1999 Toboggan Creek Steelhead Assessment

Prepared for: **Fisheries Renewal BC**

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Abstract

The fish counting fence on Toboggan Creek near Smithers, B.C. was in operation from April 15 to June 11, 1999 for steelhead enumeration; this is the seventh consecutive year of operation. Stream discharge and water temperature, fish length, sex, and age data were collected and fish tagged as part of a mark-recapture program. A population estimate of 357 adult steelhead above the fence was calculated based on the tagging program. The sex ratio of females to males indicates 0.76 females per male, and the mean fork length of females is significantly shorter than males in 1999, unlike the two previous years when female fork length was greater than male. Steelhead migration upstream occurred primarily between April 27 and May 24, 1999, and downstream movement of kelts was between May 20 and June 12, 1999. The age of the returning fish was from 4 to 8 years with most of them being 5-6 year olds. Thirteen percent of the returning fish had spawned at least once previously. A small number of previously tagged fish from Moricetown Canyon indicate that Toboggan Creek probably represents approximately 1% of the total steelhead run in the Bulkley-Morice system above the Moricetown Canyon.

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1. Introduction

1.1 Background

Toboggan Creek is a small system draining into the Bulkley River west of Smithers, B.C. and is one of three systems in the mid- and upper Skeena watershed with a fish counting fence located on it (the others being the Sustut and Babine rivers). Prior to 1993, assessment of the steelhead trout (*Oncorhynchus mykiss*) population in Toboggan Creek watershed was limited (see O'Neill, 1995 and 1996; Gibson, 1997). The Toboggan Creek counting fence was first operated for steelhead in 1993 (O'Neill, 1996) though it has been in operation for coho salmon (*Oncorhynchus kisutch*) since 1989 (SKR Consultants, 1996). Since 1993 steelhead population estimates based on fence counts have ranged from 120 - 543 with most of the estimates being in the range of 200-400 individuals (see Section 4.3 Population Estimate).

1999 was the seventh consecutive year of adult steelhead enumeration via fence counts on Toboggan Creek. This document details the findings of 1999, and also summarizes the previous six years in order to determine trends and place this years results in context. Funding and support for this project was provided by Fisheries Renewal BC.

1.2 Objectives

The objectives of this project were to:

1) Estimate the size of the adult steelhead population utilizing Toboggan Creek above the fish counting fence by a mark-recapture procedure.
2) Document run timing of steelhead to Toboggan Creek in 1999.
3) Collect information on size, sex ratio, age and life histories (via scales).

2. Study Area

Toboggan Creek is 17 km long, draining north into the Bulkley River 23 km north-northwest of Smithers, B.C. (Gibson, 1997). There are numerous tributaries contributing to the mainstem, draining an area of approximately 110 km^2 (Tredger, 1979). The stream originates from twin glaciers on Hudson Bay Mountain and is located within two Biogeoclimatic zones; the Englemann Spruce-Subalpine Fir, wet-very cold (ESSFwv) at higher elevations and the Interior Cedar Hemlock moist-cold (ICHmc) lower down (Gibson, 1997). The stream flows largely through agricultural land and pasture leases in the reaches below Toboggan Lake. The creek is also paralleled on the west side by the Canadian National (CN) rail tracks.

Toboggan Creek supports rainbow/steelhead trout (*Oncorhynchus mykiss*), cutthroat trout (*O. clarki clarki*), coho salmon (*O. kisutch*), pink salmon (*O. gorbuscha*), kokanee (*O. nerka*), Dolly Varden char (*Salvelinus malma*), mountain whitefish (*Prosopium williamsoni*), lamprey (*Lampetra* sp.) and sculpins (*Cottus* sp.) (SKR Consultants, 1996; Gibson, 1997). There is an estimated 17 km of available fish habitat in the system distributed between the mainstem and tributaries (Tredger, 1979).

The fish counting fence on Toboggan Creek is located approximately 2.5 km upstream of the confluence with the Bulkley River (SKR Consultants, 1996); the property surrounding this location of the stream is owned by Mr. K. Landrock.

3. Methods

3.1 Physical

Stream Flow

Stream height (m) was recorded daily by use of a staff gauge adjacent to the Toboggan Creek Fish Hatchery. This was converted to discharge (Litres per second [L/s]) using the function:

$$\text{Discharge (L/s)} = H_{staff} * (700\ L*min^{-1} \text{ per cm} / 60\ \text{sec.}*min^{-1})$$

Where H_{staff} = height on staff gauge (cm)

$L*min^{-1}$ = discharge in Litres/minute

These units (L/s) may be converted to the more standard m^3/s by multiplying by 0.001. However, for comparison with past reports and scaling on the graphs, L/s is more convenient for this document.

Temperature

Daily morning and afternoon temperatures (°C) were recorded in Toboggan Creek at a station adjacent to the Toboggan Creek Fish Hatchery. For purpose of this analysis, mean daily temperature was determined by averaging these morning and afternoon temperatures for each day.

3.2 Biological

Operation of the counting fence began on April 15, 1999 and continued until June 11, 1999. There were five interruptions in which the fence was laid down. These periods

of laying the fence down (Figure 1) were regularly scheduled to prevent blocking fish passage upstream and occurred April 23/24 (36 hours), May 3/4/5 (36 hours), May 9/10 (36 hours) and May 16/17 (36 hours). In addition, high flows on May 24/25 forced the fence to be laid down for 12 hours despite migrants moving downstream within this time. While the fence was operational, fish travelling upstream were captured in the box at the fence and tagged by insertion of a spaghetti tag in the right dorsal muscle and secondarily marked by punching a small hole in the caudal fin. Tag number, fish sex (female vs male), origin (hatchery vs wild) and fork length were recorded, previous tags noted, and unusual scarring (i.e. gill net marks, predator bites, etc.) recorded. Scale samples were taken for aging from every second fish of the first 100 captured then more selectively after that. No DNA samples were collected in 1999, the 1998 DNA sampling deemed as adequate.

Downstream migrating kelts were beach seined above the fence. Previously marked fish (those marked on the upstream migration) were recorded and released below the fence. Unmarked fish were spaghetti tagged, measured, origin and unusual scarring noted, and released downstream. Some heavily fungussed male kelts were not tagged.

3.3 Population Estimation Procedure

The Seber (1982) estimator of the Petersen method was used to estimate population size, and large sample binomial 95% confidence intervals were calculated. The Seber Estimator is (from Krebs, 1989):

$$N' = [((M+1)(C+1))/(R+1)]-1$$

Where N' = Estimate of population size at time of marking

M = Number of individuals marked in first sample

C = Total number of individuals captured in second sample

R = Number of individuals in second sample that are marked

The large sample binomial 95% confidence intervals are calculated as (from Krebs, 1989):

$$CI = R/C \pm Z_{\alpha/2} [((R/C)(1-R/C))/(C-1)]^{0.5}$$

Where CI = Confidence Interval

R, C = as above

$Z_{\alpha/2}$ = Standard normal deviate for $(1-\alpha)$ level of confidence;

(1.96 at $\alpha = 0.05$)

Absolute confidence interval values are calculated for lower and upper values as:

$$N'' = (1/CI)*M$$

Where N'' = Lower (upper) 95% Confidence Interval of population estimate

R, C, M = as above

3.4 Other Statistical Procedures

Steelhead fork length for 1999 was assessed for probability that it comes from a normal distribution using histograms and normal probability plots using SYSTAT 5.0. It was determined that these measurements were normally distributed and so parametric analyses were used. Mean lengths and 95% confidence intervals were calculated, and the Students *t*-test used to test for statistical differences of length between sexes. 95% confidence intervals were calculated as (from DeVore, 1987):

$$\text{mean value} \pm z_{\alpha/2} * s / n^{0.5}$$

Where: $Z_{\alpha/2}$ = Standard normal deviate for $(1-\alpha)$ level of confidence;

1.96 at $\alpha = 0.05$)

s = sample standard deviation

n = sample size

4. Results and Discussion

4.1 Stream Flow and Water Temperature

Stream Flow

Discharge in Toboggan Creek over the time of sampling ranged from 350 to 794 L/s (Figure 2, Appendix 1). Discharge rose slowly from mid- to late April, then declined gradually through late April and through the middle of May. There was a rapid increase in stream discharge on May 24th to peak at 794 L/s on May 25th. From here it declined again almost to the level prior to the peak then slowly rose through to the end of the sampling period. Only once, May 24/25, did these flows pose a hydraulic risk to the fence, and so it was lowered during this time.

Stream Temperature

Toboggan Creek stream temperature ranged from 2.75 to 9.5 °C and displayed a general increasing trend over the period of sampling (Figure 2, Appendix 1). The mean stream temperature on the day of initiation of the upstream migration was 4.25 °C.

4.2 Run Timing

The first steelhead to pass upstream through the fence were sampled April 20, 1999 (1 male) and the last date of fish passing upstream was June 1 (1 male, 1 female). Thus, the fish were passing upstream over a period of 43 days. There was an early peak in number of fish passing between April 27 and May 1 (47 fish passed) with the majority (90%) of the run having passed through by May 24 (Table 1, Figures 3 and 4). The upstream run of steelhead appears to have been largely completed by the time of the single high flow event in 1999 (Figures 4 & 5). See Appendix 2 for timing and data on upstream migrating fish.

Returning downstream, the first fish were placed over the fence May 20 (5 males, 2 females) and the last fish were June 11 (7 males, 2 females). The length of time of passage downstream was 23 days. The primary peak in numbers of fish returning downstream occurred between the week ending June 5 (Table 1, Figures 3 and 5). The majority of the run (90%) downstream had passed by June 10. See Appendix 3 for timing and data on downstream migrating kelts.

Table 1: Weekly steelhead movement upstream and downstream in Toboggan Creek April 5 - June 12, 1999.

	UPSTREAM			DOWNSTREAM		
Week ending	Male	Female	Total	Male	Female	Total
April 24	1	0	1			
May 1	27	21	48			
May 8	5	3	8			
May 15	11	4	15			
May 22	7	28	35	5	2	7
May 29	7	36	43	18	5	23
June 5	1	5	6	55	36	91
June 12				36	13	49
n	59	97	156	114	56	170

4.3 Population Estimate and Confidence Interval

The 1999 steelhead population estimate for Toboggan Creek above the fish counting fence is 357 fish, with the 95% confidence intervals bracketing the range of 306-433 individuals (Table 2). There were 156 individuals marked migrating upstream (M), and of 170 passing downstream (C), 74 were tagged (R). The sex ratio of the population is estimated at 0.766, female:male (i.e. 0.766 females/male). Figures 6 and 7 and Table 2 illustrate the current population estimate and female to male ratio together with historic estimates since 1993 (historic data from O'Neill 1994, 1995, 1996; Toboggan Creek Hatchery files, 1993, 1997; Mitchell, 1999).

Table 2: Population estimates, with 95 % confidence intervals, and female to male ratio for Toboggan Creek, 1993-1999.

Year	Population estimate (95% Confidence Intervals in brackets)	Female:Male ratio
1993	435 *	0.775
1994	237 (201 – 288)	0.977
1995	330 (296 – 370)	0.538
1996	120 (103 – 147)	0.818
1997	543 (363 - 1482) **	0.724
1998	381 (352 – 420)	1.19
1999	357(306 – 433)	0.766

* 1993 did not involve a recapture phase, estimate is based on visual observation of tagged to untagged above fence.
** 1997 estimate based on small sample size of marked (M = 43, R = 10) relative to unmarked (C = 135), thus inflating the 95% confidence intervals

The mean annual population estimate in Toboggan Creek above the counting fence between 1993 and 1999 is 344 fish (SD=137, n=7). The number of fish actually using the stream will be dependent upon environmental conditions and spawning history in that area, and appears to occasionally dip to 100 fish over the 14.5 km of available habitat above the fence. There exists some spawning habitat below the fence (personal observation; M. O'Neill pers. comm.) so some fish are expected to remain below the fence and so not be included in these estimates. Steelhead use below the fence for spawning is unknown in detail but can represent the majority of the run some years, such as 1996 (O'Neill 1996).

The sex ratio of the fish sampled has ranged from 0.54 females to males to 1.19. Interestingly, 1998 is the only year that female numbers have exceeded males though in 1994 they were equal. This demonstrates a degree of variability in female:male ratios in the sample. Over the seven years of record, the mean ratio is 0.827 females to males.

There has been some concern raised over the counting fence holding up spawner migration upstream and kelt movement downstream (M. O'Neill, pers. comm.). Saimoto (1995) reports the fence on the Sustut system delaying steelhead movement. This may result in spawners utilizing downstream areas due to difficulty accessing upstream sites,

and postponement of downstream movements of kelts. Either of these activities will affect the population estimation.

In order to more closely approximate free movement upstream and downstream for fish (i.e. allowing them to behave normally), the fence was lowered weekly to allow fish passage. Examination of the numbers of fish moving upstream on the dates prior to and after the period of the fence being down indicate that for April 23/24, May 3/4/5 and May 9/10 the daily number of fish moving into the trap were between 0 and 6 suggesting that there was little movement in the intervening periods while the fence was down. However, the fence being down for 36 hours on May 16/17 may have resulted in a significant movement of uncounted fish. On May 16, prior to lowering the fence there were only two fish captured but on May 17 after the fence had been reinstated, 15 fish were captured and on May 18, 7 fish. Therefore, a number of fish may have moved upstream in the period of May 16-17 unaccounted for. The fence was not intentionally lowered to allow passage once the downstream migrating kelts began coming through.

By allowing fish passage upstream without being counted at the fence, the assumption for the Petersen estimator of no immigration/emigration may be questioned. However, in past years the fence has had to be lowered on "emergency" bases due to hydraulic risk and so the assumption may be questioned under these conditions as well. The benefit of intentionally lowering the fence to allow passage is that it is more likely to allow natural fish behaviour and not constrain the steelhead to behaving in a non-normal manner. That this may violate the assumption of immigration/emigration and so affect the population estimate in some undetermined manner must be recognized. To estimate the number of fish moving through when the fence is down, either through planned lowering or emergency measures, a small scale tagging program of fish near the mouth of Toboggan Creek is recommended. The comparison of the number of these tagged fish observed coming through the fence and the number captured coming back through as kelts would provide numbers on how many fish got through the fence uncounted (i.e., kelts – observed at fence on upstream migration = got through without being observed). This would help

to test the assumption and so provide greater confidence in the results while still allowing the fish to behave "normally".

Since 1993 estimates of the steelhead population above the fence have been estimated with a reasonable degree of accuracy. However, downstream of the fence, the number of spawners has not been rigorously assessed. The tagging project mentioned above, coupled with visual surveys of spawners below the fence and the number of tagged fish through the fence, would provide valuable information regarding numbers of spawners below the fence and so provide accurate assessment of spawners in the entire Toboggan Creek system. While recognizing that visual surveys are biased (English and Link (1999), such a project would at least provide order-of-magnitude estimates of the use of the lower creek for spawning.

4.4 Steelhead Age, Size and Recaptures

Age

Scale samples were collected from 115 individual fish, however, five of these fish were not included in analyses as their initial annulus had been resorbed so determining age or fresh water residency was not possible. Results are provided in Appendix 4 and indicate that the mean age of spawners in 1999 was 5.4 years (Note: This is not a standard age notation; the mean age is five point four years). The minimum age was 4+ and the maximum 8+ (Figure 8). Fresh water residency of these fish prior to initial migration to salt water included 3 years (73 fish or 63.5%), 4 years (36 fish or 31.3%) and 5 years (1 fish or 1%).

Size

The mean fork length of the female steelhead sampled in Toboggan Creek in 1999 was 722.9 mm (S.D. = 72.1 mm) and the mean fork length of males was 758.4 mm (S.D. = 113.0 mm). The difference was found to be statistically significant ($t = 3.0254$, $P<0.01$). Comparison of 1999 results with historic data is provided in Table 3 and Figure 9. Both the largest and smallest fish recorded between 1993 and 1999 occurred in 1999 (500 mm male and 1,030 mm male) indicating greater variability for males in this year compared with previous ones. The females demonstrate no such similar effect.

Table 3: Minimum, mean, and maximum fork lengths (mm), and sample sizes, for steelhead in Toboggan Creek, 1993-1999.

	Female				Male			
Year	Min.	Mean	Max.	n	Min.	Mean	Max.	N
1993	635	754.5	901.7	76	609.7	774.7	939.8	98
1994	431.8	712.9	965.2	89	342.9	721.4	914.4	91
1995	558.8	745.8	873.6	112	444.5	772.4	965.2	135
1996	533.4	720.5	939.8	37	508	740.7	939.8	68
1997	560	712.4	814	67	330.5	705.4	967	101
1998	533.4	705.6	838.2	145	330.2	689.7	914.4	122
1999	510	722.9	890	111	300	758.4	1,030	141

Recaptures

Of the 156 steelhead tagged passing upstream, 74 were recaptured moving downstream, for a recapture rate of 47.4%. Of these recaptures none (0.0%) were found to have lost their tags. A total of 18 adult steelhead were found dead for a mortality rate of 5.0% of the estimated population. Fourteen of these dead steelhead had not been handled during their migration upstream (i.e., no tag or tail punch), while the remaining four dead fish had been tagged and tail punched (Appendix 3).

A total of 18 previously tagged fish (i.e. tagged elsewhere or in previous years) were captured during the 1999 sampling. These are presented in Table 4:

Table 4: Recaptures of previously tagged steelhead between April 5 and June 12, 1999

Tag Number	Capture date	Origin of previous tag
MOE 07491(wh)	April 27, 1999	Tyee Test Fishery – September 12, 1998
MOE 06687(or)	April 30, 1999	Moricetown – August 24, 1998
MOE 06264(ye)	April 30, 1999	Moricetown – August 14, 1998
DFO 00123(or)	May 01, 1999	Moricetown – September 01, 1998
MOE N5023(or)	May 04, 1999	Toboggan Creek Fence – May 27, 1997
MOE 07493(wh)	May 06, 1999	Tyee Test Fishery – September 14, 1998
MOE 06348(or)	May 09, 1999	Moricetown – September 17, 1998
MOE12024(ye)	May 11, 1999	Moricetown – September 16, 1998
MOE07235(or)	May 11, 1999	Moricetown – September 01, 1998
MOE N4999(or)	May 21, 1999	Toboggan Creek Fence – May 25, 1997
MOE N5143(or)	May 23, 1999	Toboggan Creek Fence – May 12, 1998
DFO 00113(or)	May 23, 1999	Moricetown – September 09, 1998
MOE 06597(or)	May 24, 1999	Moricetown – August 24, 1998
MOE 07058(or)	May 24, 1999	Moricetown – August 31, 1998
MOE 06683(or)	May 27, 1999	Moricetown – August 24, 1998
MOE 06475(or)	May 30, 1999	Moricetown – August 19, 1998
MOE N4974(or)	May 31, 1999	Toboggan Creek Fence – June 10, 1997
MOE 06646(or)	May 31, 1999	Moricetown – August 24, 1998

In August and September, 1998, between 1950 and 2250 tags were applied to steelhead in the Moricetown Canyon by the First Nations Fishery (R. Hooten correspondence with G. Wadley, May 19, 1999). Of the 255 individual fish (71.4% of total population estimate) handled in Toboggan Creek during 1999, 12 were found to have been previously tagged at Moricetown Canyon (0.5-0.6% of total Moricetown tags). Seven hundred and nine tags had been applied in the same location in August of 1997 and the 1998 Toboggan steelhead run had contained five of these Moricetown fish (0.7%) Assuming that tag recovery of these fish is representative of their distribution, Toboggan Creek then represents <1.0% of the steelhead run above Moricetown Canyon. Previous studies indicate that Toboggan Creek accounts for between 0 and 1.07% of the entire Bulkley/Morice run; estimates include, 0% (Beere 1991) up to 1.07% (Lough 1992, 1993). Setting Toboggan Creek contribution to 1% of the total steelhead run above

Moricetown Canyon, the corollary is that, using Toboggan as an index stream, the population of adult steelhead above Moricetown Canyon must be on the order of 35,000 fish. Using a different evaluation procedure, Wadley (1999) estimated a minimum of 31,000-36,000 fish above Moricetown contemporary with the 1999 Toboggan Creek steelhead stock.

It should also be noted that the 1999 escapement is very similar to the 1998 spawning stock, with only a five percent difference in stock strength between the years. The 1998 steelhead escapement was slightly larger than in 1999, 377 steelhead (range 323-456) compared to 357 steelhead (range 306-433) respectively.

4.5 Repeat Versus Maiden Spawning Migrations

Of the scales sampled from the 115 individual fish, 15 (13%) were found to be repeat spawners. Of these, 13 were found to have spawned once before and two had spawned twice previously. The fresh water residency and initial seawater duration for these repeat spawners were 3.1 for the twice previous spawners and for five of the once previous spawners. The remaining once previous spawners were 3.2 (5 fish), 4.1 (1 fish) and 4.2 (2 fish).

5. Conclusion and Recommendations

Conclusions

Sampling at the Toboggan Creek counting fence in 1999 provided an estimate of 357 adult steelhead utilizing Toboggan Creek upstream of the fence. The sex ratio of females to males indicates 0.76 females per male, and the mean fork length of females is significantly shorter than males in 1999, unlike the two previous years when female fork length was greater than male. Steelhead migration upstream occurred primarily between April 27 and May 24, 1999, and downstream movement of kelts was between May 20 and June 12, 1999. The age of the returning fish was from 4 to 8 years with most of them being 5-6 year olds. Thirteen percent of the returning fish had spawned at least once previously. A very small sample of previously tagged fish from Moricetown Canyon indicate that Toboggan Creek probably represents approximately 1% of the total steelhead run in the Bulkley-Morice system above the Moricetown Canyon.

Recommendations

The following recommendations are for the future operation of the Toboggan Creek steelhead enumeration program.

1. Continued fence operation for the monitoring of population size, fish length and sex ratio should be a high priority. This fence provides valuable information and now has a seven year database for examining changes over time.

2. The regular lowering of the fence to allow fish passage should be continued. Ideally the time period should be shorter (i.e., 12-24 hours rather than >30) to limit the proportion of the total run which gets through uncounted. This strategy should be done in conjunction with Recommendation #3.

3. A small scale sampling program near the mouth of Toboggan Creek to assess movement of fish between lower Toboggan Creek and the fence, to estimate the number of spawners using the lower 2.5 km, and also the number of fish

moving through the fence when it is down is recommended. This would provide better estimates of the use of Toboggan Creek by steelhead.

4. More consistent and detailed recording of location and magnitude of damage (i.e. seal bites, gill net marks, hook scars, etc.). These are indirect evidence of predation and human pressures on these fish and may be useful in assessing relative importance of various pressures.

5. Angling guides on Bulkley and Morice Rivers be encouraged to keep accurate and detailed records of steelhead captures with respect to tagged and untagged fish. This would be very useful for corroborating estimates of mark:unmarked fish in Toboggan Creek, and resulting estimates of proportion of Bulkley run in Toboggan Creek.

6. An intensive angling sampling program for Moricetown marked fish throughout the Bulkley system is recommended. In conjunction with detailed guide data, such a program would yield more accurate estimates of marked to unmarked fish above Moricetown canyon which could be used in conjunction with Toboggan Creek estimates to evaluate population sizes in the Bulkley system and determine the contribution by Toboggan Creek. Such a program should involve random sampling and experienced fishers.

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Personal Communications

M. O'Neill. Manager. Toboggan Creek. Toboggan Creek Salmon and Steelhead Enhancement Society. Smithers, B.C.

7. Acknowledgements

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Also, the contribution of funding from Fisheries Renewal BC is appreciated.

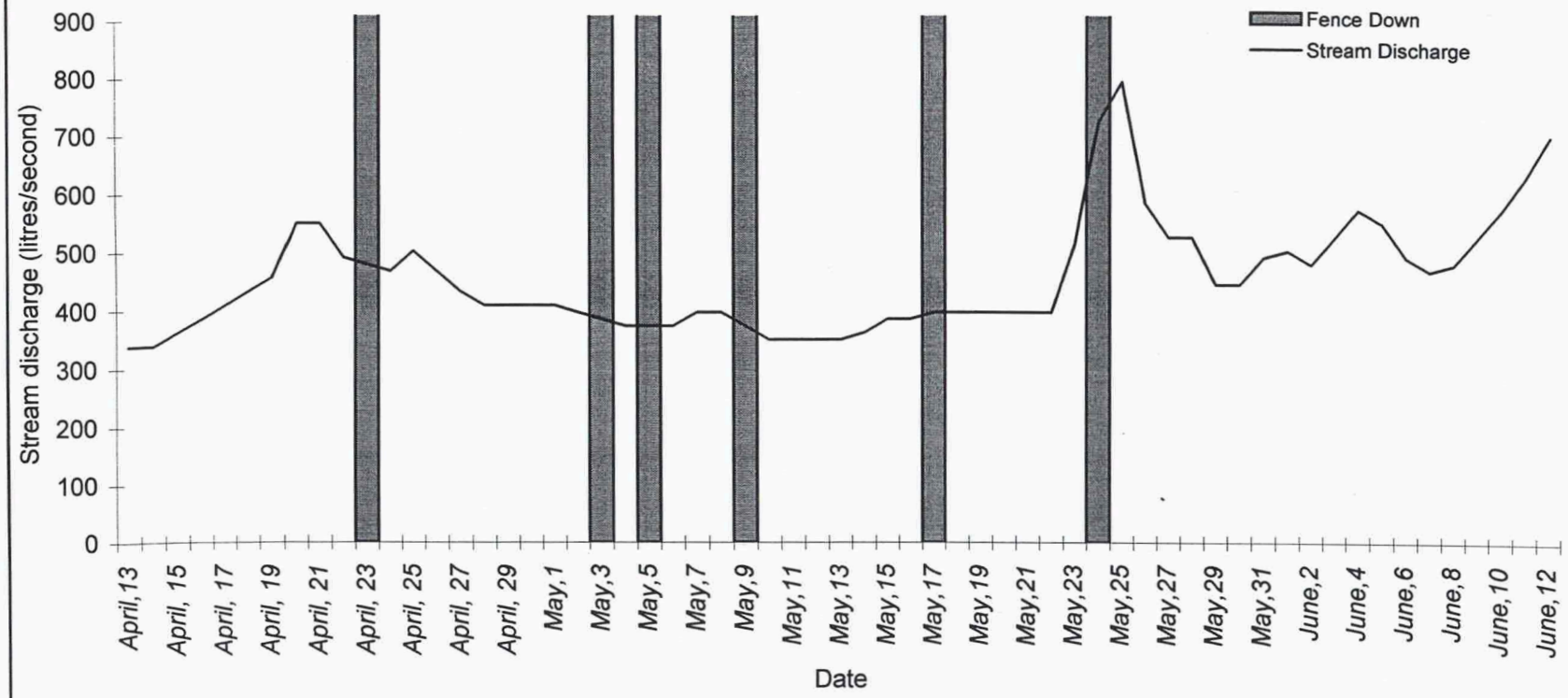

Figure 1: Periods of fence being laid down compared with stream discharge, Toboggan Creek, April 13 - June 12, 1999. See also Figure 2 for stream discharge

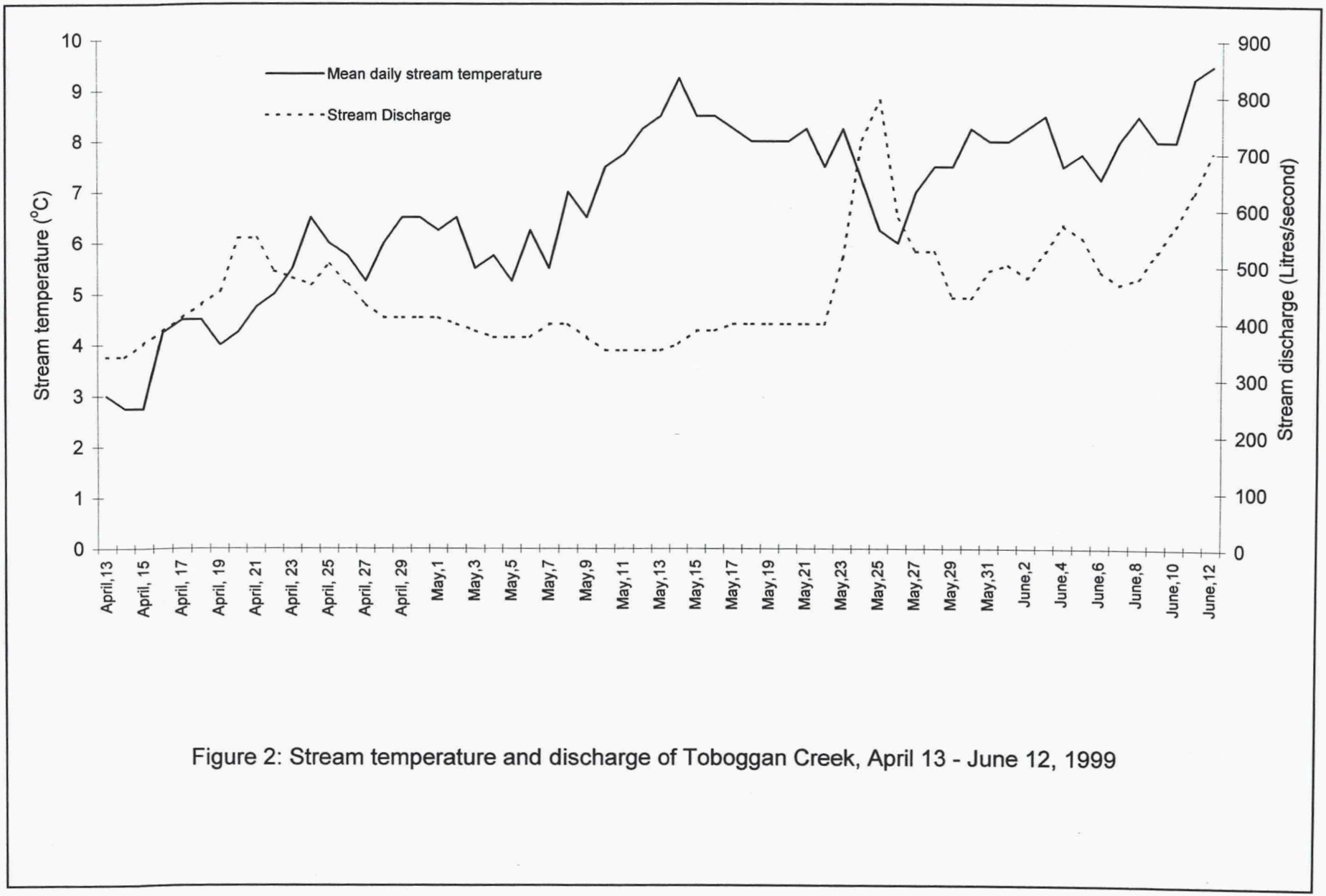

Figure 2: Stream temperature and discharge of Toboggan Creek, April 13 - June 12, 1999

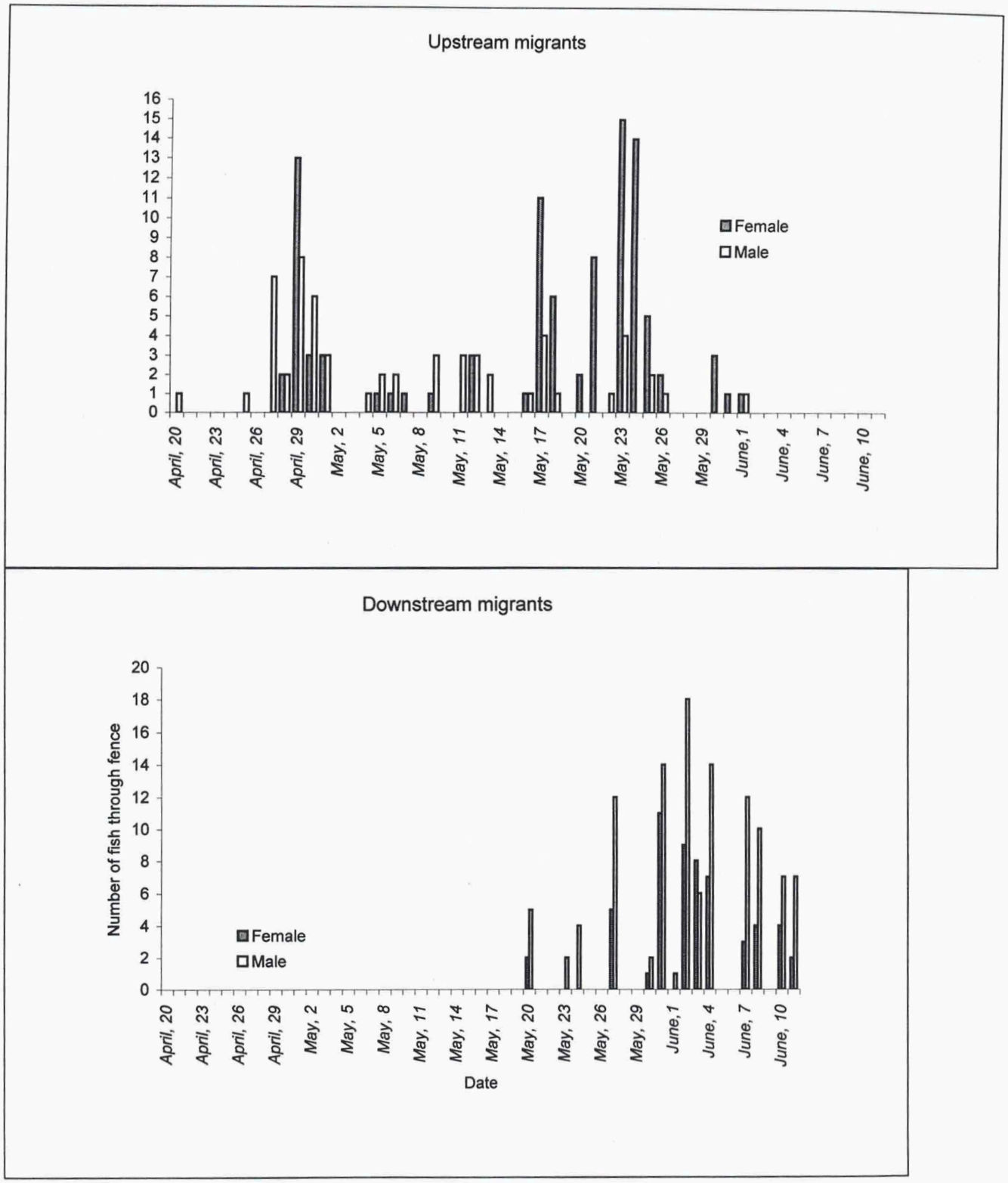

Figure 3: Number of steelhead passing upstream (upper) and downstream through fence by date

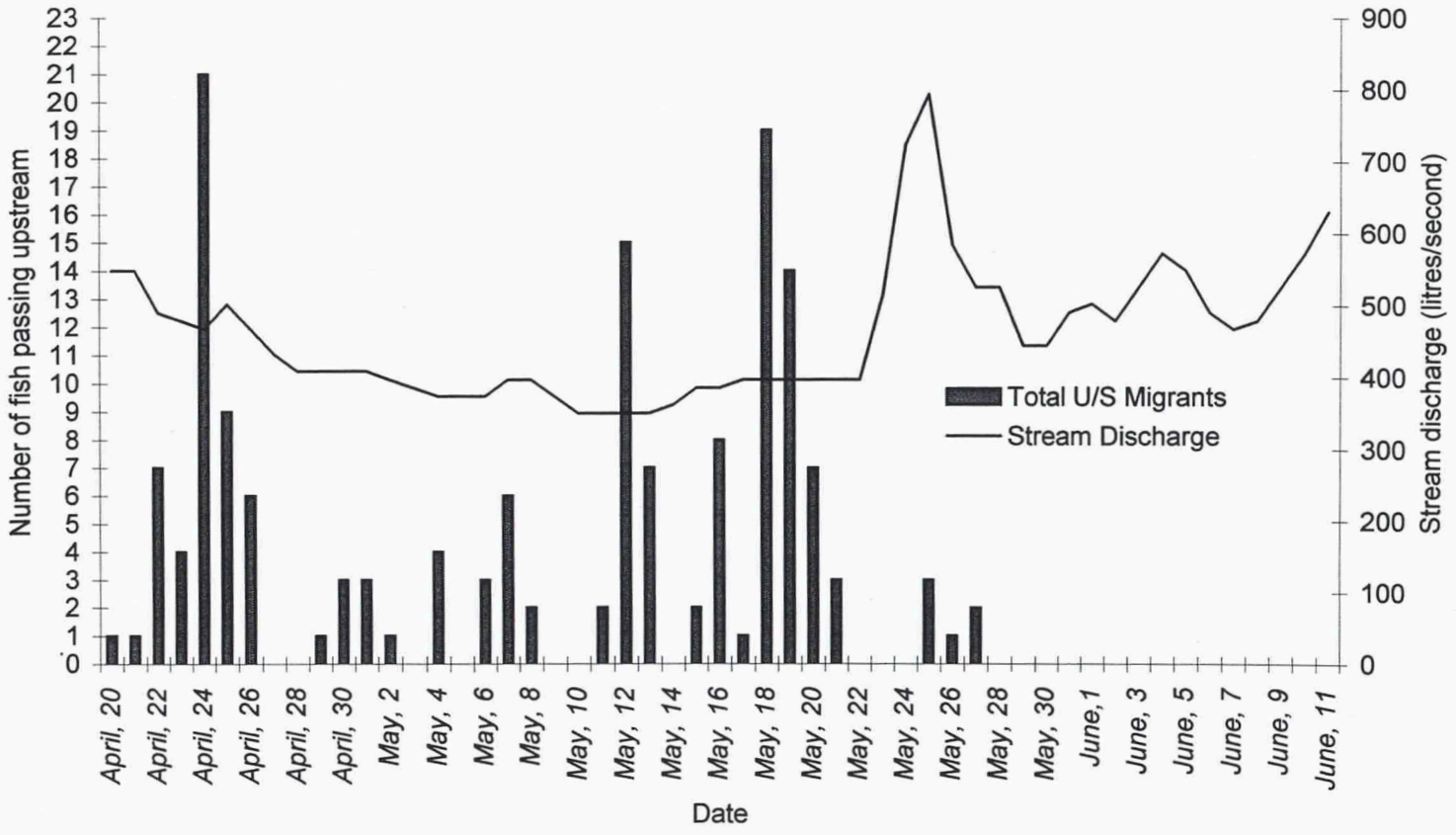

Figure 4: Stream discharge and steelhead passage upstream, Toboggan Creek, April 20 - June 11, 1999

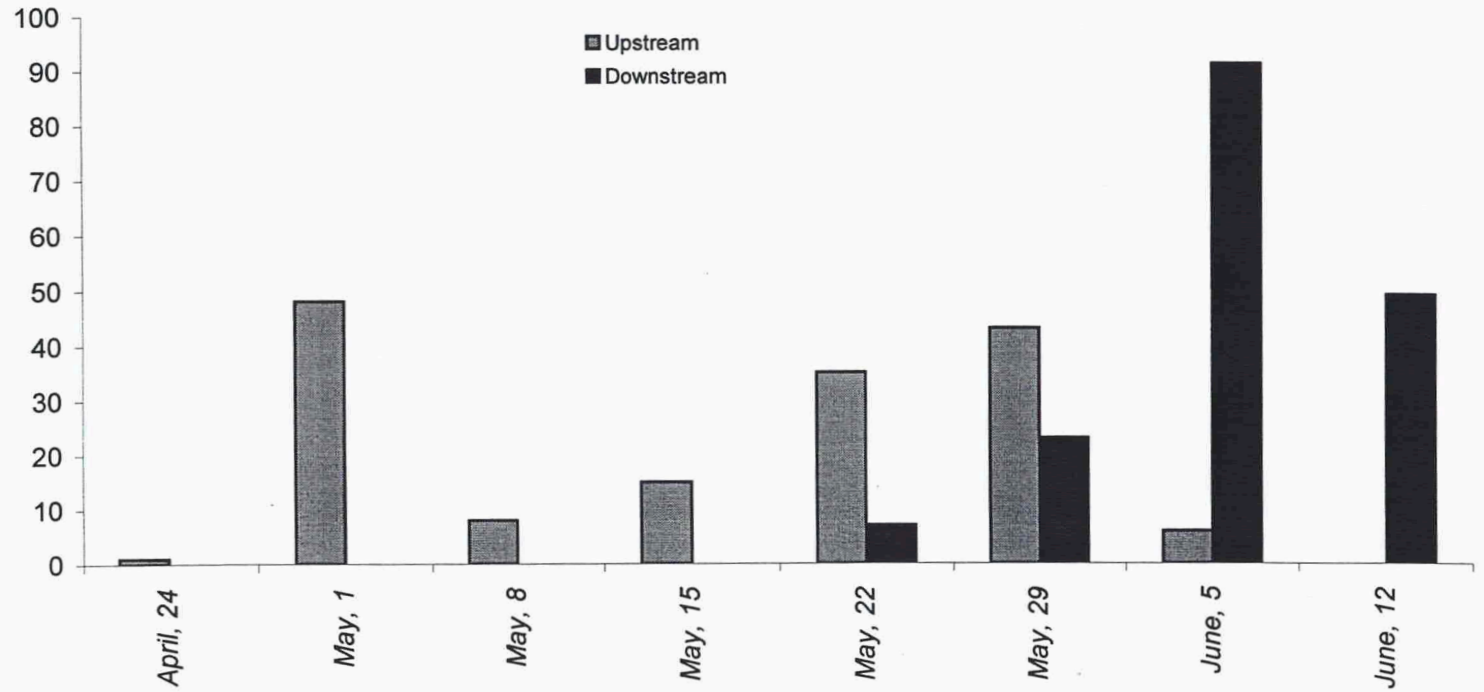

Figure 5: Run timing of steelhead upstream and downstream past Toboggan Creek counting fence, for weeks ending April 24 - June 12, 1999

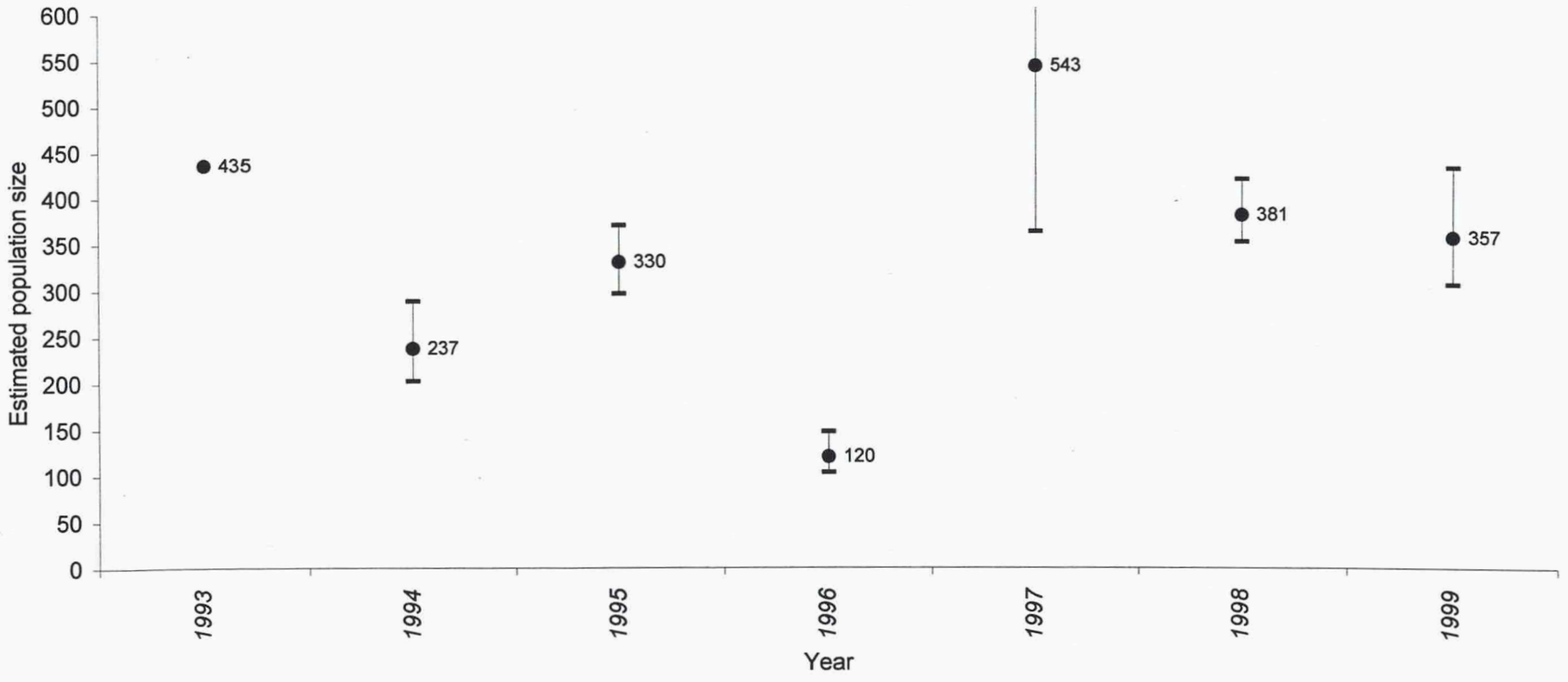

Figure 6: Steelhead population estimates with 95% confidence intervals for Toboggan Creek, 1993-1999 (1993 not mark-recapture so no confidence intervals; 1997 upper confidence interval (1448) not shown for clarity of remaining points).

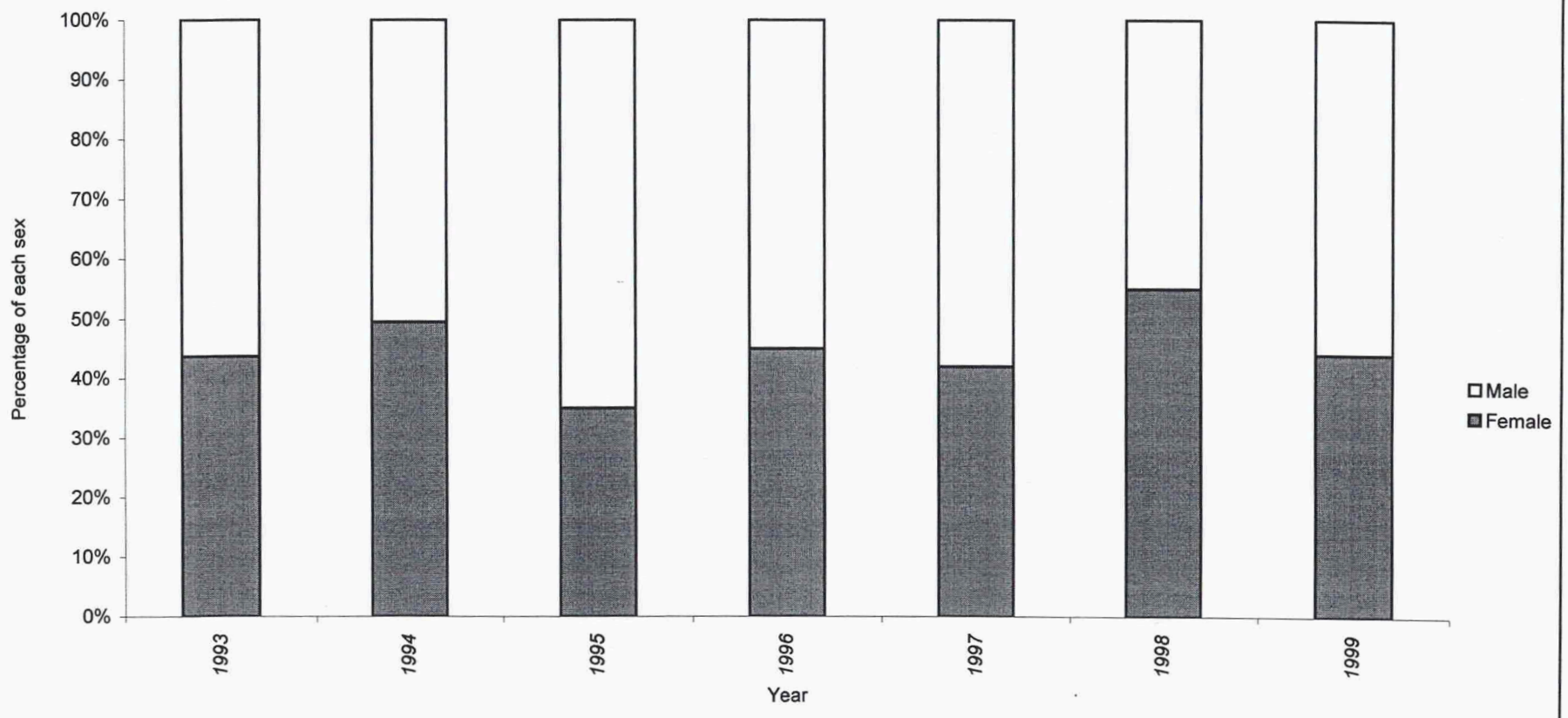

Figure 7: Proportion of each sex comprising steelhead population in Toboggan Creek, 1993-1999.

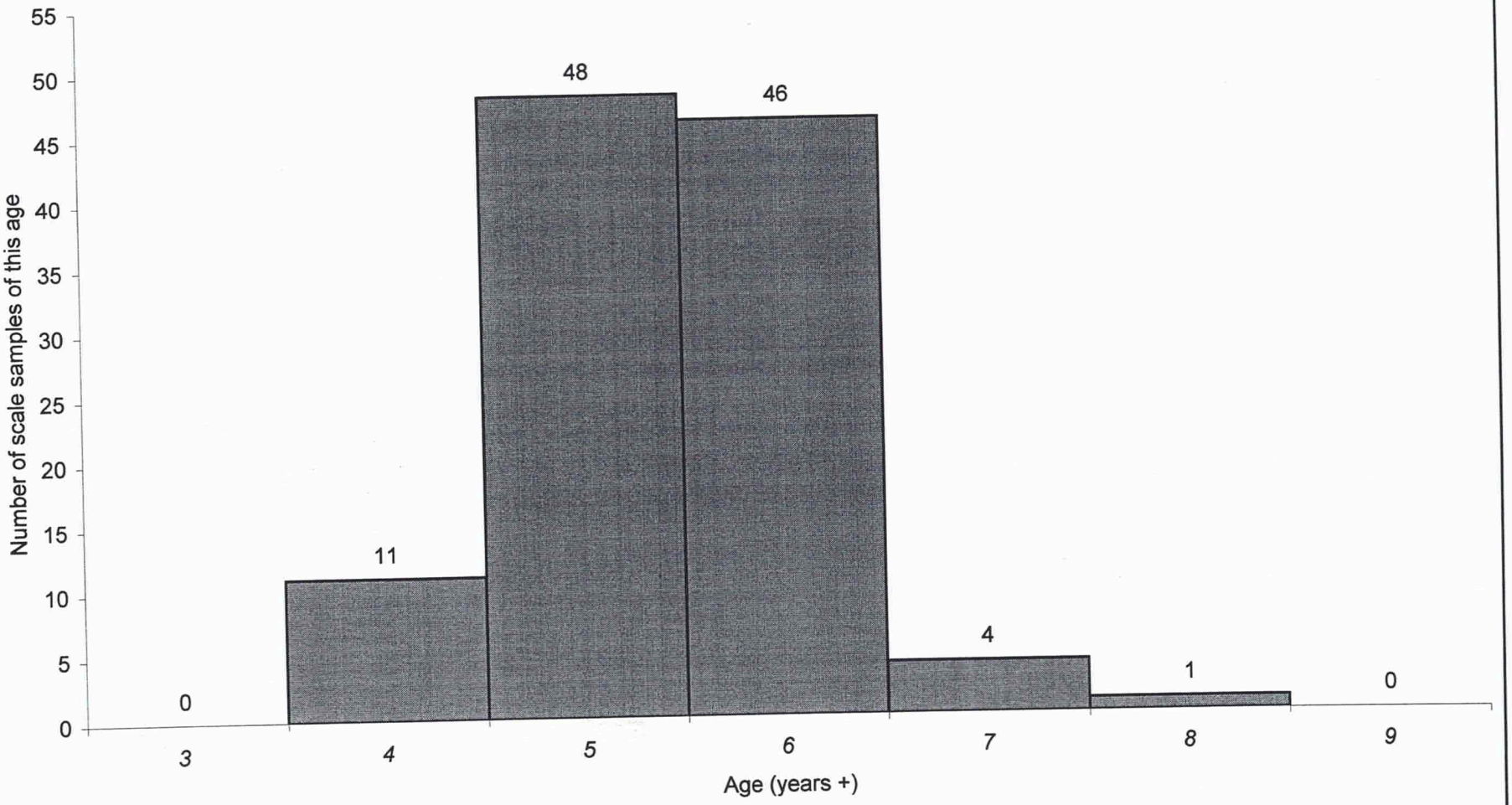

Figure 8: Age distribution of steelhead in Toboggan Creek, 1999, based on sampling of 110 scales.

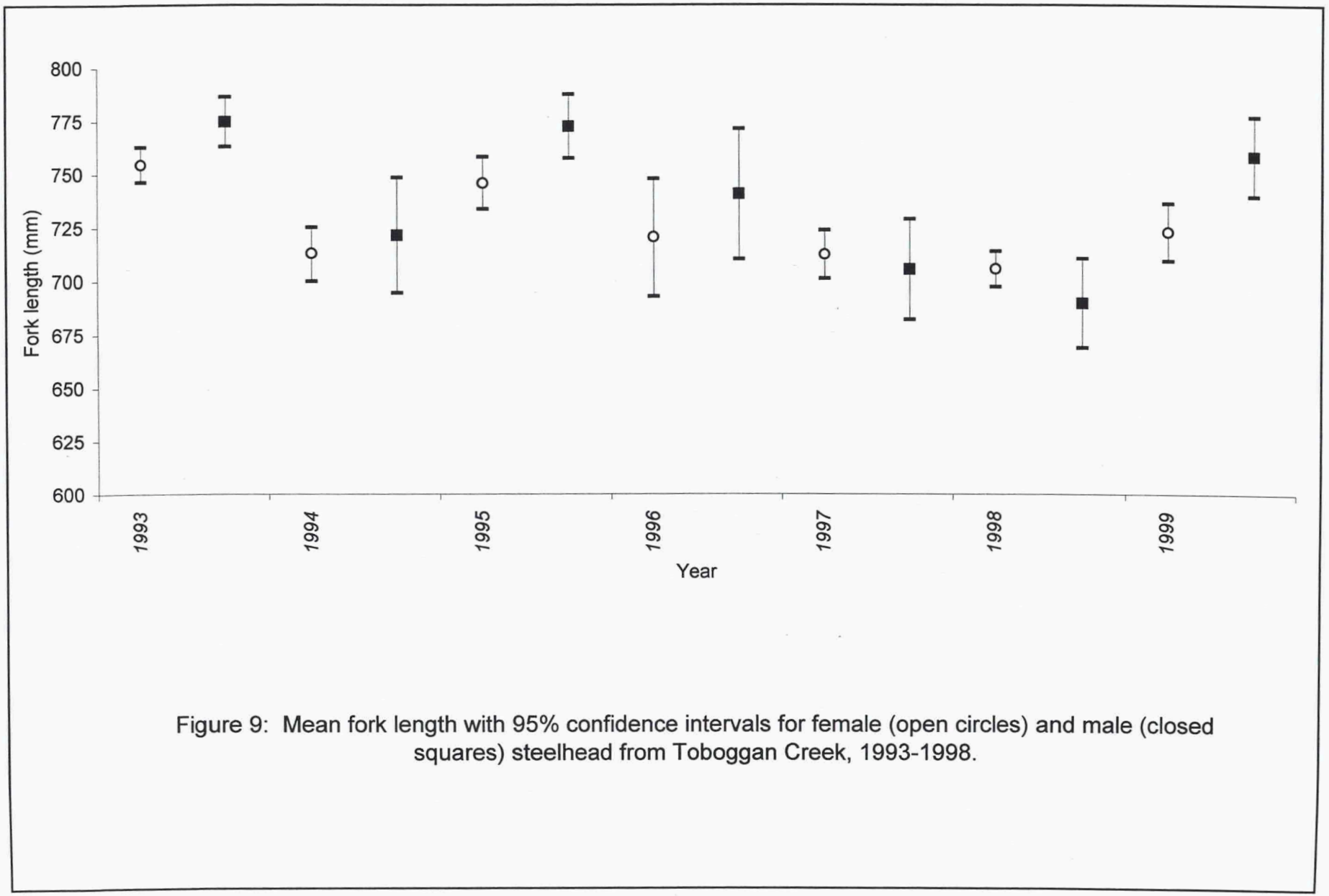

Figure 9: Mean fork length with 95% confidence intervals for female (open circles) and male (closed squares) steelhead from Toboggan Creek, 1993-1998.

Appendix 1: Daily stream discharge and water temperature data for Toboggan Creek as measured at the toboggan Creek fish hatchery

Date	Creek level (m)	Temperature AM	Temperature PM	Mean daily stream temperature (°C)	Stream Discharge
April,13	0.29	1	5	3	338.33
Arpril,14	0.29	1.5	4	2.75	338.33
April, 15	0.31	1	4.5	2.75	361.67
April, 16	0.33	2.5	6	4.25	385.00
April, 17	0.35	3	6	4.5	408.33
April, 18	0.37	3	6	4.5	431.67
April, 19	0.39	3	5	4	455.00
April, 20	0.47	3.5	5	4.25	548.33
April, 21	0.47	2.5	7	4.75	548.33
April, 22	0.42	3	7	5	490.00
April, 23	0.41	4	7	5.5	478.33
April, 24	0.4	4.5	8.5	6.5	466.67
April, 25	0.43	4	8	6	501.67
April, 26	0.4	3.5	8	5.75	466.67
April, 27	0.37	3.5	7	5.25	431.67
April, 28	0.35	4	8	6	408.33
April, 29	0.35	5	8	6.5	408.33
April, 30	0.35	5	8	6.5	408.33
May,1	0.35	4.5	8	6.25	408.33
May,2	0.34	5	8	6.5	396.67
May,3	0.33	4	7	5.5	385.00
May,4	0.32	3.5	8	5.75	373.33
May,5	0.32	4	6.5	5.25	373.33
May,6	0.32	5	7.5	6.25	373.33
May,7	0.34	4	7	5.5	396.67
May,8	0.34	5	9	7	396.67
May,9	0.32	5	8	6.5	373.33
May,10	0.3	5	10	7.5	350.00
May,11	0.3	6.5	9	7.75	350.00
May,12	0.3	6.5	10	8.25	350.00
May,13	0.3	7	10	8.5	350.00
May,14	0.31	7.5	11	9.25	361.67
May,15	0.33	7	10	8.5	385.00
May,16	0.33	7	10	8.5	385.00
May,17	0.34	7	9.5	8.25	396.67
May,18	0.34	7	9	8	396.67
May,19	0.34	6	10	8	396.67
May,20	0.34	6.5	9.5	8	396.67
May,21	0.34	7	9.5	8.25	396.67
May,22	0.34	7.5	7.5	7.5	396.67
May,23	0.44	7	9.5	8.25	513.33
May,24	0.62	6.5	8	7.25	723.33

Appendix 1: (con't)

Date	Creek level (m)	Temperature AM	Temperature PM	Mean daily stream temperature (°C)	Stream Discharge
May,25	0.68	4.5	8	6.25	793.33
May,26	0.5	5	7	6	583.33
May,27	0.45	5	9	7	525.00
May,28	0.45	6	9	7.5	525.00
May,29	0.38	6	9	7.5	443.33
May,30	0.38	7.5	9	8.25	443.33
May,31	0.42	7	9	8	490.00
June,1	0.43	6	10	8	501.67
June,2	0.41	6.5	10	8.25	478.33
June,3	0.45	7	10	8.5	525.00
June,4	0.49	7	8	7.5	571.67
June,5	0.47	7	8.5	7.75	548.33
June,6	0.42	5.5	9	7.25	490.00
June,7	0.4	7	9	8	466.67
June,8	0.41	7	10	8.5	478.33
June,9	0.45	7	9	8	525.00
June,10	0.49	6.5	9.5	8	571.67
June,11	0.54	7	11.5	9.25	630.00
June,12	0.6	7.5	11.5	9.5	700.00
Minimum	0.29	1	4	2.75	338.33
Maximum	0.68	7.5	11.5	9.5	793.33
Mean	0.3904918	5.25409836	8.28688525	6.770491803	455.57
Std. Dev.	0.0826524	1.76687802	1.67446264	1.653465478	96.43
Median	0.37	5	8.5	7.25	431.67

Appendix 2: Upstream migrating steelhead spawners put through Toboggan Creek counting fence , April 15 - June 12, 1999

Date 1999	Sex	Length (mm)	Tag Number	Scale Number	Previous Tags/Comments
April, 20	M	760	12201	39075-R1	
April, 25	M	790	12202		
April, 27	M	890	12203	39075-R2	
	M	830	12204		
	M	860	12205	39075-R3	
	M	800	12206		
	M	800	12207	39075-R4	07491(MOE) White
	M	760	12208		
	M	740	12209	39075-R5	
April, 28	M	300	12210		
	F	830	12211	39076-R1	
	F	711	12212		
	M	740	12213	39076-R2	
April, 29	F	760	12214		
	M	890	12215	39076-R3	
	F	710	12216		
	M	890	12217	39076-R4	
	M	950	12218		
	M	725	12219	39076-R5	
	M	760	12220		
	F	740	12221	39077-R1	
	M	855	12222		
	F	740	12223	39077-R2	
	M	775	12224		
	F	710	12225	39077-R3	
	F	710	12226		
	F	620	12227	39077-R4	
	F	740	12228		
	M	800	12229	39077-R5	
	F	760	12230		
	F	740	12231	39078-R1	
	F	750	12232		
	F	760	12233	39078-R2	
	F	890	12234		
April, 30	F	790	12235	39078-R3	
	M	925	12236		06687(MOE) Orange
	M	790	12237	39078-R4	
	F	740	12238		

Appendix 2: (Con't)

Date 1999	Sex	Length (mm)	Tag Number	Scale Number	Previous Tags/Comments
April, 30	M	580	12239	39078-R5	
	M	880	12240		06264(MOE)Yellow
	M	790	12241	39079-R1	
	M	820	12242		
	F	760	12243	39079-R2	
May, 1	M	880	12244		
	F	710	12245	39079-R3	
	F	840	12246		
	M	660	12247	39079-R4	
	M	620	12248		
	F	800	12249		00123 (DFO) Orange
May, 4	M	740	12250	39079-R5	N05023 (orange)
May, 5	M	790	12251		
	F	740	12252		predator bite on dorsal lobe of tail
	M	825	12253		
May, 6	M	750	12254	39080-R1	07493 (white)
	M	610	12255		Damaged dorsal
	F	790	12256	39080-R2	Damaged gill plate
May, 7	F	760	12257		
May, 9	M	840	12258	39080-R3	
	M	580	12259	39080-R4	06348 (orange)
	F	740	12260		
	M	810	12261	39080-R5	
May, 11	M	810	12262	39081-R1	12024 (yellow)
	M	840	12263		
	M	790	12264	39081-R2	07235 (orange)
May, 12	M	610	12265		
	M	790	12266		
	F	750	12267		
	M	620	12268		
	F	820	12269	39081-R3	
	F	840	12270	39081-R4	
May, 13	M	855	12271		
	M	825	12272	39081-R5	

Appendix 4: Scale results of 115 samples from Toboggan Creek steelhead, April 15 - June 11, 1999. Scale analyses conducted by Birkenhead Scale Analyses

Sample #	Book #	Row #	Scale #	Age	Comments
1	39075	1	8	3.1S1+	
2		2	8	3.3+	
3		3	6	3.3+	
4		4	1	3.3+	
5		5	3	3.2+	
6	39076	1	1	4.2S1+	
7		2	8	3.2+	
8		3	6	3.3+	
9		4	4	3.3+	
10		5	10	R.2+	
11	39077	1	4	4.2+	
12		2	9	3.2+	
13		3	2	3.2+	
14		4	2	3.2+	
15		5	6	R.2+	
16	39078	1	4	4.2+	
17		2	2	3.2+	
18		3	6	3.3+	
19		4	5/10	3.1S1S1+	looks like 3.1SS+
20		5	7	R.1+	
21	39079	1	5	4.2+	
22		2	4	3.2+	
23		3	7	3.2+	
24		4	6	4.1+	
25		5	9	3.2+	resorbed
26	39080	1	7	3.2+	
27		2	10	4.2S1+	
28		3	4	3.3+	1st marine annulus close to fw annulus
29		4	5	3.1+	
30		5	9	3.2+	
31	39081	1	2	3.2+	
32		2	7	4.2+	
33		3	3	3.2+	
34		4	3	3.2S1+	
35		5	6	3.1S1S1+	resorbed
36	39082	1	6	R.1+	
37		2	7	3.3+	
38		3	7	4.2+	
39		4	9	4.2+	
40		5	10	3.1S1+	
41	39083	1	5	3.3+	length outlier
42		2	9	4.2+	

Appendix 4: (Con't)

Sample #	Book #	Row #	Scale #	Age	Comments
43		3	9	4.2+	
44		4	6/8	4.2+	
45		5	1	3.2+	
46	39084	1	2	3.1+	
47		2	4	3.2+	
48		3	7	4.2+	
49		4	1	3.2+	
50		5	6	4.2+	
51	52129	1	2	3.2S1+	
52		2	1	3.2+	
53		3	10	3.2+	
54		4	4	3.1+	
55		5	8	4.1+	
56	52130	1	2	3.2+	
57		2	3	4.2+	
58		3	10	4.2+	
59		4	5	3.2+	
60		5	8	4.1S1+	
61	52146	1	2	3.2S1+	
62		2	9	3.2+	
63		3	6	4.2+	
64		4	4	3.2+	
65		5	3	3.2+	
66	52147	1	10	3.2S1+	
67		2	9	3.2+	
68		3	1	3.3+	
69		4	6	3.2+	
70		5	7	3.1+	
71	52148	1	5	4.1+	
72		2	4	4.2+	
73		3	5	3.2S1+	
74		4	8	4.2+	
75		5	2	3.2+	
76	52149	1	1	4.2+	
77		2	2	R.2+	
78		3	8	4.1+	
79		4	4	4.2+	
80		5	2	4.2+	
81	52116	1	1	3.3+	
82		2	4	3.1+	
83		3	6	3.1+	
84		4	1	3.3+	
85		5	9	3.2+	
86	52117	1	1	4.2+	
87		2	1	3.2+	

Appendix 4: (Con't)

Sample #	Book #	Row #	Scale #	Age	Comments
88		3	3	4.2+	
89		4	4	4.3+	
90		5	3	3.1S1+	length outlier
91	52118	1	1	3.3+	
92		2	10	4.2+	length outlier
93		3	8	3.2+	
94		4	3	4.2+	
95		5	1	4.2+	
96	52119	1	4	4.3+	
97		2	4/6	5.1+	
98		3	8	3.1+	
99		4	9	3.2+	
100		5	6	4.1+	
101	52120	1	4	3.2+	
102		2	5	3.1+	
103		3	3	3.2+	
104		4	2	3.2+	
105		5	1	3.1S1+	
106	52121	1	8	3.2+	
107		2	7	3.2+	
108		3	10	3.1S1+	length outlier
109		4	6	3.1+	
110		5	9	3.1+	
111	52122	1	3	3.2+	
112		2	3	3.2+	
113		3	2	4.1+	
114		4	5/8	4.4+	
115		5	10	3.1+	

Appendix 2: (Con't)

Date 1999	Sex	Length (mm)	Tag Number	Scale Number	Previous Tags/Comments
May, 16	M	790	12273		
	F	610	12274	39082-R1	
May, 17	M	960	12275	39082-R2	
	F	740	12276		
	F	710	12277	39082-R3	
	F	840	12278		
	F	750	12279	39082-R4	
	M	810	12280		
	M	740	12281	39082-R5	
	F	760	12282		
	F	700	12283	39083-R1	
	F	740	12284		
	F	710	12285	39083-R2	
	F	740	12286		
	F	740	12287	39083-R3	
	M	510	12288		
	F	740	12289	39083-R4	
May, 18	F	740	12290	39083-R5	
	F	700	12291		
	F	590	12292	39084-R1	
	M	610	12293		
	F	810	12294	39084-R2	
	F	660	12295		
	F	685	12296	39084-R3	
May, 20	F	790	12297	39084-R4	
	F	710	12298	39084-R5	
May, 21	F	690	12299		
	F	810	12300	52129-R1	N04999 (MOE) Orange
	F	740	12301		
	F	700	12302	52129-R2	
	F	760	12303		
	F	740	12304	52129-R3	
	F	740	12305		
	F	580	12306	52129-R4	
May, 22	M	930	12307		
May, 23	F	660	12309	52129-R5	00113 (DFO) Orange
	F	560	12310		
	M	740	12311	52130-R1	

Appendix 2: (Con't)

Date 1999	Sex	Length (mm)	Tag Number	Scale Number	Previous Tags/Comments
May, 23	M	580	12312		
	F	710	12313	52130-R2	
	F	745	12314		
	F	760	12315	52130-R3	
	F	690	12316		
	F	690	12317	52130-R4	
	F	760	12318		
	F	760	12319	52130-R5	
	F	760	12321		
	F	790	12322	52146-R1	N05143 (MOE) Orange
	F	560	12323		
	M	760	12324	52146-R2	
	M	820	12325		
	F	720	12326	52146-R3	
	F	740	12350		
	F	750	12349	52146-R4	
May, 24	F	760	12327		
	F	690	12328	52146-R5	
	F	710	12329		
	F	810	12330	52147-R1	06597 (MOE) Orange
	F	740	12331		
	F	790	12332	52147-R2	
	F	690	12333		
	F	760	12334	52147-R3	
	F	710	12335		
	F	740	12336	52147-R4	
	F	580	12337	52147-R5	
	F	660	12338		
	F	520	12339	52148-R1	
	F	740	12340		07058 (MOE) Orange
May, 25	F	790	12341	52148-R2	
	F	880	12342	52148-R3	
	F	790	12343		
	F	750	12344	52148-R4	
	M	690	12345		
	M	750	12346		
	F	805	12347	52149-R1	
May, 26	M	810	12348		
	F	710	12351	52149-R2	
	F	560	12352		

Appendix 2: (Con't)

Date 1999	Sex	Length (mm)	Tag Number	Scale Number	Previous Tags/Comments
May, 30	F	580	12353	52149-R3	
	F	690	12354		
	F	725	12355	52149-R4	
May, 31	F	700	12356		
June,1	M	840	12357		
	F	700	12358	52149-R5	

Appendix 3: Downstream migrating steelhead kelts out through Toboggan Creek counting fence April 15 - June 11, 1999

Date 1999	Sex	Length (mm)	Tagged/Punched	Tag Number	Scale Number	Comments
May, 20	M	790	N/N	12501	52116-R1	
	M	810	N/N	12502		
	M	560	N/N	12503	52116-R2	
	F	690	N/N	12504		
	F	790	T/P	12235		
	M	960	T/P	12275		
	M		T/P	12229 (yellow)		Dead Pitch
May, 23	M		T/P	12220 (yellow)		Dead Pitch
	M	840	N/N			Dead Pitch
May, 24	M	810	N/N			Dead Pitch
	M	760	N/N			Dead Pitch
	M	580	N/N			Dead Pitch
	M	850	N/N			Dead Pitch
May, 27	M	840	N/N	12505		Heavy fungus
	M	610	N/N	12506	52116-R3	
	M	630	N/N	12507		
	M	1030	N/N	12508	52116-R4	
	F	610	N/N	12509		
	M	760	N/N	12510	52116-R5	
	M	800	N/N	12511		
	M	780	N/N	12512	52117-R1	
	F	670	N/N	12513		
	F	700	N/N	12514	52117-R2	06683 (orange)
	F	690	N/N			Dead Pitch
	M	825	T/P	12272		
	M	810	T/P	12348		
	M	880	T/P	12244		
	F	750	T/P	12267		
	M	580	T/P	12312		
	M	820	T/P	12325		
May,30	F	760	N/N		52117-R3	06475 (orange); Dead Pitch
	M	850	N/N			Dead Pitch
	M	880	N/N		52117-R4	Dead Pitch
May, 31	M	860	N/N		52117-R5	N04974 (orange)
	M	870	N/N			
	M	810	N/N		52118-R1	
	M	840	N/N			
	M	860	N/N		52118-R2	

Appendix 3: (Con't)

Date 1999	Sex	Length (mm)	Tagged/Punched	Tag Number	Scale Number	Comments
May, 31	F	710	N/N	12515	52118-R3	
	M	790	N/N			
	M	800	N/N		52118-R4	
	F	530	N/N	12516		
	M	700	N/N		52118-R5	06646 (orange)
	F	880	T/P	12342		
	M	930	T/P	12307		
	M	775	T/P	12224		
	M	840	T/P	12263		
	M	810	T/P	12280		
	F	790	T/P	12297		
	F	590	T/P	12292		
	F	710	T/P	12285		
	F	760	T/P	12282		
	F	740	T/P	12331		
	F	700	T/P	12302		
	M	760	T/P	12201		
	F	740	T/P	12304		
	F	720	T/P	12326		
	M		T/P	12258 (yellow)		Dead Pitch
June, 1	M	860	N/N			Dead Pitch
June, 2	M	760	N/N			
	M	970	N/N		52119-R1	Dead Pitch
	M	620	N/N	12517	52119-R2	
	M	570	N/N	12518		
	M	690	N/N	12519	52119-R3	
	F	800	N/N	12520		
	M	760	N/N		52119-R4	
	M	810	N/N			
	M	580	N/N	12521	52119-R5	
	M	910	N/N	12522		
	M	760	N/N	12523	521120-R1	
	M	800	N/N	12524		
	M	610	N/N	12525	52120-R2	
	M	750	N/N	12526		
	M	840	T/P	12357		
	M	660	T/P	12247		
	F	690	T/P	12333		
	F	760	T/P	12334		
	M	750	T/P	12346		
	F	710	T/P	12329		
	F	560	T/P	12352		

Appendix 3: (Con't)

Date 1999	Sex	Length (mm)	Tagged/Punched	Tag Number	Scale Number	Comments
June, 2	F	760	T/P	12327		
	M	740	T/P	12213		
	F	810	T/P	12330		
	F	740	T/P	12284		
	F	690	T/P	12299		
	M		T/P	12240 (yellow)		Dead Pitch
June, 3	M	790	N/N	12527	52120-R3	
	F	510	N/N	12528		
	M	775	N/N	12529	52120-R4	
	F	660	N/N	12530		
	M	710	N/N	12531	52120-R5	
	F	740	N/N	12532		
	F	810	T/P	12294		
	F	660	T/P	12295		
	M	790	T/P	12264		
	M	620	T/P	12268		
	F	690	T/P	12328		
	M	610	T/P	12255		
	F	560	T/P	12323		
	F	790	T/P	12343		
June, 4	M	800	N/N			
	M	840	N/N	12533		
	M	530	N/N	12534		
	M	890	N/N			
	M	810	N/N			
	M	580	N/N	12535		
	M	790	N/N			
	M	710	N/N	12536		
	F	760	N/N	12537		
	M	530	N/N	12538		
	M	760	N/N			
	M	810	N/N			
	M	810	N/N			Dead Pitch
	F	660	T/P	12338		
	M	790	T/P	12266		
	F	790	T/P	12291		
	F	740	T/P	12340		
	F	520	T/P	12339		
	F	710	T/P	12277		
	M	790	T/P	12273		
	F	790	T/P	12341		

Appendix 3: (Con't)

Date 1999	Sex	Length (mm)	Tagged/Punched	Tag Number	Scale Number	Comments
June, 7	M	760	N/N			
	F	700	N/N	12539	52121-R1	
	M	760	N/N			
	M	660	N/N	12540	52121-R2	
	M	800	N/N	12541		
	M	855	N/N	12542	52121-R3	
	M	800	N/N	12543		
	M	660	N/N	12544	52121-R4	
	M	630	N/N	12545		
	M	550	N/N	12546	52121-R5	
	M	790	N/N	12547		
	M	690	T/P	12345		
	M	610	T/P	12265		
	F	700	T/P	12358		
	F	760	T/P	12303		
June, 8	M	630	N/N	12548		
	M	660	N/N	12549		
	M	740	N/N	12550		
	M	610	N/N	12551		
	M	810	N/N			
	M	850	N/N			Dead Pitch
	M	880	N/N			Dead Pitch
	F	725	T/P	12355		
	M	580	T/P	12259		
	F	580	T/P	12306		
	M	810	T/P	12261		
	M	790	T/P	12241		
	F	805	T/P	12347		
	F	700	T/P	12356		
June, 10	M	740	N/N	12552	52122-R1	
	M	790	N/N	12553		
	M	645	N/N	12554	52122-R2	
	M	560	N/N	12555	52122-R3	
	M	990	N/N		52122-R4	
	F	810	T/P	12300		
	F	710	T/P	12335		
	M	760	T/P	12324		
	M	580	T/P	12239		
	F	710	T/P	12298		
	F	740	T/P	12301		

Appendix 3: (Con't)

Date 1999	Sex	Length (mm)	Tagged/Punched	Tag Number	Scale Number	Comments
June, 11	M	590	N/N	12556		
	M	650	N/N	12557	52122-R5	
	M	790	N/N	12558/12559		
	M	820	N/N	12560		
	M	610	N/N	12561		
	M	760	N/N	12562		
	F	750	T/P	12349		
	F	710	T/P	12351		
	M	740	T/P	12311		