Return, Size, Age, and Movement of Steelhead at the Besadny Anadromous Fisheries Facility, 1999

Steve Hogler and Steve Surendonk

ABSTRACT

An annual steelhead assessment project was begun at the Besadny Anadromous Fisheries Facility (BAFF) to (1) assess the return of the three steelhead strains to BAFF, (2) collect basic biological information on each strain, and in past years (3) to floy tag adult fish to determine: handling mortality, angler return rate, and movement.

Spring 1999 operations began on March 8, and continued until April 20. Time of operation was approximately one month earlier than historical average start and stop times. During this time period a total of 732 steelhead were handled. The run consisted of 220 Chambers Creek strain steelhead, 237 Ganaraska, 23 Skamania, and 252 unclipped, misclipped or strays from other streams or states. The total number of fish handled during the spring of 1999 declined from the 1998 level, making the 1999 run the smallest in the past six years.

Chambers Creek steelhead ranged in length from 386 mm to 890 mm, with an average length of 683 mm. Weight ranged from 0.7 kg to 7.0 kg and averaged 3.25 kg. Average weight decreased from 1997 levels, while standard weight remained the same and trophy weight increased.

Ganaraska lengths ranged from 269 mm to 815 mm and averaged 633 mm. Weights ranged from 0.3 kg to 6.2 kg with an average of 2.76 kg. All three weight indices increased in 1999 over 1998 levels.

The summer/fall migration of steelhead was sporadic. A total of 145 steelhead were collected, of which 93 had identifiable Skamania clips. Of the Skamania, 77 were sent to KMSFH to be held until ready for spawning and remainder were passed upstream or died during processing.

INTRODUCTION

Wisconsin began its Lake Michigan rainbow/steelhead trout fishery in 1963 when rainbow trout were stocked in a Door County stream (Daly 1968). During the years following the original stocking, many changes in the fishery occurred including changes in the strains and age of fish stocked. Most recently, Wisconsin chose three steelhead strains, Skamania, Chambers Creek, and Ganaraska for its Lake Michigan steelhead program. Although similar in appearance, each strain has unique characteristics that make each important to the overall steelhead program. It was hoped that these strains would provide a good return to the creel and provide more fishing opportunities throughout the year for anglers in tributary streams.

To further enhance the steelhead fishery and continue the time series of biological information collected during earlier studies, a steelhead assessment project was initiated by Fisheries Management at the C.D. Besadny Anadromous Fishery Facility (BAFF) weir. The goals of this project are to (1) assess the return of the three steelhead strains to BAFF, (2) to collect basic biological information on each strain, and in past years (3) to floy tag adult fish to determine: handling mortalities from the spawning operation, angler return rate and movement of these fish in the Kewaunee River and in Lake Michigan. This report summarizes the data collected from the 1999 migratory runs of steelhead at BAFF.

METHODS

BAFF operations begin during early spring when ice on the Kewaunee River starts to break up and continues until ice up during early winter (Baumgartner 1995). Water is passed through the collection ponds and down the fish ladder, attracting migrating steelhead up the ladder and into the ponds. Ponds are sorted at least once a week and fish are passed upstream, spawned and passed, or held, depending on clip and ripeness. During spring migrations as fish proceed through the BAFF spawning building, the fish are checked for clips, sex and ripeness. Steelhead are measured to the nearest 1 mm and weighed to the nearest 0.01 kg. Ripe fish with the appropriate strain fin clip are spawned, allowed to recover, and then passed upstream. Fish that are not ripe, but have the appropriate fin clip are returned to a holding pond. All other fish and 20% of the target strain are measured, weighed, revived, and then passed upstream.

Late summer/early fall collection procedures differ from spring procedures because of warm water conditions, which may increase mortality of the handled steelhead. To maximize survival, fish are handled as little as possible. Steelhead are checked for fin clips, and sexed. This fall, when conditions permitted (cool water), a subsample of steelhead were measured and weighed. Fish with target fin clips were sent to the Kettle Moraine Springs Fish Hatchery (KMSFH) and held until spawned. All other steelhead were passed upstream.

Data was analyzed using basic fishery statistics, such as average lengths and weights by sex and clip. A regression of length and weight for each strain was calculated. By using standard weight and trophy weight, which is the measure of the weight of a 660 mm steelhead and the weight of the 95th percentile of steelhead respectively, we are able to track recent weight trends in the population. Handling mortality was estimated from the number of tagged dead fish found in holding ponds, recovery tanks, and around the river release site. Tag returns were used to track movement of marked fish. Catch numbers per day of weir operation were plotted to examine the timing of spring migratory runs.

RESULTS

Spring

Spring operations began on March 8, and continued until April 20. Time of operation was approximately one month earlier than the historical average. During this time period a total of 732 steelhead were handled (Table 1). The run consisted of 220 Chambers Creek strain steelhead (30.1% of the run), 237 Ganaraska (32.4%), 23 Skamania (3.1%), and 252 (34.4%) unclipped, misclipped or strays from other streams or states. The total number of fish handled during the spring of 1999 decline from the 1998 total, making it the smallest run of the previous six springs.

Chambers Creek strain

Processing of Chambers Creek strain fish began on March 23, peaked on April 5, and decreased substantially thereafter to end on the last day of BAFF operations (Table 2). Length of Chambers Creek steelhead ranged from 386 mm to 900 mm, with an average length of 684 mm (Table 1). Weight ranged from 0.7 kg to 7.0 kg and averaged 2.96 kg.

Males comprised 49.8% of the run and averaged 681 mm in length, and 3.15 kg in weight (Table 3). A total of three different Chambers Creek fin clips were observed for male fish, with the left maxillary (LM) the most common. With the use of fin clips, returning fish can be assigned to age classes. Males returned at ages 2 through 5 (Table 4). Age 4 was the most common, and averaged 712 mm in length and 3.48 kg in weight. Age 3 males also returned in good number.

Females averaged 686 mm in length and 3.36 kg in weight and were represented by three different fin clips (Table 3). The most common clip was LM. Females returned at ages 3 through 5 (Table 4). Age 4 females returned in the greatest number followed by age 5 fish. Age 4 females averaged 684 mm in length and 3.33 kg in weight.

Handling mortality was 0.5% (Table 5). This was a decrease from 1998 levels, and was lowest on record. Uncrowded ponds and short holding time may have reduced the handling mortality rate.

Ganaraska strain

Ganaraska processing began on March 23 peaked on April 5 and ended on the last day of BAFF operation (Table 2). Lengths ranged from 269 mm to 815 mm and averaged 633 mm. Weights ranged from 0.3 kg to 6.2 kg with an average of 2.76 kg.

Males made-up 38.4% of the run, and had an average length of 637 mm and weight of 2.74 kg (Table 3). A total of four different ganaraska fin clips were observed, with the adipose, right ventral (ARV) clip the most common. Based on fin clip, ages 2 through 6 returned during the spring migration (Table 4). Age 4 fish were the most common, followed by age 3. Age 4 males averaged 648 mm in length and 2.98 kg in weight.

Females comprised 61.6% of the run and averaged 631 mm in length and 2.74 kg in weight (Table 3). A total of four different Ganaraska clips were detected for female fish, with ARV the most common. The majority of returning females were age 4, having an average length of 652 mm and average weight of 2.92 kg (Table 4).

Handling mortality was 0.4%, with 1 death out of the 237 fish handled (Table 5). The mortality rate was the same as in 1998, which was the lowest rate observed for Ganaraska.

Skamania

Although Skamania are a minor component of the spring run, 23 fish were collected early in the spring run (Table 2). Skamania ranged in length from 571 mm to 903 mm with an average of 759 mm (Table 1). Weight ranged from 1.9 kg to 5.7 kg, with an average weight of 3.73 kg. While it is common to capture ripe males during spring migrations, for the third consecutive year ripe females were collected, with 3 of 12 fish handled judged ripe.

Males comprised 47.8% of the run, with an average length of 802 mm and weight of 4.27 kg (Table 3). Right maxillary (RM) and adipose, right maxillary (ARM) clipped fish returned in equal number, and were age 4 and age 5 respectively (Table 4).

Females averaged 719 mm in length and 3.23 kg in weight (Table 3). Similar to males, the majority of females had a RM clip, with the remainder having an ARM clip (Table 4).

For the third consecutive spring handling mortality was 0.0% for Skamania (Table 5).

Non-broodstock steelhead

The final component of the spring run were those steelhead not used for broodstock collection. Although the majority of these fish were Chambers Creek, Ganaraska, or Skamania strain steelhead, they were not clipped, misclipped, or were study fish from another stream. Clipped or nonclipped fish from other states were also part of this category. Members of this group were collected during each day of operation (Table 2), and were the largest single component of the spring run (Table 1).

Handling mortality for this group of steelhead was 0.0% which was the lowest rate for this group of fish in seven years (Table 5).

Tagging Update

Anglers have returned an additional 12 tags from steelhead tagged in 1997 and 1998 since the last report. From 1997 tagged fish, one tag each was returned from Chambers Creek and Ganaraska strains and two tags from non-clipped fish (Table 6). All four tags were returned by anglers fishing in Lake Michigan (Appendix 1).

Eight additional tags were returned from fish marked in 1998 (Table 6). One tag was from a Chambers Creek strain fish, 3 from Ganaraska strain and 4 from non-clipped steelhead. Seven tags were from anglers fishing in rivers and one tag was from a Lake Michigan angler (Appendix 2).

Summer/Fall

The summer/fall migration of steelhead was sporadic, with an increase in number over 1998, but still much lower than during 1994 and 1995 (Table 7). Most fish returned in August or September, with substantially fewer fish later in the season (Table 2). A total of 145 steelhead were collected, of which 93 had identifiable Skamania clips (Table 7). Of the Skamania, 77 were sent to KMSFH to be held until ready for spawning and remainder were passed or died during processing.

Of non-Skamania strain steelhead captured, most (51 of 52) were unknown strain steelhead (Table 7). Included in this total are 20 steelhead that ran prior to summer start-up of the weir and were counted but not handled in the BAFF bypass channel. One handled fish was a Chambers Creek strain steelhead.

DISCUSSION

Over the years we have been monitoring trends of several factors associated with the annual steelhead spawning migrations up the Kewaunee River to BAFF. They include abundance and run timing for each strain, length and weight, return rate, handling mortality, and movement based on tagging done at the weir.

Timing and Abundance of the Run

Spring

The 1998 and 1999 spring steelhead runs at BAFF were markedly different in timing compared to previous years (Hogler and Surendonk 1997 and 1998). Unusually mild winters brought early runoff and ice free river conditions. Early favorable conditions were then followed by rapidly declining flow rates. These environmental conditions caused the spring run to begin and end approximately one month earlier than average spring runs (Figures 1, 2 and 3).

The total number of steelhead handled at BAFF during the 1999 spring run continued to decline and was just 24.6% of the peak run in 1994 (Figure 4). Chambers Creek and Ganaraska strains returned in similar number as in 1998. Skamania and unknown strains each decreased in number.

The decrease in run number over time may be the result of unusual weather conditions, increased mortality of stocked smolts or adults, or a combination of reasons. Unfavorable weather may explain some of the decline observed in 1998 and 1999 runs of adult fish. Smolts have been consistently stocked in both time of year and location with low water possibly contributing to some increased mortality, but does not explain reduced runs in 1998 and 1999. However, angler harvest of adult fish may also affect the number of returning spawners and may be one cause of declining return number trend observed at BAFF since 1992. Record numbers of steelhead were harvested in 1993 (104,765) through 1995 (117,508) which were substantially higher the average harvest of 1990 through 1996 (87,609). High harvest in these years may have reduced the number of adult fish available to return to the weir (Eggold, 1998). Although not as high as the record years, the 1998 harvest of 110,888 steelhead may impact future spring runs.

Fall

The total number of steelhead handled at BAFF in fall 1999 increased from the 1998 level, but still was substantially lower than the 540 fish captured in 1995 (Figure 4). Low flow and warm temperature conditions severely limited the run from late September into November. Seventy-seven Skamania were sent to KMSFH to be held until ready for spawning.

As has been the case since 1994, very few fall run Chambers Creek steelhead were captured.

Lake harvest of Skamania (which remain in Lake Michigan longer than other strains), stocking location of smolts, and unfavorable river conditions may also affect return number.

Strain Performance

Chambers Creek

For the second consecutive spring average length and weight of Chambers Creek steelhead decreased (Table 1). The decline may be due to the small number of fish returning including fewer older (larger) fish or may be an indication of forage conditions on Lake Michigan. Standard weight increased from 1998 to 1999 while trophy weight remained essentially the same (Figure 5).

Return rates from an individual year of stocking can also be evaluated by the use of fin clips. Since the majority of Chambers Creek fish return at age 4, we would be expect to see the highest return rate of a year class occur three years after fish were stocked. In 1999, 4-year-old Chambers Creek steelhead stocked in 1996 returned at a better rate than 4-year-old fish the previous spring (95 stocked fish), but this was still 50 % less than the 4-year-old return rate previous to 1998 (Table 8). High harvest numbers on Lake Michigan or low water may be reducing the fish available to return to spawn.

Ganaraska

Ganaraska strain steelhead have had more variation in average length and weight than Chambers Creek strain fish. After a decline in average length and weight from 1997 to 1998, average length and weight increased in 1999 (Table 1). Standard and trophy weights also increased from 1998 levels (Figure 5).

Return rate indicates that fish stocked in 1996 returned at a higher rate than those stocked in 1995 (Table 8). Overall, since 1991, Ganaraska stocked in 1992 have had the highest total return rate, while 1996 stocked fish have returned at an average rate.

Skamania

Skamania collected during the spring run have been a small, but consistent portion of the spring run. Average length and weight decreased from 1998 levels (Table 1). Standard weight in increased from 1998 levels while trophy weight increased (Figure 5). Ages of returning fish have also been consistent, with mostly age 4 and 5 fish present in the run (Table 4). Since this strain normally migrates upriver in late summer and fall, return rates during the spring are low. This spring a return rate of 1.44 fish per 1000 stocked was observed for fish stocked in 1994 (Table 8).

The number of Skamania collected during the fall run has varied greatly. High lake harvest and poor water conditions may be responsible for the variation of run number and run timing.

Summary of all strains

All strains of steelhead continue to exhibit decreasing return to the weir. Of the spring run strains since 1993, Chambers Creek has returned in greatest number despite a sharp decline in number during the past two spring migrations. Survival based on return per thousand stocked also indicates Chambers Creek return at a higher rate than does Ganaraska strain steelhead, although Ganaraska stocked in 1996 returned at a higher rate than Chambers Creek fish stocked the same spring. Summer run Skamania have had reduced run numbers since the 1995 peak. The return rate of Skamania is the lowest of the three strains of steelhead and may be the result of longer lake residence time or from poorer river conditions during fall migrations than during spring movements.

Skamania continue to be the largest steelhead in all weight indices, followed by Chambers Creek then Ganaraska. Mixed results from the three weight indices used to track trends in the population may indicate forage problems on Lake Michigan or that larger fish of some strains are being harvested at a high rate, making younger (smaller) fish more common during spawning runs.

Handling Mortalities

Spring

Handling mortalities, as expressed by absolute number or by percentage decreased to their lowest level in the past 7 years during the spring 1999 run. Uncrowded ponds and short holding times were likely responsible for the decline. The use of good handling techniques by BAFF personnel and hatchery and management staff while fish were held in ponds, during collection of biological data, and spawning operations led to decreases in mortality. Further reductions in handling mortality may be difficult to achieve, but returning the healthiest possible steelhead to the Kewaunee River will always be a priority.

Summer/Fall

Mortality caused by handling and holding steelhead during warm summer months is generally a problem. Because the majority Skamania that returned in 1999 entered the facility over a short period of time in August, holding time was minimal as well as crowding caused by other species, handling mortality was limited to the earliest (hot weather, low flow stress) and latest returns (crowding).

Movements

Tagged fish were recaptured throughout Lake Michigan and from many Wisconsin and Michigan tributary streams. The movement of steelhead around the Lake Michigan basin indicates the mobile nature of these fish on order to look for preferred prey items or water temperatures. It is also indicates that steelhead are an important component of the Lake Michigan fishery. Finally it shows that handled fish, spawned or not, survive to provide fishing opportunities to Kewaunee River anglers and to anglers that fish on Lake Michigan or other streams.

SUMMARY

The 1999 spring run total was substantially less than run totals since 1992. Early warmth and runoff were followed by several weeks of cold temperature and low flow. These unusual conditions may have caused the decline in the spring migration observed for all strains of steelhead. Gamete collections of Chambers Creek and Ganaraska strain steelhead were difficult, but should result in near quota yearling stocking in 2000 for Ganaraska, with shortages in Chambers Creek. Future declines in average, standard and trophy weights may signal potential forage problems or overharvest of steelhead in Lake Michigan.

Summer/fall runs of steelhead were also affected by weather. Hot and dry conditions decreased the flow of the Kewaunee River to near zero. Upstream migration of steelhead was improved over the 1998 run but still much lower than the 1993 run. With Adult Skamania collection much lower than required, eggs from other sources may be needed.

If the low water trend continues, it may be necessary to reevaluate stocking location and to be prepared to collect fish in either lower river sections or from harbors to ensure enough gametes are collected to provide for genetic diversity as well as the number needed for the stocking quota.

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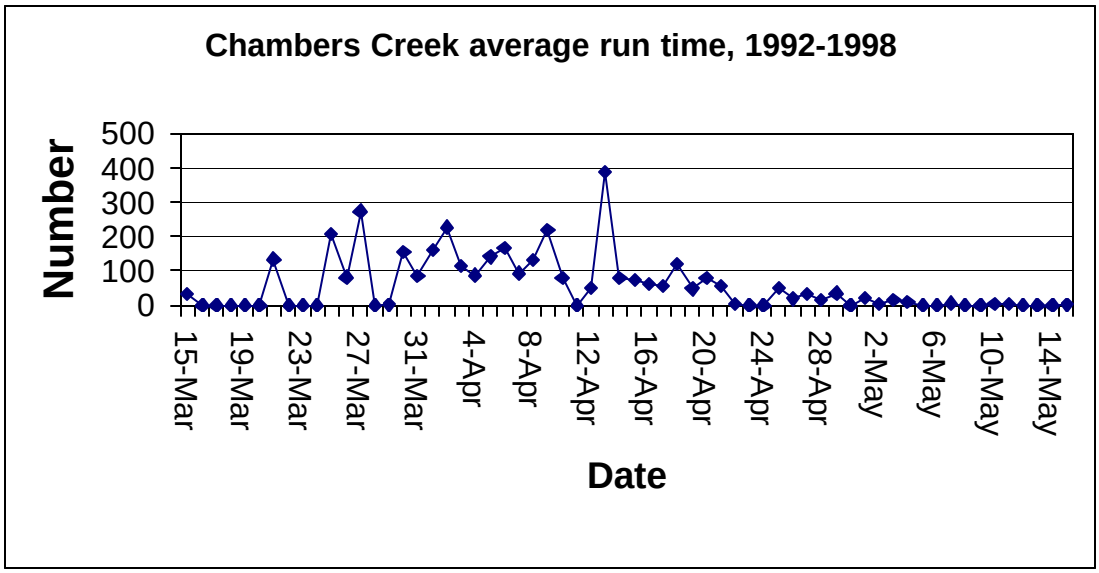
A.



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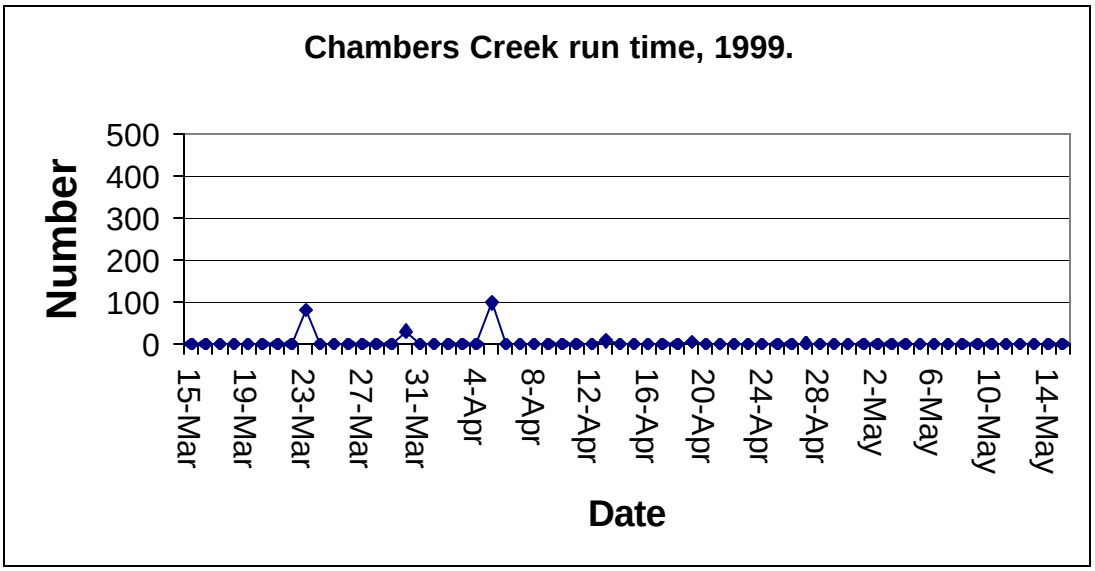

Figure 1. Spring run timing on the Kewaunee River for Chambers Creek steelhead: (A) 1992-1998 average run time, (B) 1999 run time.

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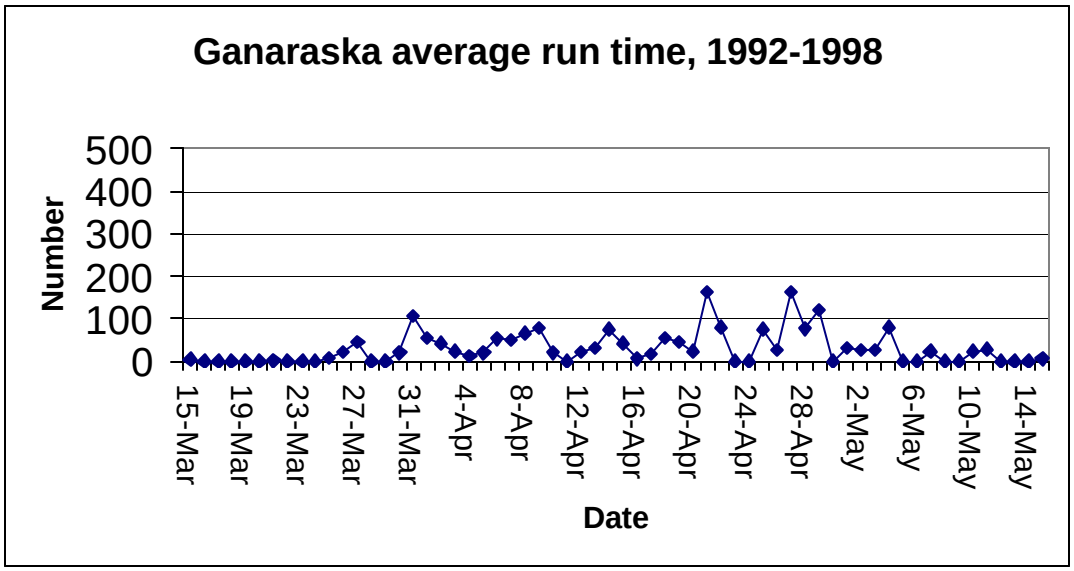

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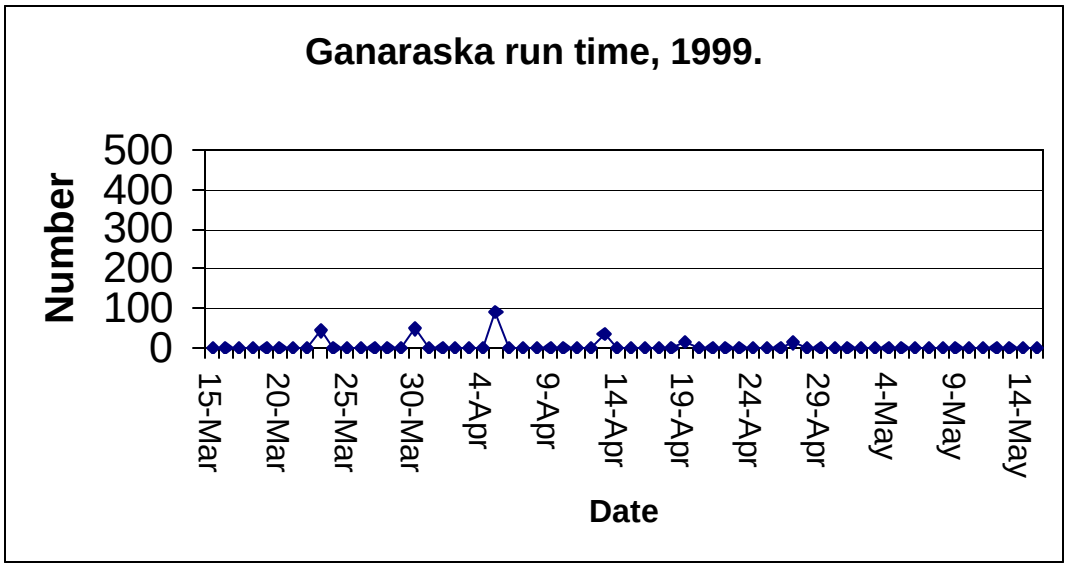

Figure 2. Spring run timing on the Kewaunee River for Ganaraska steelhead: (A) 1992-1998 average run time, (B) 1999 run time.

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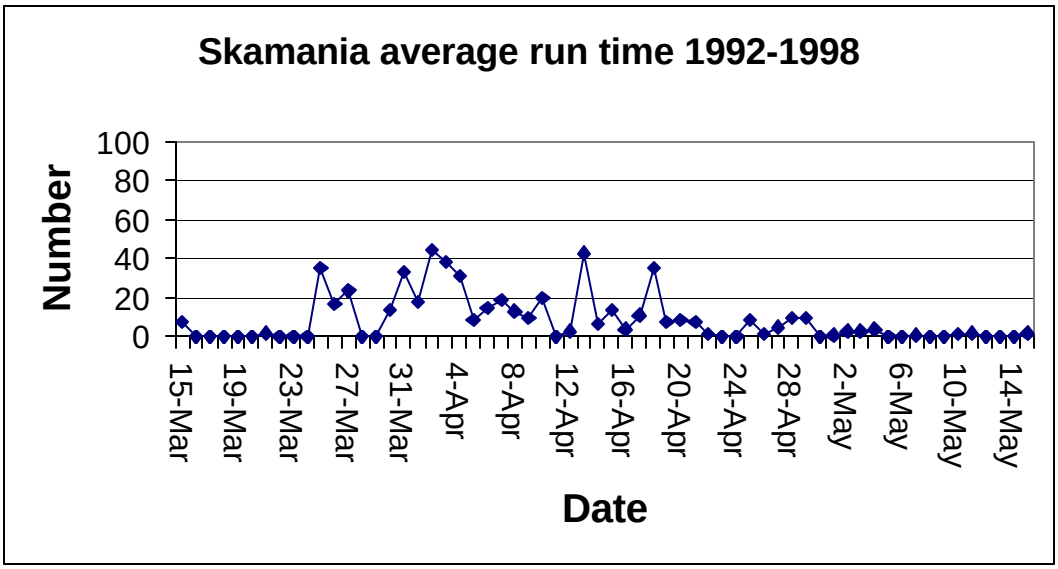

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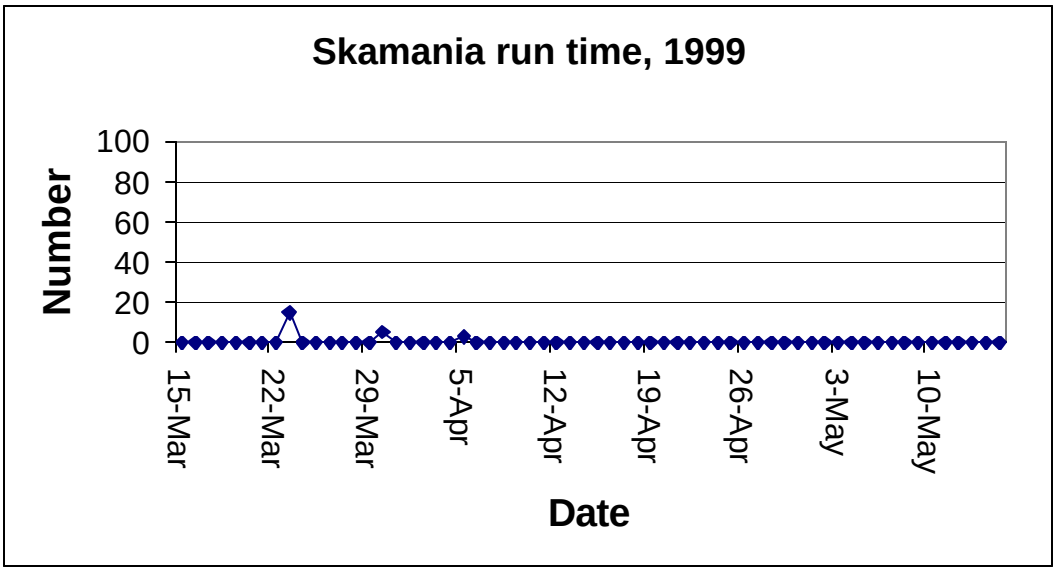

Figure 3. Spring run timing on the Kewaunee River for Skamania steelhead (A) 1992-1998 average run time, (B) 1999 run time.

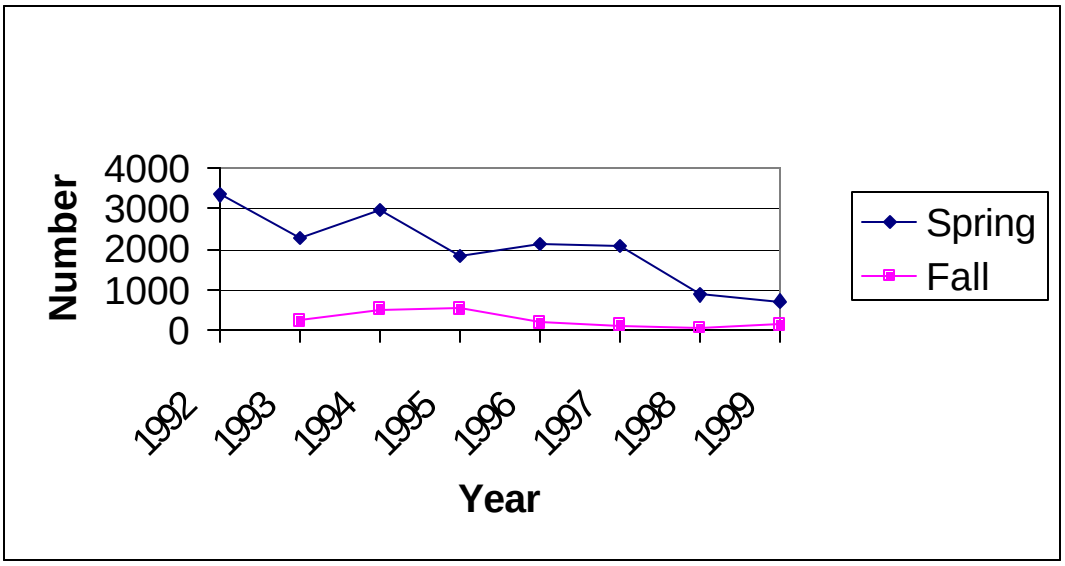

Figure 4. Steelhead return number to BAFF, 1992 through 1999.

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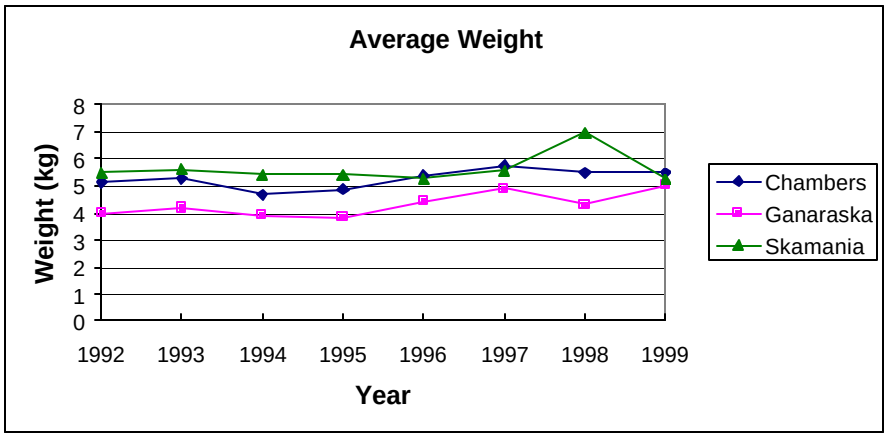

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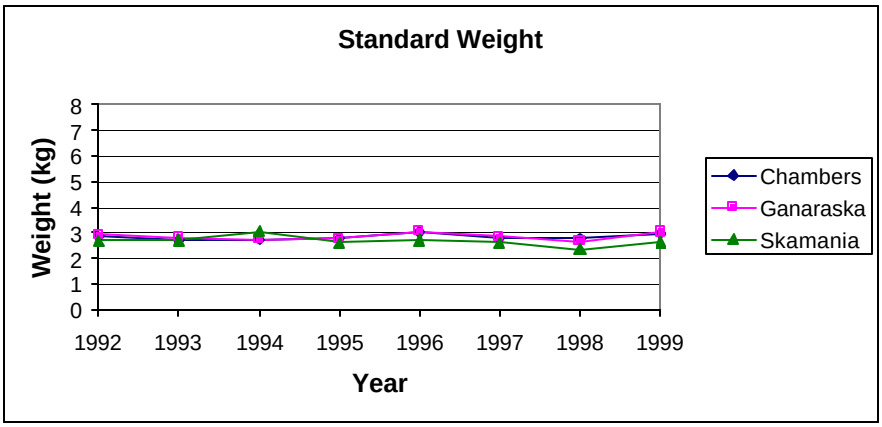

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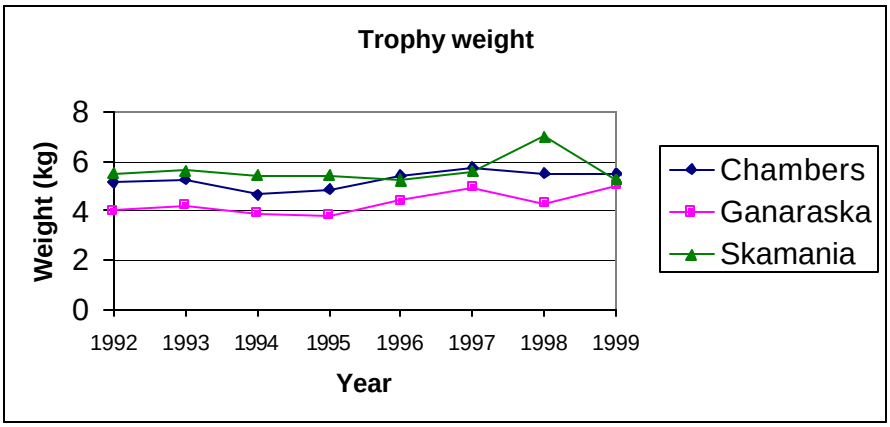

Figure 5. Weight trends for steelhead during spring migrations at BAFF, 1992-1999: (A) Average weight of each strain for that run year, (B) Standard weight of steelhead based on the projected weight of a 660 mm steelhead, (C) Trophy weight for each strain based on the weight of the 95th. percentile of weighed steelhead.

Table 1. Summary of steelhead length and weight data collected during spring migratory runs at BAFF, on the Kewaunee River, 1993-1999.

Year	Strain	Number	Run %	Average Length (mm)	Length Range (mm)	Average Weight (kg)	Weight Range (kg)	Standard Weight (kg)*	Trophy Weight (kg)**
1993	Chambers	831	36.6	717	358-941	3.30	0.1-6.8	2.71	5.26
	Ganaraska	737	32.4	608	304-854	2.30	0.1-6.3	2.82	4.19
	Skamania	96	4.2	770	454-931	3.67	1.4-6.5	2.73	5.62
	Other	609	26.8	--	--	--	--	--	--
	Total	2,273							
1994	Chambers	1,268	42.7	656	158-911	2.70	0.1-6.3	2.74	4.66
	Ganaraska	685	23.1	582	202-830	2.01	0.1-6.0	2.74	3.91
	Skamania	133	4.5	776	379-993	4.28	0.2-8.1	3.05	6.57
	Other	882	29.7	--	--	--	--	--	--
	Total	2,968							
1995	Chambers	928	50.2	695	293-920	3.17	0.2-6.3	2.79	4.87
	Ganaraska	331	17.9	593	402-847	2.05	0.6-5.7	2.76	3.83
	Skamania	57	3.1	713	547-945	3.25	1.6-6.4	2.59	5.41
	Other	531	28.8	--	--	--	--	--	--
	Total	1,847							
1996	Chambers	731	34.1	699	390-950	3.49	0.6-8.2	3.02	5.40
	Ganaraska	414	19.3	630	341-865	2.72	0.4-6.1	3.05	4.41
	Skamania	175	8.2	734	436-907	3.52	0.8-6.9	2.73	5.25
	Other	824	38.4	--	--	--	--	--	--
	Total	2,144							
1997	Chambers	610	29.2	721	471-915	3.60	1.1-7.3	2.76	5.74
	Ganaraska	364	17.4	657	365-812	2.82	0.5-7.4	2.86	4.92
	Skamania	288	13.8	757	420-934	3.77	0.7-6.6	2.59	5.57
	Other	829	39.6	--	--	--	--	--	--
	Total	2,091							
1998	Chambers	236	26.9	706	394-900	3.38	0.6-6.9	2.79	5.50
	Ganaraska	241	27.5	593	270-795	2.09	0.5-5.1	2.67	4.31
	Skamania	74	8.4	795	540-953	4.33	1.7-7.4	2.36	6.97
	Other	325	37.1	--	--	--	--	--	--
	Total	876							
1999	Chambers	220	30.1	683	386-890	3.25	0.7-7.0	2.96	5.51
	Ganaraska	237	32.4	633	269-815	2.76	0.3-6.2	3.03	5.01
	Skamania	23	3.1	759	571-903	3.73	1.9-5.7	2.64	5.27
	Other	252	34.4	--	--	--	--	--	--
	Total	732							

* Standard weight is a prediction based on a 660.4 mm steelhead.

Table 2. Daily totals during 1999 operations at BAFF, by strain of steelhead including recaptured fish.

Spring

Date	Chambers Creek	Ganaraska	Skamania	Other	Day Total
March 23	80	42	15	86	223
March 30	31	47	5	57	140
April 05	98	89	3	72	262
April 13	7	34	0	25	66
April 19	3	14	0	8	25
April 27	1	11	0	4	16
Total	220	237	23	252	732

Summer/Fall

Date	Chambers Creek	Ganaraska	Skamania	Other	Day Total
July 6	1		1		2
July 15			8	1	9
August 18			77	24	101
August 27			2	2	4
September 2			1		1
September 30				20	20
October 4			1		1
October 14				1	1
October 19				2	2
October 21				1	1
October 26			2		2
November 11			1		1
Total	1		93	51	145

Table 3. Average length, weight and run number by strain, clip, and sex during the spring spawning run at BAFF, 1999.

	Male			Female		
Strain and Clip	Average Length (mm)	Average Weight (kg)	Run Number	Average Length (mm)	Average Weight (kg)	Run Number
Chambers Creek	681	3.15	109	686	3.36	110
Left Maxillary, Left Ventral (LMLV)	580	1.99	25	603	2.33	4
Adipose, Left Maxillary (ALM)	703	3.76	4	727	3.89	14
Left Maxillary (LM)	712	3.48	80	684	3.33	92
Ganaraska	637	2.78	91	631	2.74	146
Adipose, Left Ventral (ALV)	614	2.56	5	646	3.11	26
Adipose, Right Ventral (ARV)	648	2.98	55	652	2.92	84
Left Ventral (LV)	747	3.53	4	625	2.80	1
Both Ventral (BV)	602	2.30	27	570	2.06	35
Skamania	802	4.27	11	719	3.23	12
Adipose, Right Maxillary (ARM)	835	4.43	6	746	3.55	7
Right Maxillary (RM)	762	4.09	5	680	2.78	5

Table 4. The age distribution, length, and weight of returning clipped steelhead by strain and sex for the Kewaunee River, spring 1999.

Chambers Creek

Age (Male)	2	3	4	5	6	Age (Female)	2	3	4	5	6
Measured	1	25	80	3	0	Measured	0	4	92	14	0
Average Length (mm)	386	580	712	808		Average Length (mm)		603	684	727	
Range (mm)		536-605	560-830	764-890		Range		590-610	585-815	660-771	
Weighed	1	25	78	3	0	Weighed	0	4	90	13	0
Average Weight (kg)	.68	1.99	3.48	4.79		Average Weight (kg)		2.33	3.33	3.89	
Range (kg)		1.44-2.10	1.82-7.02	3.90-6.24		Range (kg)		2.20-2.46	1.92-5.82	2.86-4.96	

Ganaraska

Age (Male)	2	3	4	5	6	Age (Female)	2	3	4	5	6
Measured	1	27	55	4	4	Measured	4	35	84	22	1
Average Length (mm)	410	602	648	667	747	Average Length (mm)	454	570	652	681	625
Range (mm)		522-700	269-815	585-730	684-795	Range	425-469	454-660	480-765	625-758	
Weighed	1	27	55	4	4	Weighed	4	34	80	20	1
Average Weight (kg)	0.80	2.30	2.98	3.00	3.53	Average Weight (kg)	1.11	2.06	2.92	3.51	2.8
Range (kg)		1.60-3.78	0.64-6.16	2.14-3.42	2.86-4.46	Range (kg)	0.84-1.44	0.90-3.12	0.30-5.18	2.20-5.72	

Skamania

Age (Male)	2	3	4	5	6	Age (Female)	2	3	4	5	6
Measured	0	0	5	6	0	Measured	0	0	5	7	0
Average Length (mm)			762	835		Average Length (mm)			680	746	
Range (mm)			571-903	785-885		Range			600-770	690-774	
Weighed	0	0	5	6	0	Weighed	0	0	5	7	0
Average Weight (kg)			4.09	4.43		Average Weight (kg)			2.78	3.55	
Range (kg)			1.86-5.72	3.22-5.22		Range (kg)			1.88-3.76	2.34-4.34	

Table 5. Handling mortality by strain at BAFF during spring operations for the years 1993-1999.

Year	Strain	Number of fish handled	Number Dead	Percent Mortality
1993	Chambers	831	23	3.1
	Ganaraska	737	24	3.3
	Skamania	96	3	3.1
	Unknown	609	7	1.1
	Total	2,273	57	2.5
1994	Chambers	1,268	24	1.9
	Ganaraska	685	10	1.5
	Skamania	133	2	1.5
	Unknown	882	8	0.9
	Total	2,968	44	1.5
1995	Chambers	928	11	0.9
	Ganaraska	331	3	0.6
	Skamania	57	1	1.8
	Unknown	531	6	0.9
	Total	1,847	21	1.1
1996	Chambers	731	41	5.6
	Ganaraska	414	7	1.7
	Skamania	175	3	1.7
	Unknown	824	7	0.9
	Total	2,144	58	2.7
1997	Chambers	610	4	0.6
	Ganaraska	364	7	1.8
	Skamania	288	0	0.0
	Unknown	869	5	0.6
	Total	2,091	16	0.7
1998	Chambers	236	5	2.1
	Ganaraska	241	1	0.4
	Skamania	74	0	0.0
	Unknown	325	4	1.2
	Total	876	10	1.1
1999	Chambers	220	1	0.5
	Ganaraska	237	1	0.4
	Skamania	23	0	0.0
	Unknown	252	0	0.0
	Total	732	2	0.3

Table 6. Tag return summary of steelhead tagged at BAFF and returned by anglers during the years 1992-1999*.

Year	Strain	Number Tagged	Total Return	Percent Return	River Returns	Percent River	Lake Returns	Percent Lake
1992	Chambers	1,513	97	6.4	75	77.3	22	22.7
	Ganaraska	940	37	3.9	36	97.3	1	2.7
	Skamania	119	9	6.7	9	100.0	0	0.0
	Unknown	671	45	6.7	33	73.3	12	26.7
	Total	3,243	188	5.8	153	81.4	35	18.6
1993	Chambers	794	45	5.7	38	84.4	7	15.6
	Ganaraska	663	24	3.6	16	69.6	8	30.4
	Skamania	93	6	6.5	4	66.7	2	33.3
	Unknown	609	28	4.6	16	57.2	12	42.9
	Total	2,159	103	4.8	74	71.8	29	28.2
1994	Chambers	1,264	79	6.3	57	72.2	22	27.8
	Ganaraska	671	35	5.2	31	88.6	4	11.4
	Skamania	133	12	9.0	7	58.3	5	41.7
	Unknown	882	58	6.6	40	69.0	18	31.0
	Total	2,950	184	6.2	135	73.6	49	26.4
1995	Chambers	898	50	5.6	37	74.0	13	26.0
	Ganaraska	318	19	6.0	15	78.9	4	21.1
	Skamania	56	4	7.1	3	75.0	1	25.0
	Unknown	539	26	4.8	20	76.9	6	23.1
	Total	1,811	99	5.5	75	75.8	24	24.2
1996	Chambers	666	34	5.1	21	61.8	13	38.2
	Ganaraska	346	15	4.3	9	60.0	6	40.0
	Skamania	174	8	4.6	5	62.5	3	37.5
	Unknown	817	49	6.0	26	53.1	23	46.9
	Total	2,003	106	5.3	61	57.6	45	42.5
1997	Chambers	612	52	8.5	38	73.1	14	26.9
	Ganaraska	357	11	3.1	5	45.5	6	54.5
	Skamania	288	11	3.8	9	81.8	2	18.2
	Unknown	825	70	8.5	43	61.4	27	38.6
	Total	2,082	144	6.9	95	66.0	49	34.0
1998	Chambers	178	10	5.6	8	80.0	2	20.0
	Ganaraska	166	7	3.6	5	71.4	2	28.6
	Skamania	74	4	5.4	4	100.0	0	0.0
	Unknown	324	22	6.8	18	81.8	4	18.2
	Total	742	43	5.8	35	81.4	8	18.6

* Tag returns for 1998 tagged fish are those that have been received by December 31, 1999.

Table 7. Steelhead fin clip patterns detected at BAFF during fall migrations, 1994-1999.

Strain and fin clip	1994	1995	1996	1997	1998	1999
Skamania						
Adipose, Right Maxillary (ARM)	60	41	97	57	8	8
Right Maxillary (RM)	325	356	63	53	20	76
Right Maxillary,Right Ventral (RMRV)						8
Right Maxillary,Left Pectoral (RMLP)						1
Right Pectoral, Left Ventral (RPLV)	2	6				
Right Pectoral (RP)	1	2	1		2	
Right Maxillary, Left Ventral (RMLV)		1				
Left Maxillary, Left Ventral (LMLV)			2			
Total Skamania	388	406	163	110	30	93
Chambers Creek						
Left Maxillary (LM)		1	4	1		1
Left Ventral (LV)	2					
Adipose, Left Maxillary (ALM)		2	1			
Total Chambers Creek	2	3	5	1		1
Ganaraska						
Adipose, Right Ventral (ARV)						
Adipose, Left Ventral (ALV)						
Left Ventral (LV)						
Left Ventral, Right Pectoral (LVRP)		1				
Total Ganaraska		1				
Unknown						
No Clips	131	130	20	17	15	30
Both Maxillary (LMRM)			1			
Adipose (?), Right Ventral (A?RV)			4			
Adipose (A)				1		1
Other				2	1	20
Total Unknown	131	130	25	20	16	51
Total Fall Steelhead Run	521	540	193	131	46	145

Table 8. Return rates (number per thousand stocked) of steelhead to the Kewaunee River during spring migrations by strain, 1992-1998.

chambers Creek

Year Stocked

Return Year	1992	1993	1994	1995	1996	1997	1998
1993	0.98	--	--	--	--	--	--
1994	18.51	0.40	--	--	--	--	--
1995	20.23	3.79	0.20	--	--	--	--
1996	4.36	10.57	4.01	1.10	--	--	--
1997	0.00	1.78	10.33	5.49	0.00	--	--
1998	0.00	0.00	0.68	4.99	0.85	0.11	--
1999	0.00	0.00	0.00	0.48	5.26	0.80	0.03
Total	44.08	16.54	15.22	12.06	6.11	0.91	0.03

Ganaraska

Year Stocked

Return Year	1992	1993	1994	1995	1996	1997	1998
1993	3.16	--	--	--	--	--	--
1994	11.73	1.77	--	--	--	--	--
1995	4.43	5.08	0.26	--	--	--	--
1996	1.04	7.37	3.00	0.94	--	--	--
1997	0.32	1.25	4.39	4.18	0.30	--	--
1998	0.00	0.00	0.37	2.67	3.57	0.35	--
1999	0.00	0.00	0.14	0.74	4.17	1.68	0.16
Total	20.68	15.47	8.16	8.49	8.04	2.03	0.16

Skamania

Year Stocked

Return Year	1992	1993	1994	1995	1996	1997	1998
1993	0.00	--	--	--	--	--	--
1994	0.46	0.12	--	--	--	--	--
1995	0.97	0.06	0.00	--	--	--	--
1996	4.23	0.56	0.00	0.00	--	--	--
1997	0.71	4.71	2.84	0.03	0.03	--	--
1998	0.00	0.00	1.44	0.68	0.06	0.00	0.00
1999	0.00	0.00	0.00	0.37	0.30	0.00	0.00

Total	6.37	5.45	4.28	1.08	0.39	0.00	0.00