Root River Steelhead Facility
Fall 1998 - Spring 1999 Report

Bradley T. Eggold
Fisheries Management
Plymouth, Wisconsin 53073

Summary: A total of 3,977 chinook salmon, 4,000 coho salmon, 2,414 steelhead and 228 brown trout were examined at the Root River Steelhead Facility (RRSF) in fall 1998 and spring 1999.

Of the 3,977 chinook salmon examined at the RRSF in the fall of 1998, the majority of them (3,845 or 97%) were passed upstream. Only 65 chinook had to be sacrificed for either disease or contaminant analysis or were too weak to pass upstream. Four consecutive years of stocking either Lake Ontario Strain (LOS) or Lake Michigan Strain (LMS) chinook salmon produced runs of 3+ and 4+ LMS chinook salmon in 1998. Lake Michigan strain chinook salmon returned as 3+ fish at 0.41% (403 fish) from the 1995 year class. Age 4+ fish from the 1994 year class returned at 0.04% (43 fish). Data from this study will be completed in 1999 but preliminary analysis shows that the LMS chinook salmon returned at a much higher rate than the LOS chinook salmon.

The number of coho salmon returning to RRSF was 4,000 in 1998. A total of 3,336 coho salmon were passed upstream in 1998, 336 were saved for contaminant or fish health analysis and 328 were taken to a hatchery to be held until spawning. In the fall of 1998, we saw the third adult return of coho salmon from the fall fingerling versus spring yearling stocking study. Age 2+ adult coho salmon stocked as yearlings returned at three and a half times the rate as those stocked as fingerlings (3.17% vs. 0.92%). This was the second year in a row the return rates from yearlings were considerable higher than fingerling coho salmon.

Steelhead returns were low for Skamania in the fall, but relatively high for Chambers Creek and Ganaraska in the spring. Of the 151 steelhead examined at RRSF in the fall of 1998, 86 were taken to the Kettle Moraine Fish Hatchery for brood stock and 64 were passed upstream. This year's run was comprised of slightly older fish, primarily age 4+. Chambers Creek and Ganaraska comprised the bulk of the spring 99 run. A total of 2,263 steelhead returned to RRSF in the spring of 1999, with 94% passed upstream and 132 saved for contaminant or fish health analysis. This year's run was comprised of younger fish, with the majority being 2+ and 3+ steelhead. The recent addition of a 3rd set of finclips for the steelhead (RMRV, LMLV and BV) has allowed a more accurate assessment of the ages of returning steelhead.

Based on the high variability of the population estimates in a given year there was only one significant change that occurred in the 1998-99 spawning runs. The coho salmon run was calculated to be about 3,000 less than the 1997 run but very similar to the spawning runs in 1996 and 1995. The chinook salmon population was estimated at 4,146 ± 156 fish. The other estimates were as follows: coho salmon 4,389 ± 493, Skamania 1,088 ± 609 and brown trout 539 ± 118. No estimates could be calculated for Chambers Creek and Ganaraska steelhead because of poor recapture data from the creel survey.

The Root River has historically been a tremendous source of fish for both anglers, who want to catch them and fishery managers, who want to study them. The river has been stocked with large numbers of salmonids. Past efforts by managers to study these fish populations have been very labor intensive. Portable weirs as well as electrofishing efforts have been implemented to sample fish. Both methods were very labor intensive, costly and provided only a fraction of the fisheries data that the Wisconsin Department of Natural Resources needs to manage the Lake Michigan fishery. To combat these problems the Root River Steelhead Facility (RRSF) was constructed in 1994 through a cooperative effort by the WDNR, Salmon Unlimited, City of Racine and the U.S. Fish and Wildlife Service. Its main purpose is to provide brood stock for the steelhead fishery in Lake Michigan but is an excellent backup to the Strawberry Creek Weir for chinook salmon and to the Kewaunee Weir for coho salmon. It also provides a unique educational tool for school groups and interested people.

In order to fully utilize the RRSF, a project was written in 1993 and continues today with the following objectives: develop a long term index of chinook/coho/steelhead populations in the Root River to track the 1) abundance of returning adults; 2) age-specific growth and condition factors; 3) size and age distribution of returning adults; and 4) return to creel of these species stocked in the Root River. This annual report addresses these objectives.

METHODS

During the operation of the RRSF, for all targeted species and finclips, a minimum of 100 fish sample per species per finclip was obtained. These fish were measured to the nearest millimeter, weighed to the nearest 0.10 lb, examined for finclips, gender and condition and either held for brood stock, passed upstream or sacrificed (fish health or contaminant analysis). The remaining fish were tallied by species, sex and finclip and passed upstream. All fish that were passed upstream were given an upper caudal clip for population estimates.

All non-targeted species or finclips were tallied by species, finclip and sex, caudally clipped and passed upstream. All coded-wire-tagged (CWT) fish were measured and weighed. Heads were removed from behind the opercular flap and frozen for later examination. Fish needed for other studies such as disease analysis, contaminant analysis or other studies were frozen for later examinations.

Population estimates

Population estimates for each species or strain were derived from one of two equations. For those species with adequate sample sizes, the following Petersen equation for mark and recapture was used

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

where

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

with the appropriate sample standard deviation of

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

For those species with low sample sizes, the

Bailey's modified equation was used

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

with the appropriate sample standard deviation of

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

Several studies along with the general objectives and methods outlined above, have been initiated using fish stocked into the Root River.

Chinook salmon strain evaluation

Chinook salmon harvests have been highly variable over the last 6 years. One reason may be the poor performance of the Lake Michigan strain (LMS) chinook salmon that seems to be highly susceptible to Bacterial Kidney Disease (BKD) (Peeters and Royseck, 1996). To address this problem, a Lake Ontario strain (LOS) chinook salmon was stocked in 1992 acquired from New York Department of Environmental Conservation (NYDEC). These fish were not experiencing a BKD outbreak and it was hoped they would survive better than the LMS chinook salmon. In 1993 through 1995, Lake Michigan strain (LMS) chinook salmon were stocked. All lots were marked with a distinctive finclip so that a comparison could be made on the return rates and survival of these two strains.

Accelerated growth fall fingerlings vs spring yearlings

The coho salmon harvest has declined from historical levels which prompted fish managers to closely scrutinize the methods used to raise coho salmon. Prior to 1988, most coho salmon were stocked as yearlings (age 1+) which provided a good harvest averaging 110,000 fish per year. Starting in 1988, coho salmon were stocked as accelerated growth fingerlings (0+). These fish spent less time in the hatchery and were cheaper to raise. Unfortunately, the switch to accelerated growth fingerlings was not properly evaluated and has possibly lead to declines in harvest which averaged 70,000 fish per year. To evaluate the impact of rearing techniques, both accelerated growth fingerling and yearling coho salmon from the same year class, were stocked into the Root River from 1994-1996. All three groups were marked with distinctive finclips and will be evaluated during fall spawning runs from 1994-1998.

Steelhead strain evaluation

Since the Root River has been a backup for steelhead brood stock collections and primary source since the RRSF was constructed, approximately 33,000 fish per steelhead strain have been stocked annually. Of continuing importance are the performance of these three strains of steelhead; Skamania, Chambers Creek and Ganaraska. Because each strain must be marked with a distinct finclip for correct brood stock identification, strain evaluations can be conducted including age of returning fish, return rates and population estimates. Starting in 1997, a third set of distinct finclips was added to the finclip rotation (Table 7). This will allow WDNR to more accurately access the age and performance of each steelhead strain.

Size and condition

Trends in size and condition of all species processed at RRSF have been calculated since 1994. Only fish for which both total length and weight were recorded were used in the calculations. Three measures of estimated weight

were calculated and analyzed including 1) average weight; 2) trophy weight (weight of the 95th percentile of the weight distribution); and 3) standard weight (predicted weight of a given length fish developed from a length-weight regression model.

RESULTS AND DISCUSSION

The fifth season of operation for the RRSF started on October 5, 1998 and concluded on April 8, 1999. A total of 3,977 chinook salmon, 4,000 coho salmon, 2,414 steelhead and 228 brown trout were examined.

CHINOOK SALMON

A total of 3,977 chinook salmon were examined at the RRSF in the fall of 1998. The majority of them (3,845 or 97%) were passed upstream (Table 3). Some of these were stripped of eggs or sperm but the majority of fish remained healthy enough to pass upstream. Only 65 chinook had to be sacrificed for either disease or contaminant analysis or were too weak to pass upstream. A total of 93,000 eggs were collected this year at RRSF.

In 1998 based on an age-length key from 3,926 known aged finclipped and unclipped chinook salmon (see below), age 1+ fish comprised 7% of the total number examined, age 2+ were 5%, age 3+ were 81% and age 4+ were 7% (Table 4). Because the majority of chinook salmon returning to the RRSF were unclipped, a percentage based on approximated ages of measured clipped chinook salmon had to be applied to all unclipped fish in order to develop an age composition of the run.

The 1998 spawning run was comprised of much older fish compared to 1997. The run this year was heavily weighted to older fish with only 7% comprised of 1+ chinook salmon while 81% were 3+ chinook salmon compared to only 58% in 1996 (Table 4). This deviates slightly from the first three years of operation at the RRSF as well as the trends noted at the Strawberry Creek Weir for the past 3 years (Peeters and Royseck, 1997). This age structure is drastically different then previous years with a large percentage of 3+ chinook salmon. Part of the reason was because known age 3+ chinook salmon (BV) dominated the measured sample. This caused a large number of unclipped chinook salmon to be lumped into this age group. This estimate is probably not very accurate and probably will be the last estimate at RRSF until more finclipped fish are stocked in the Root River.

Chinook salmon average weight decreased by 0.5 lb. in 1998 compared to 1997 (Table 2, Table 4). Standard weight of chinook salmon increased slightly from 1997 to 9.5 lbs. in 1998 (Table 2). Trophy weight declined to 19.6 lbs. indicating a more balanced age structure than the one calculated.

Chinook salmon strain evaluation

Four consecutive years of stocking either LOS or LMS chinook salmon produced runs of 3+ and 4+ LMS chinook salmon in 1998 (Table 6). Lake Michigan strain chinook salmon returned as 3+ fish at 0.41% (403 fish) from the 1995 year class. Age 4+ fish from the 1994 year class returned at 0.04% (43 fish). In all cases, LMS chinook salmon returned at a higher percentage compared to similarly aged LOS chinook salmon. In addition, the total return rate for the 1992 year class LOS chinook salmon was only 0.24% compared to 2.02% from the LMS chinook salmon 1993 year class and 1.53% from the LMS chinook salmon 1994 year class(Table 6)

Average lengths and weights of both strains are shown in Appendix A & B. Since no data were collected on Age 1+ LOS chinook salmon a comparison could not be made to the three years of LMS 1+ data. However by age 2+ and 3+, the

LOS chinook salmon were considerably smaller than age 2+ and 3+ LMS chinook salmon in both length and weight for both males and females. Data from 1998 show that age 3+ and 4+ LMS chinook salmon were smaller than similarly aged fish in 1997 and similar to LOS 3+ and 4+ fish. Despite this one year, it appears that based on return rates and size of returning chinook salmon, the LMS chinook salmon are surviving better and growing bigger than LOS chinook salmon in most cases. Similar results were also recorded at BAFF, where both 2+ and 3+ LMS chinook salmon were larger than LOS chinook salmon (Peeters and Royseck, 1997).

COHO SALMON

A total of 4,000 coho salmon were examined at the RRSF from October 5 through November 18, 1998 (Table 7). The majority of coho salmon were passed upstream (3,336) and comprised 83% of all coho salmon processed through the RRSF. A total of 336 fish were saved for contaminant or health analysis and 328 were transferred to a hatchery for spawning. Egg take (760,000) and sampling goals were successfully reached.

In order to properly evaluate the accelerated growth fall fingerling versus spring yearling study, extra man power was added to the staff at RRSF to insure that all possible coho salmon returning to the Root River were captured in the facility. This undoubtedly lead to higher numbers of coho salmon as well as chinook salmon that were captured at the facility.

Percent age composition of returning coho salmon was disproportinately distributed between age 1+ and age 2+ fish. A total of 4,170 fish were used to determine that only 12% were age 1+ and 88% were age 2+ (Table 8). This contrasts with the first 3 years of RRSF operation in which the returning coho salmon were split 33/66 between the two ages.

Average and trophy weight for coho salmon increased in 1998 compared to 1997 (Table 2). Average weight increased 0.5 lbs. while trophy weight rose 0.7 lbs. This does corroborate evidence from other sources that showed a slight increase in size of coho salmon in 1998. However, standard weight of coho salmon has been fairly constant over the past 5 years at about 3.5 lbs. (Table 2). Since this indicator is more statistically valid than either average and trophy weight, the size and condition of coho salmon appears not to have changed much over the last 5 years at RRSF.

Accelerated growth fall fingerlings vs spring yearlings

Age 2+ adult coho salmon, stocked as spring yearlings in 1997, returned at 3.17% (1,526 fish) while those stocked as fall fingerlings in 1996 from the same year class returned at 0.92% (583 fish) (Table 10).

The average lengths and weights of precocious coho salmon (age 1+) from the two different stocking procedures from the 1994 - 1996 year classes were almost identical for both males and females (Appendix C.). The majority of the jack returns were sexually mature males. The average lengths and weights of the 1995 and 1996 year class of adult coho salmon (age 2+) from the two different stocking procedures were different. Coho salmon stocked as yearlings were heavier (2.2 compared to 1.7 kg) and longer (630 mm compared to 600 mm (Appendix C).

Results from the three year classes of coho salmon returning to RRSF suggest that the return rate was much higher for coho salmon stocked as yearlings compared to fingerling stocked fish. The 1994 year class yearlings returned 74% higher, the 1995 year class yearlings returned 287% higher and the 1996 year class yearlings returned 344% higher compared to fall fingerlings.

STEELHEAD

A total of 2,414 steelhead were examined at the RRSF from October 5, 1998 to April 8, 1999. The majority of all fish (2,195 or 91%) were passed upstream (Table 11). Those steelhead harvested in late summer were Skamania strain (86) to be used for brood stock and those in spring were Chambers Creek and Ganaraska (0). A total of 132 fish were used for contaminant or disease analysis. The majority of fish returning in the spring were comprised of both Chambers Creek and Ganaraska strain steelhead while the fall run was mainly Skamania strain. Additionally, a total of 662,000 Chambers Creek eggs, 741,000 Ganaraska eggs and 100,000 Skamania eggs from capture brood stock were collected from fish returning to RRSF.

Steelhead strain evaluation

Based on age-length keys from 75 fall run and 385 spring run known aged finclipped steelhead the percent age composition of both runs could be calculated (Table 12). Skamania steelhead comprised all 75 of the fall fish with age 1+ comprising 0.0% of the total number, age 2+ were 0.0%, age 3+ were 29.3%, age 4+ were 44.0%, age 5+ were 25.3% and age 6+ were 1.4%. This year's spawning run was comprised of slightly older fish, primarily age 3+ and 4+, compared to the 1997 run. The number of Skamania steelhead returning to the RRSF has declined every year since 1994 except in 1997 when 644 were captured at RRSF.

Chambers Creek and Ganaraska steelhead comprised all of the 385 fish used in the spring 99 analysis. The age breakdown was 2.1% for age 1+, 46.5% for age 2+, 44.2% for age 3+ and 7.3% for age 4+. These ages were very similar to those in the spring 1998 run, although because of the added 3rd set of finclips, the calculated ages of the run were more accurate in 1999.

The 1999 spring run had significantly higher percentage of 2+ and 3+ fish compared to the fall 1998 Skamania run, which was dominated by age 4+ and 5+. These differences are most likely due to specific characteristics of each strain. In addition, this was the second year of return from some of the steelhead clipped with the third set of finclips. A strong return of 1+ and 2+ Ganaraska and 2+ Chambers Creek steelhead helped lower the age at return of the spring run fish.

Stocking densities are shown in Table 13. All three strains have been stocked in nearly equal numbers the past 9 years. Each strain receives a distinct finclip that alternate each year. Because of the overlap in sizes from steelhead with the same finclip, lengths and weights for each year class could not be accurately calculated. However, starting in 1997, we added a third set of distinct finclips which should allowed us to more accurately age finclipped steelhead and calculate the age composition of returning steelhead as well as length and weight at age for each year class. Appendix D shows the results for Ganaraska strain 2+ steelhead which averaged 610.0 mm and 2.3 kg for males and 594.0 mm and 2.2 kg for females. Chambers Creek 2+ steelhead averaged 609 mm and 2.2 kg for males and 560 mm and 1.9 kg for females. Data from subsequent years will be used to compare the length and weight at age for each strain.

POPULATION ESTIMATES

Each fish that was passed upstream of the RRSF received a caudal clip which can be identified by a creel clerk during the recapture phase of the population estimate. An estimated 4,146 ± 156 chinook salmon were present during the fall run while 4,389 ± 493 coho salmon were calculated to be in the Root River (Table 14). Population estimates for steelhead could not be calculated for

Ganaraska and Chambers Creek because of poor recapture data from the creel survey. The Skamania population was estimated at 1,088 ± 609 fish. Only coho salmon showed a significant decrease in population size from the 1997 spawning season.

REFERENCES

Peeters. P and K. Royseck. 1997. Harvest, Age and Size at age of chinook and coho salmon at Strawberry Creek Weir and Besadny Anadromous Fisheries Facility, Fall 1997. Wisconsin Department of Natural Resources, Sturgeon Bay, WI.

Table 1. Summary of chinook salmon, coho salmon, steelhead, brown and brook trout captured at the Root River Steelhead Facility, 1994-99, including number of fish harvested, passed upstream and sampled.

CHINOOK SALMON

Harvest Year	Number of fish harvested	Number passed upstream	Number of misc. samples	Total number
Fall - 94	129	1,726	3	1,858
Fall - 95	300	2,663	16	2,979
Fall - 96	62	5,440	87	5,589
Fall - 97	0	3,974	128	4,102
Fall - 98	**67**	**3,845**	**65**	**3,977**

COHO SALMON

Harvest Year	Number of fish harvested	Number passed upstream	Number of misc. samples	Total number
Fall - 94	285	513	15	813
Fall - 95	1,191	2,115	15	3,321
Fall - 96	161	3,940	305	4,406
Fall - 97	655	6,909	330	7,894
Fall - 98	**328**	**3,336**	**336**	**4,000**

STEELHEAD

Harvest Year	Number of fish harvested	Number passed upstream	Number of misc. samples	Total number
Fall - 94	218	583	47	848
Spring - 95	120	2,582	18	2,720
Fall - 95	330	208	0	538
Spring - 96	150	2,970	49	3,169
Fall - 96	248	105	0	353
Spring - 97	2	2,918	125	3,045
Fall - 97	408	228	8	644
Spring - 98	0	382	0	382
Fall - 98	**86**	**64**	**1**	**151**
Spring - 99	**0**	**2,131**	**132**	**2,263**

BROWN TROUT

Harvest Year	Number of fish harvested	Number passed upstream	Number of misc. samples	Total number
Fall - 94	0	259	0	259
Fall - 95	46	645	0	691
Spring - 96	0	4	0	4
Fall - 96	70	244	0	314
Spring - 97	0	2	0	2
Fall - 97	114	369	3	486
Spring - 98	**0**	**2**	**0**	**2**
Fall - 98	**14**	**202**	**12**	**228**

BROOK TROUT

Harvest Year	Number of fish harvested	Number passed upstream	Number of misc. samples	Total number
Fall - 94	0	160	0	160
Spring - 95	0	1	0	1
Fall - 95	0	6	0	6
Fall - 96	0	5	0	5
Fall - 97	0	2	0	1
Fall - 98	**0**	**1**	**0**	**1**

Table 2. Average weight, average length, standard and trophy (95th percentile) weight for the four major salmonid species returning to the Root River Steelhead Facility, 1994-1999

Season	Number used in analysis	Average Weight	Average Length	Standard Weight	Trophy Weight
Chinook Salmon					
94-95	343	8.9 ± 5.3	27.7 ± 5.6	9.7	17.8
95-96	443	12.0 ± 5.9	30.7 ± 5.2	10.1	21.0
96-97	703	11.7 ± 5.7	30.7 ± 5.4	9.8	21.1
97-98	490	12.7 ± 4.9	32.5 ± 4.4	9.4	21.1
98-99	389	12.2 ± 4.9	31.9 ± 4.4	9.5	19.6
Coho Salmon					
94-95	208	1.5 ± 1.1	15.9 ± 2.5	3.7	3.0
95-96	594	3.1 ± 2.5	19.6 ± 5.0	3.6	9.0
96-97	1,273	5.1 ± 2.4	23.9 ± 4.7	3.5	8.3
97-98	828	3.8 ± 1.8	21.8 ± 3.6	3.5	6.7
98-99	477	4.3 ± 1.7	23.4 ± 3.2	3.4	7.5
Steelhead					
94-95	638	5.9 ± 2.8	25.4 ± 4.7	3.5	10.7
95-96	963	6.2 ± 2.7	25.6 ± 4.3	3.7	11.0
96-97	626	7.2 ± 2.4	27.4 ± 3.3	3.6	11.2
97-98	522	5.8 ± 2.9	25.7 ± 4.9	3.4	11.2
98-99	603	6.2 ± 2.0	25.9 ± 3.4	3.9	9.8
Brown Trout					
94-95	108	4.9 ± 1.5	22.1 ± 2.7	3.4	7.0
95-96	201	5.3 ± 2.2	22.4 ± 3.3	3.6	9.0
96-97	162	4.6 ± 2.1	21.4 ± 4.0	3.4	7.8
97-98	250	6.7 ± 3.4	24.0 ± 3.7	3.8	14.1
98-99	55	6.6 ± 3.2	24.3 ± 3.5	3.5	13.5

Table 3. Number of chinook salmon harvested, passed upstream and sampled at the Root River Steelhead Facility during fall 1998.

Date	Number of fish harvested	Number of fish passed upstream	Number of misc. samples[1]	Total number of fish
Oct 5	-	386	-	386
Oct 6	-	618	-	618
Oct 7	-	776	1	777
Oct 8	-	475	-	475
Oct 9	-	345	-	345
Oct 12	-	266	-	266
Oct 13	-	129	1	130
Oct 19	67	431	60	558
Oct 22	-	267	2	269
Oct 27	-	82	1	83
Nov 4	-	52	-	52
Nov 5	-	4	-	4
Nov 12	-	10	-	10
Nov 18	-	4	-	4
Nov 14	-	-	-	-
Totals	67	3,845	65	3,977

1 Fish collected and sacrificed for other studies (i.e. disease, contaminants)

Table 4. Estimated age composition of chinook salmon (sexes combined) examined at the Root River Steelhead Facility, 1994-1998. Age is based on age-length key developed from known aged finclipped chinook salmon. Total number represents the number of chinook salmon used in the analysis.

Year of Return	Percent Age Composition 1+	2+	3+	4+	Total Number
1994	39	45	16	-	1,809
1995	25	45	30	-	2,874
1996	31	30	34	5	5,425
1997	2	32	58	8	4,031
1998*	7	5	81	7	3,926

* Three year old chinook salmon (RP) dominated the measured sample which influenced the age structure of the spawning run

Table 5. **Summary of chinook salmon stocking numbers by strain and finclip stocked into the Root River 1991-1998.**

Year Stocked	Total Number	Strain	Finclip
1991	174,933	L. Michigan	none
1992	166,989	L. Ontario	RMLV
1993	99,345	L. Michigan	LMRV
	70,000	L. Ontario	none
1994	75,533	L. Michigan	LP
	60,000	L. Michigan	none
1995	99,000	L. Michigan	RP
	69,250	L. Michigan	none
1996	158,000	L. Michigan	none
1997	142,500	L. Michigan	none
1998	161,500	L. Michigan	none

Table 6. **Return rate of chinook salmon at age and strain to the Root River Steelhead Facility in the fall of 1994-1998. Return rate expressed as a percent of the number of chinook salmon stocked in the Root River that were actually recovered at RRSF. Number of actual chinook salmon returning to the facility are in parentheses.**

	PERCENT AGE AT RETURN				
	1+	2+	3+	4+	Total Return
1992 YEAR CLASS					
[1]L. Ontario (RMLV)	-	0.15 (245)	0.09 (152)	0.01 (17)	0.24 (414)
1993 YEAR CLASS					
L. Michigan (LMRV)	0.33 (323)	0.78 (775)	0.85 (840)	0.06 (68)	2.02 (2,006)
1994 YEAR CLASS					
L. Michigan (LP)	0.10 (73)	0.58 (440)	0.81 (612)	0.04 (43)	1.53 (1,168)
1995 YEAR CLASS					
L. Michigan (RP)	0.19 (189)	0.35 (346)	0.41 (403)		

[1] Total return for the L. Ontario strain chinook salmon from the 1992 year class was calculated only using ages 2-4. Actual total return rate was probably higher for this stocking.

Table 7. Number of coho salmon harvested, passed upstream and sampled at the Root River Steelhead Facility during fall 1998.

Date	Number of fish harvested	Number of fish passed upstream	Number of misc. samples[1]	Total number of fish
Oct 5	-	272	15	287
Oct 6	-	84	1	85
Oct 7	-	224	-	224
Oct 8	-	116	-	116
Oct 9	328	155	-	483
Oct 12	-	130	-	130
Oct 13	-	57	-	57
Oct 19	-	345	3	348
Oct 22	-	426	1	427
Oct 23-26	-	-	14	14
Oct 27	-	595	31	626
Oct 28-31	-	-	14	14
Nov 1	-	-	95	95
Nov 3	-	-	28	28
Nov 4	-	149	134	283
Nov 5	-	194	-	194
Nov 12	-	351	-	351
Nov 18	-	238	-	238
Totals	328	3,336	336	4,000

1 Fish collected and sacrificed for other studies (i.e. disease, contaminants)

Table 8. **Estimated age composition of coho salmon (sexes combined) examined at the Root River Steelhead Facility, fall 1994-98. Age is based on age-length key developed from known aged finclipped coho salmon. Total number represents the number of coho salmon used in the analysis.**

Year of Return	Percent Age Composition 1+	2+	Total Number
1994	53	47	780
1995	24	76	3,049
1996	32	68	4,211
1997	5	95	7,699
1998	12	88	4,170

Table 9. **Summary of coho salmon stocking numbers by strain and finclip stocked into the Root River 1993-1998. REL = red elastomer mark in adipose tissue of left eye.**

Year Stocked	Total Number	Strain	Finclip	Age
1993	-			
1994	66,080	L. Ontario	none	Spring Yearling 1+
	55,954	L. Ontario	RMLP	Fall Fingerling 0+
	50,389	L. Michigan	RP	Spring Fingerling 0+
1995	65,100	L. Michigan	RMRP	Spring Yearling 1+
	54,832	L. Michigan	RMLV	Fall Fingerling 0+
1996	40,590	L. Michigan	RMRV	Spring Yearling 1+
	63,697	L. Michigan	LP	Fall Fingerling 0+
1997	48,107	L. Michigan	RP	Spring Yearling 1+
	6,668	L. Michigan	REL	Spring Yearling 1+
	4,208	L. Michigan	none	Spring Yearling 1+
	20,604	L. Michigan	none	Fall Fingerling 0+
1998	33,666	L. Michigan	none	Spring Yearling 1+
	10,000	L. Michigan	none	Fall Fingerling 0+

Table 10. **Return rate of coho salmon (percent and number) at age and stocking treatment to the Root River Steelhead Facility in the fall 1994-1998 based on year class. Return rate expressed as a percent of the number of coho salmon stocked in the Root River that were actually recovered at RRSF. Number of actual coho salmon returning to the facility are in parentheses.**

		AGE AT RETURN (Percent)	
Year Class	Stocking Treatment	1+	2+
1992	Fall Fingerling (RPLV)	-	0.88 (303)
1993	Spring Yearling (none)	0.71 (472)	3.20 (2,100)
1994	Fall Fingerling (RMLP)	0.88 (495)	1.50 (864)
	Spring Fingerling (RP)	0.59 (297)	0.00 (8)
	Spring Yearling (RMRP)	0.41 (266)	2.60 (1,700)
1995	Fall Fingerling (RMLV)	0.69 (381)	3.83 (2,098)
	Spring Yearling (RMRV)	2.09 (847)	11.03 (4,478)
1996	Fall Fingerling (LP)	0.04 (24)	0.92 (583)
	Spring Yearling (RP)	0.25 (119)	3.17 (1,526)

Table 11. Number of steelhead harvested, passed upstream and sampled at the Root River Steelhead Facility during fall 1998 and Spring 1999.

Date	Number of fish harvested	Number of fish passed upstream	Number of misc. samples[1]	Total number of fish
Oct 5	10	1	-	11
Oct 6	18	2	-	20
Oct 7	27	3	-	30
Oct 8	2	1	-	3
Oct 9	-	2	-	2
Oct 12	3	2	-	5
Oct 13	2	-	1	3
Oct 19	15	6	-	21
Oct 22	8	1	-	9
Oct 27	-	2	-	2
Nov 4	1	6	-	7
Nov 5	-	-	-	-
Nov 12	-	6	-	6
Nov 18	-	32	-	32
Mar 4	-	181	-	181
Mar 19	-	420	-	420
Mar 23	-	241	32	273
Mar 30	-	485	39	524
Mar 31	-	324	1	325
Apr 6	-	423	60	483
Apr 8	-	57	-	57
Totals	86	2,195	133	2,414

1 Fish collected and sacrificed for other studies (i.e. disease, contaminants)

Table 12. Estimated age composition of steelhead (sexes combined) examined at the Root River Steelhead Facility, 1994-1999. Age is based on age-length key developed from known aged finclipped steelhead. Total number represents the number of steelhead lengths used in the analysis.

Year of Return	Percent Age Composition 1+	2+	3+	4+	5+	6+	Total Number
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

Table 13. Summary of steelhead stocking numbers by strain and finclip stocked into the Root River 1990-1998.

Year Stocked	Total Number	Strain	Finclip
1990	35,370	Skamania	RM
	35,008	Chambers Cr.	LM
	34,761	Ganaraska	ARV
1991	43,622	Skamania	ARM
	35,022	Chambers Cr.	ALM
	37,035	Ganaraska	ALV
1992	39,383	Skamania	RM
	36,600	Chambers Cr.	LM
	34,629	Ganaraska	ARV
1993	35,276	Skamania	ARM
	27,963	Chambers Cr.	ALM
	37,781	Ganaraska	ALV
1994	30,417	Skamania	RM
	35,124	Chambers Cr.	LM
	34,759	Ganaraska	LV
1995	37,347	Skamania	ARM
	37,819	Chambers Cr.	ALM
	34,494	Ganaraska	ALV
1996	34,254	Skamania	RM
	34,579	Chambers Cr.	LM
	35,404	Ganaraska	ARV
1997	35,262	Skamania	RMRV
	35,024	Chambers Cr.	LMLV
	35,201	Ganaraska	BV
1998	37,484	Skamania	ARM
	33,187	Chambers Cr.	ALM
	33,548	Ganaraska	ALV

Table 14. Population estimates for chinook, coho and steelhead salmon returning to the Root River in 1994 - 1999. No estimates for coho salmon in 1994 could be calculated because of small sample size. s.d. = standard deviation.

Year and species	Number of marked fish	Number of recaptured fish	Number of marked fish in recapture sample	Population size (± 1 s.d.)
Fall - 94				
Chinook	1,720	143	44	5,590 ± 701
Coho	513	2	0	-
Skamania	556	22	6	1,827 ± 539
Spring - 95				
Chambers Cr	1,653	117	45	4,298 ± 503
Ganaraska	453	74	11	2,718 ± 691
Fall - 95				
Chinook	2,663	36	21	4,478 ± 594
Coho	1,354	33	13	3,288 ± 651
Skamania	482	36	6	2,547 ± 811
Spring - 96				
Chambers Cr	1,045	48	28	1,765 ± 206
Ganaraska	1,457	77	31	3,551 ± 475
Fall - 96				
Chinook	5,440	37	36	5,587 ± 147
Coho	3,940	9	9	3,940 ± 0
Skamania	105	29	0	3,150 ± 2,189
Spring - 97				
Chambers Cr	900	38	6	5,014 ± 1,606
Ganaraska	139	23	5	5,356 ± 1,753
Fall - 97				
Chinook	3,974	40	31	5,127 ± 436
Coho	6,909	52	45	7,983 ± 436
Skamania	228	16	2	1,297 ± 509
Spring - 98				
Chambers Cr	93	15	2	501 ± 226
Ganaraska	217	17	1	1,962 ± 1,067
Fall - 98				
Chinook	3,845	55	51	4,146 ± 156
Coho	3,336	25	19	4,389 ± 493
Skamania	64	33	1	1,088 ± 609
Brown	202	31	11	539 ± 118
Spring - 99				
Chambers Cr	678	-	-	-
Ganaraska	1,043	-	-	-

Appendix A. Average length (mm) and weight (kg) by age, sex and year of return of **Lake Michigan strain chinook salmon** examined in the Root River, fall 1994-1998. M=males, F=females, L=length, W=weight, sd=standard deviation and n=sample size.

Year of Return			AVERAGE LENGTH AT AGE 1+	2+	3+	4+
1994	M	$\bar{L}$ (sd)	559.9 (53.4)			
		range	410-661			
		n	95			
	F	$\bar{L}$ (sd)	531.2 (44.3)			
		range	460-588			
		n	9			
1995	M	$\bar{L}$ (sd)	551.8 (74.8)	782.0 (84.9)		
		range	466-754	491-999		
		n	21	108		
	F	$\bar{L}$ (sd)	-	796.0 (39.9)		
		range	-	752-848		
		n	-	8		
1996	M	$\bar{L}$ (sd)	579.7 (53.3)	761.4 (64.7)	916.1 (74.9)	
		range	490-795	577-880	720-1067	
		n	100	107	58	
	F	$\bar{L}$ (sd)	830.0 (21.2)	774.5 (95.5)	884.4 (52.8)	
		range	815-845	707-842	724-965	
		n	2	2	47	
1997	M	$\bar{L}$ (sd)		744.4 (53.6)	864.5 (84.4)	885.9 (104.3)
		range		629-880	596-1008	665-1022
		n		94	73	9
	F	$\bar{L}$ (sd)		752.9 (83.4)	856.8 (49.4)	842.4 (74.5)
		range		630-901	741-990	705-990
		n		9	53	20
1998	M	$\bar{L}$ (sd)		757.4 (113)	839.9 (93.5)	797.9 (143.2)
		range		645-978	619-980	578-1020
		n		9	51	9
	F	$\bar{L}$ (sd)		797.7 (29.9)	841.2 (52.8)	844.3 (108.9)
		range		771-830	687-941	643-985
		n		3	64	9

Year of Return			AVERAGE WEIGHT AT AGE 1+	2+	3+	4+
1994	M	$\bar{W}$ (sd)	1.8 (0.8)			
		range	0.5-6.9			
		n	95			
	F	$\bar{W}$ (sd)	1.6 (0.4)			
		range	1.0-2.2			
		n	9			
1995	M	$\bar{W}$ (sd)	1.8 (0.8)	4.9 (1.5)		
		range	0.9-4.1	1.4-8.6		
		n	21	108		
	F	$\bar{W}$ (sd)	-	6.0 (1.3)		
		range	-	4.5-7.7		
		n	-	8		
1996	M	$\bar{W}$ (sd)	2.0 (0.7)	4.4 (1.2)	7.7 (2.1)	
		range	1.1-5.6	1.6-7.4	3.7-12.5	
		n	100	107	58	
	F	$\bar{W}$ (sd)	6.0 (0.2)	4.9 (1.8)	7.7 (1.4)	
		range	5.9-6.1	3.6-6.1	4.9-10.8	
		n	2	2	47	
1997	M	$\bar{W}$ (sd)		3.9 (0.9)	6.2 (1.8)	6.7 (2.3)
		range		2.1-6.7	2.4-10.2	3.3-11.0
		n		94	73	9
	F	$\bar{W}$ (sd)		4.5 (1.5)	6.6 (1.4)	6.3 (1.7)
		range		2.3-6.9	4.0-11.0	3.8-10.8
		n		9	53	20
1998	M	$\bar{W}$ (sd)		4.2 (2.0)	5.6 (2.0)	5.0 (2.4)
		range		2.4-8.7	2.0-8.9	1.7-9.5
		n		9	51	9
	F	$\bar{W}$ (sd)		4.9 (0.5)	6.2 (1.4)	6.4 (2.2)
		range		4.2-5.3	3.2-9.2	3.1-9.7
		n		3	64	9

Appendix B. Average length (mm) and weight (kg) by age, sex and year of return of **Lake Ontario strain chinook salmon** examined in the Root River, fall 1994-1997. M=males, F=females, L=length, W=weight, sd=standard deviation and n=number.

Year of Return			AVERAGE LENGTH AT AGE 1+	2+	3+	4+
1994	M	$\bar{L}$ (sd)		736.6 (80.1)		
		range		451-883		
		n		83		
	F	$\bar{L}$ (sd)		695.4 (125.9)		
		range		476-770		
		n		5		
1995	M	$\bar{L}$ (sd)			849.3 (129.4)	
		range			569-999	
		n			31	
	F	$\bar{L}$ (sd)			845.6 (59.0)	
		range			630-951	
		n			69	
1996	M	$\bar{L}$ (sd)				974.0 (0.0)
		range				974
		n				1
	F	$\bar{L}$ (sd)				827.0 (1.7)
		range				825-828
		n				3

Year of Return			AVERAGE WEIGHT AT AGE 1+	2+	3+	4+
1994	M	$\bar{W}$ (sd)		4.1 (1.3)		
		range		0.8-7.1		
		n		83		
	F	$\bar{W}$ (sd)		3.7 (1.6)		
		range		1.1-5.1		
		n		5		
1995	M	$\bar{W}$ (sd)			6.6 (2.7)	
		range			1.8-13.2	
		n			31	
	F	$\bar{W}$ (sd)			6.9 (1.5)	
		range			2.3-10.5	
		n			69	
1996	M	$\bar{W}$ (sd)				10.1 (0.0)
		range				10.1
		n				1
	F	$\bar{W}$ (sd)				6.8 (1.3)
		range				5.9-8.3
		n				3

Appendix C. Average length (mm) and weight (kg) by stocking age, sex, age and year of return of finclipped **coho salmon** examined in the Root River, fall 1995-98. M=males, F=females, L=length, W=weight, sd=standard deviation and n=number.

Year of Return			LENGTH AT AGE			
			Fingerling Stocked		**Yearling Stocked**	
			1+	2+	1+	2+
1995	M	L (sd)	392.9 (23.6)		388.4 (34.5)	
		range	338-444		315-577	
		n	100		134	
	F	$\bar{L}$ (sd)	426.5 (4.9)		541.0 (0)	
		range	423		541	
		n	2		1	
1996	M	$\bar{L}$ (sd)	380.8 (24.6)	690.6 (61.6)	418.3 (33.0)	669.3 (60.2)
		range	316-443	422-798	353-506	346-785
		n	99	112	99	259
	F	$\bar{L}$ (sd)		671.1 (41.6)	486.3 (95.1)	657.1 (38.1)
		range		392-769	392-665	530-741
		n		200	6	264
1997	M	$\bar{L}$ (sd)	385.1 (18.3)	585.8 (59.6)	402.1 (24.0)	622.3 (64.0)
		range	366-410	446-771	352-440	396-783
		n	7	120	29	130
	F	$\bar{L}$ (sd)		559.5 (45.2)	408.9 (28.3)	589.0 (52.1)
		range		445-688	353-459	411-688
		n		133	9	153
1998	M	$\bar{L}$ (sd)		606.9 (64.1)		633.8 (55.4)
		range		496-757		495-772
		n		43		109
	F	$\bar{L}$ (sd)		584.1 (55.1)		610.6 (56.8)
		range		404-672		442-720
		n		41		103

Year of Return			WEIGHT AT AGE			
			Fingerling Stocked		**Yearling Stocked**	
			1+	2+	1+	2+
1995	M	$\bar{W}$ (sd)	0.6 (0.2)		0.6 (0.2)	
		range	0.5-0.9		0.5-1.8	
		n	100		134	
	F	$\bar{W}$ (sd)	0.9 (0)		1.8 (0)	
		range	0.9		1.8	
		n	2		1	
1996	M	$\bar{W}$ (sd)	0.5 (0.1)	3.0 (0.7)	0.7 (0.2)	2.7 (0.7)
		range	0.3-0.9	0.8-4.8	0.4-1.3	0.4-4.4
		n	99	112	99	259
	F	$\bar{W}$ (sd)		3.0 (0.6)	1.3 (0.8)	2.8 (0.6)
		range		0.6-5.2	0.5-2.8	1.1-4.6
		n		200	6	264
1997	M	$\bar{W}$ (sd)	0.5 (0.1)	1.9 (0.6)	0.6 (0.1)	2.3 (0.7)
		range	0.4-0.5	0.8-3.7	0.3-0.8	0.5-4.7
		n	7	120	29	130
	F	$\bar{W}$ (sd)		1.7 (0.5)	0.7 (0.1)	2.0 (0.6)
		range		0.8-3.6	0.5-0.9	0.6-3.5
		n		133	9	153
1998	M	$\bar{W}$ (sd)		1.9 (0.7)		2.2 (0.7)
		range		0.9-4.0		1.0-4.3
		n		43		109
	F	$\bar{W}$ (sd)		1.9 (0.6)		2.2 (0.6)
		range		0.7-3.0		0.7-3.9
		n		41		103

Appendix D. Average length (mm) and weight (kg) by year class, strain, sex and age of finclipped **steelhead** examined in the Root River, fall 1997-1998. M=males, F=females, L=length, W=weight, sd=standard deviation and n=number.

Year Class			LENGTH AT AGE 1+	2+	3+	4+	5+
1996							
	GANARASKA (BV)						
	M	L (sd)	420.0 (25.9)	610.4 (40.8)			
		range	348-466	525-690			
		n	43	64			
	F	$\bar{L}$ (sd)	502.5 (52.5)	594.9 (29.6)			
		range	450-555	519-692			
		n	2	103			
	CHAMBERS CREEK (LMLV)						
	M	L (sd)		609.1 (40.4)			
		range		510-656			
		n		12			
	F	$\bar{L}$ (sd)		560.0 (0.0)			
		range		560			
		n		1			

Year class			WEIGHT AT AGE 1+	2+	3+	4+	5+
1996							
	GANARASKA (BV)						
	M	W (sd)	3.3 (0.6)	2.3 (0.4)			
		range	2.0-4.8	1.4-3.7			
		n	43	64			
	F	$\bar{W}$ (sd)	5.5 (1.3)	2.2 (0.4)			
		range	4.2-6.8	1.4-3.0			
		n	2	103			
	CHAMBERS CREEK (LMLV)						
	M	W (sd)		2.2 (0.4)			
		range		1.6-2.8			
		n		12			
	F	$\bar{W}$ (sd)		1.9 (0.0)			
		range		1.9			
		n		1			