strain, reduced to 27,000 chambers creek and ganaraska after 1998.

Year stocked	Total number	Strain	Fin clip
1994	30,417	Skamania	RM
	35,124	Chambers Creek	LM
	34,759	Ganaraska	LV
1995	37,347	Skamania	ARM
	37,819	Chambers Creek	ALM
	34,494	Ganaraska	ALV
1996	34,254	Skamania	RM
	34,579	Chambers Creek	LM
	35,404	Ganaraska	ARV
1997	35,262	Skamania	RMRV
	35,024	Chambers Creek	LMLV
	35,201	Ganaraska	BV
1998	37,484	Skamania	ARM
	33,187	Chambers Creek	ALM
	33,548	Ganaraska	ALV
1999	35,528	Skamania	RM
	26,951	Chambers Creek	LM
	26,963	Ganaraska	ARV
2000	37,010	Skamania	RMRV
	27,287	Chambers Creek	LMLV
	27,118	Ganaraska	BV
2001	35,247	Skamania	ARM
	27,060	Chambers Creek	ALM
	27,100	Ganaraska	ALV
2002	33,634	Skamania	RM
	27,064	Chambers Creek	LM
	27,125	Ganaraska	ARV



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