Results of the Upper Sustut River Weir Steelhead Assessment Project 2008

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Executive Summary

In 2008, a floating PVC fish fence was in operation on the upper Sustut River from August 1 to September 30. The fish fence has been used in conjunction with a trap box, since 1992, as an annual indicator of upper Sustut River adult steelhead (*Oncorhynchus mykiss*) abundance. The fence has been in its current location since 1994. During site visits, general weather conditions, water level, air temperature and water temperature were recorded between 0800 hrs and 0900 hrs and 1900 hrs and 2100 hrs. Hourly water temperature was also collected via temperature data loggers located near the fence. Water levels ranged from 0.135 m to 0.435 m with a mean level of 0.226 m. Water temperatures ranged from 1.59°C to 16.84°C with a mean of 9.11°C.

One hundred and ninety three adult steelhead were enumerated between August 1 and September 30, 2008. This is the second lowest recorded value for steelhead since the fence location and method was standardized in 1994. The three fence counts prior to 1994 were greater than 400 steelhead. The mean number of steelhead from1994 to 2007 is 623. The previous low count was 133 in 2006. The steelhead count in 2008 represents the fourth consecutive year that fence counts are below minimum requirements (Johnston *et al.* 2002). On September 30, the fence crew conducted a visual count of the fence pool and approximately 45 steelhead were observed. One hundred and ninety three represents 18.6% of the estimated carrying capacity (1036) of the upper Sustut River adult steelhead population, and well below number of spawners (418) at MSY (*Maximum Sustainable Yield*) (Tautz *et al.* 1992). Other species enumerated in 2008 include: rainbow trout (n=2), bull trout (*Salvelinus confluentus*) (n=6), Rocky Mountain whitefish (*Prosopium williamsoni*) (n=50), chinook salmon (*O. tshawytscha*) (n=793), sockeye salmon (*O. nerka*) (n=212) and coho salmon (*O. kisutch*) (n=38). The first steelhead was captured on August 8, and the last steelhead was captured on September 30.

Gillnet marks were observed on 3.1% of all steelhead enumerated during the 2008 project. The ratio of female to male steelhead that migrated past the fence was 1.92:1. In a typical year, approximately 20% of the steelhead migrating past the fence are handled to collect length data, genetic samples and scale samples for annual comparisons. To minimize the potential for stressing steelhead, in a l year of low abundance, biological parameters and steelhead scale samples for annual ageing analysis were not collected in 2008.

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Introduction

Upper Sustut River steelhead are a unique population within the Skeena River watershed (Baxter 1997). Over-wintering, spawning and rearing occur at high elevations: Sustut Lake (1306m); Johanson Lake (1448m). The short growing season in this region prolongs the rearing component of their life-history. The mean smolt age for upper Sustut River steelhead is 4.5 years (Tautz et al. 1992). In comparison, most British Columbia steelhead populations produce smolts that range from two to three years of age (McPhail 2007).

Since 1994, adult upper Sustut River summer run steelhead (*Oncorhynchus mykiss*) index has been used as an annual indicator of stock status for all early run Skeena River summer steelhead. The early run Skeena River steelhead stocks are susceptible to marine commercial fisheries for sockeye (*O. nerka*) and pink (*O. gorbuscha*) salmon where they susceptible to capture in a mixed stock fishery (Ward *et al.* 1993; Cox-Rogers 1994). Due to their long freshwater migration Sustut River steelhead are also intercepted in First Nations fisheries and catch and release recreational fisheries on the Skeena River and lower Sustut River. Access to the fishable portion of the Sustut River is limited to helicopter, fixed wing aircraft or jet boat access from the two angling lodges on the lower river.
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The Sustut River is designated as a Class 1 Classified Water from September 1 to October 31. The river is closed to angling from January 1 to May 31, and the portion of river upstream of the BC Railway Bridge is closed to angling throughout the year.

The objectives of the Sustut River enumeration program are:

1. to enumerate the upper Sustut River summer-run steelhead population.
2. to examine the sex ratio of steelhead throughout the run.
3. to examine the effect of water level and temperature on steelhead migration.
4. to examine the number of gillnet marked steelhead and the distribution of gillnet marked fish throughout the run.
5. to examine the relative run timing of male and female steelhead.
6. to enumerate salmon and resident trout populations.

Although the objectives of the project are related to steelhead, other species are captured during fence operation. Data for chinook, sockeye, coho salmon, bull trout, Rocky Mountain whitefish and rainbow trout are recorded concurrently. Salmon data is forwarded to Fisheries and Oceans Canada for analysis and archiving.

2.0 Study Area

The Sustut River is located in north central British Columbia and is a tributary to the upper Skeena River (Figure 1). It originates in the Omineca Mountains approximately 220 km north of Smithers, B.C. The Sustut River flows for 8 km northwest from Sustut and Mud lakes where it joins Johanson Creek near the main spawning area for upper Sustut steelhead (Bustard 1993). The river then flows 3 km west to it's confluence with Moosevale Creek before turning southwest for approximately 100 km and flows into the Skeena River. The Sustut River drains approximately 3,574 km^2 and has seven main tributaries: Birdflat Creek, Bear River, Asitka River, Red Creek, Two Lake Creek, Moosevale Creek and Johanson Creek. Fish species known to inhabit the upper Sustut River include summer-run steelhead, chinook salmon, sockeye salmon, coho salmon, bull trout, Dolly Varden char, Rocky Mountain whitefish, and burbot [2] (Bustard 1993). The physical area that defines the upper Sustut River steelhead population is the Sustut River upstream of the Bear River confluence including Johanson Creek and Sustut and Johanson lakes (Spence *et al*. 1990) (Figure 2). The physical area that defines the lower Sustut River steelhead population is the Sustut River downstream of the Bear River confluence, including Bear River and Bear Lake (Spence *et al*. 1990) (Figure 2).

3.0 Methods

3.1 Steelhead Enumeration

A floating fish counting fence constructed from 3.8 cm PVC pipe was installed in the Sustut River 500 m upstream of the confluence with Moosevale Creek and 70 km upstream of the confluence with the Bear River (Figure 2). The fence was in operation between August 1 and September 30. Fish are directed into an aluminum trap box where they remain until a gate is opened allowing upstream migration to continue.

The total number of steelhead migrating past the fence between August 1 and September 30 is used as an estimate of adult upper Sustut River steelhead abundance. The Sustut River count is hypothesized to indicate steelhead abundance for upper Skeena River summer run steelhead stocks. Fish holding immediately downstream of the fence were visually counted on October 1 prior to fence removal. The pool downstream of the fence contains multiple species which makes an accurate visual count of steelhead difficult. Therefore, the visual count is considered an estimate.

The fence was inspected a minimum of three times a day. During site visits debris was removed and repairs made as necessary. The fence trap box was

[2] In August, 1999 a single juvenile burbot (<10 cm fork-length) was found in a beaver impoundment by Ministry staff on the Sustut River approximately 800 meters upstream of its confluence with Johanson Creek.

checked in the morning, afternoon and evening during low levels of fish migration. At peak migration the fence was checked in the morning and a member of the project crew remained on site throughout the afternoon and evening. Experience indicates that human activity around the fence often halts or delays migration. Therefore, the removal of debris and carcasses from the fence were conducted at the end of the day when fish migration has slowed. After chinook spawning is completed fence cleaning may only be required once every four or five days (Ron Steffy pers comm.).

The fence monitors used the visual characteristics described in Scott and Crossman (1973) and McPhail and Carveth (1994), to identify the species of all fish captured during the project. For data collection purposes, a plexiglass viewing box was used to identify and record fish by species, sex, presence of gillnet marks, tags, wounds and general condition.

Figure 1. Location of Sustut River

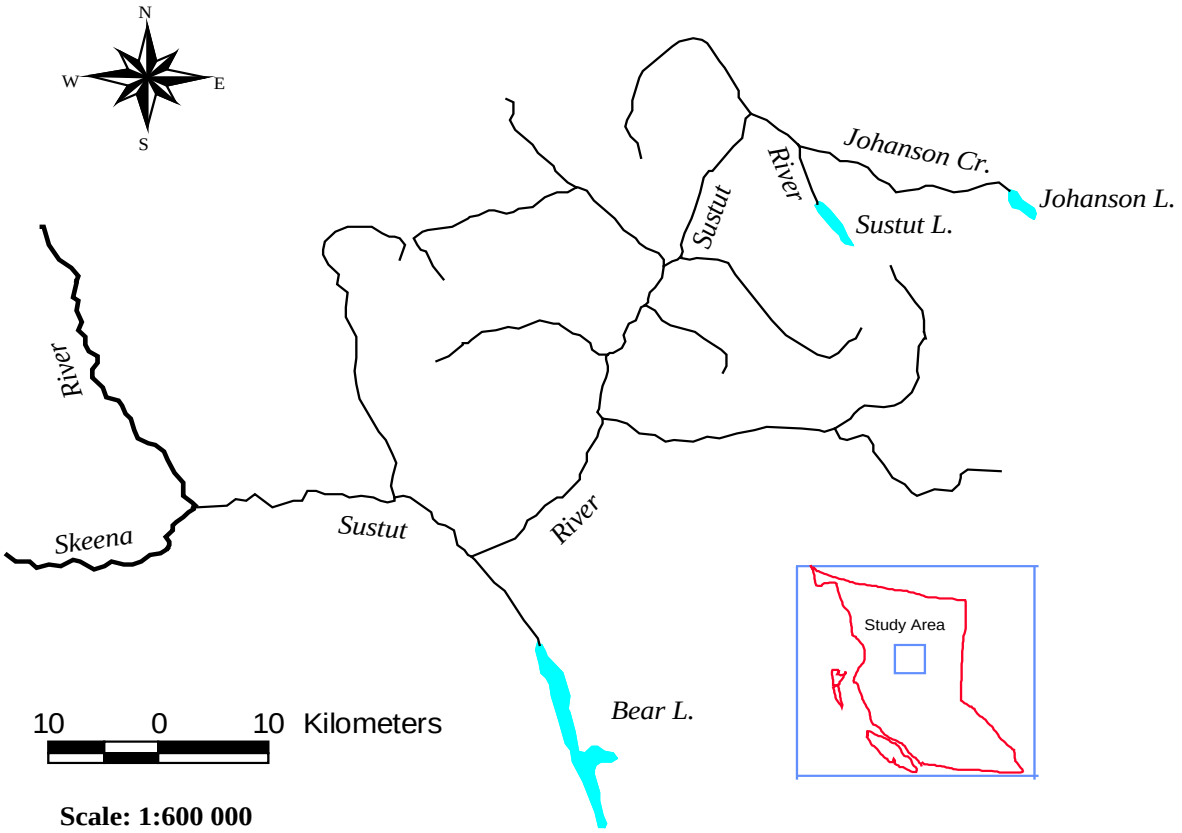


Figure 2. Map of Sustut River and tributaries.

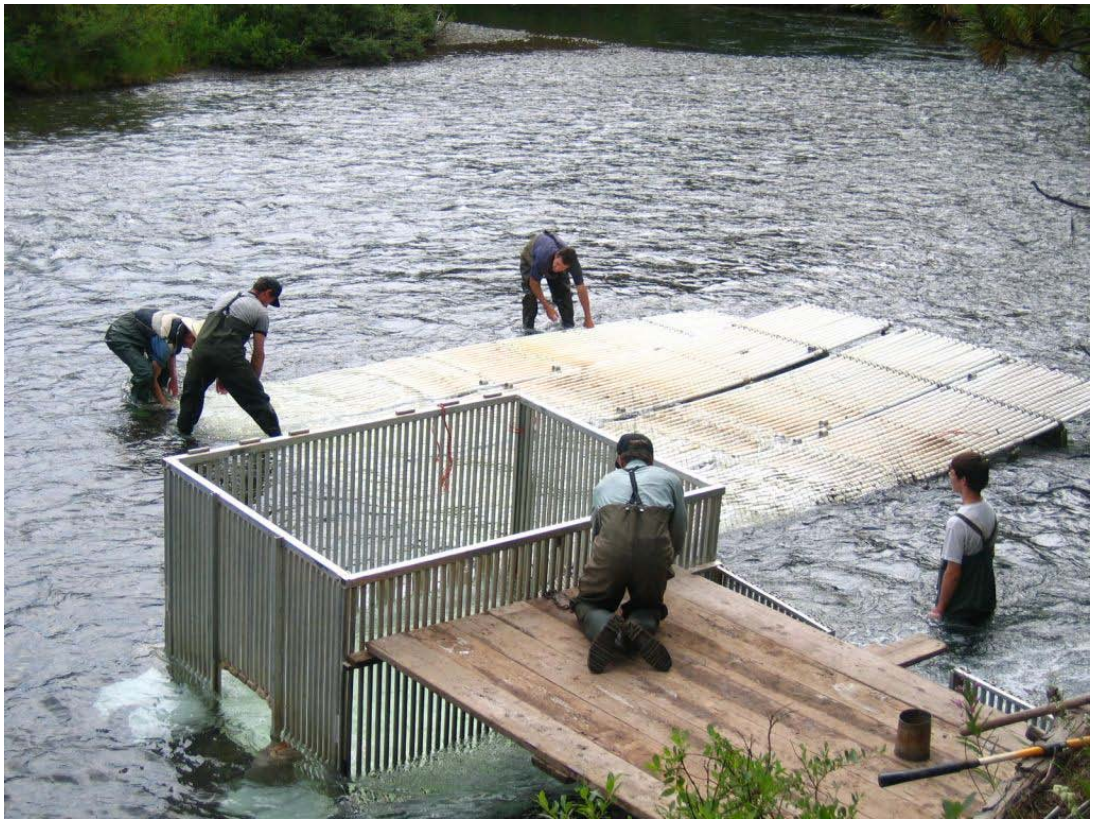


Figure 3. Photograph steelhead enumeration fence assembly (a) and fence in operation. (b), 2008. Courtesy of Brome and Leaf Steffey.

3.2 Steelhead Migration and Physical Data

Stream water temperatures were recorded manually each day using a minimum-maximum thermometer (Brannon Ltd). Also, Optic Stowaway temperature data loggers (Onset Computer Corporation, Pocasset, MA) were deployed in the river and in a tree near the fence site to record water and air temperatures hourly. Water levels were recorded in the morning and the evening using a metric staff gauge. Fence staff also recorded air temperature and weather conditions daily. Mean daily water temperature and level were compared against steelhead migration to measure potential links between the two variables and daily steelhead migration. Annual steelhead abundance was also compared to mean annual water level and mean annual temperature to investigate potential relationships between steelhead abundance and the two environmental variables.

3.3 Gillnet Marks

Sustut River steelhead migrate with other species of anadromous salmonids that are captured in tidal and non-tidal gillnet fisheries. The presence or absence of gillnet marks was noted for all steelhead as they migrated past the fence. This was facilitated by the use of a viewing box, avoiding the need to handle fish. Steelhead that exhibited wounds from a gillnet encounter were identified using this method.

3.4 Male and Female Steelhead Run Timing

The run timing of male and female steelhead was examined by plotting cumulative percent male and female steelhead by date over the duration of fence operation. The date of first arrival and median migration date past the fence for male and female steelhead was also compared.

4.0 Results

4.1 Steelhead Results

Between August 1 and September 30, 2008, 193 steelhead migrated past the upper Sustut River fence (Table 1; Appendix Table 1). Approximately 45 steelhead were in the pool immediately downstream of the fence, prior to removal, resulting in a total count of 238 steelhead. The standardized count of 193 represents the second lowest recorded value since the current fence

location was established in 1994. One hundred and ninety three represents 18.6% of the estimated carrying capacity (1036) for the upper Sustut River steelhead population (Tautz *et al*. 1992). The lowest recorded fence count was 133 in 2006 (Fig 4). The 13 year mean fence count (1994-2007) is 623. The fence count in 2008 represents the fourth consecutive year that the results are below the minimum requirements described by Johnston *et al.* 2002 (Fig.5).

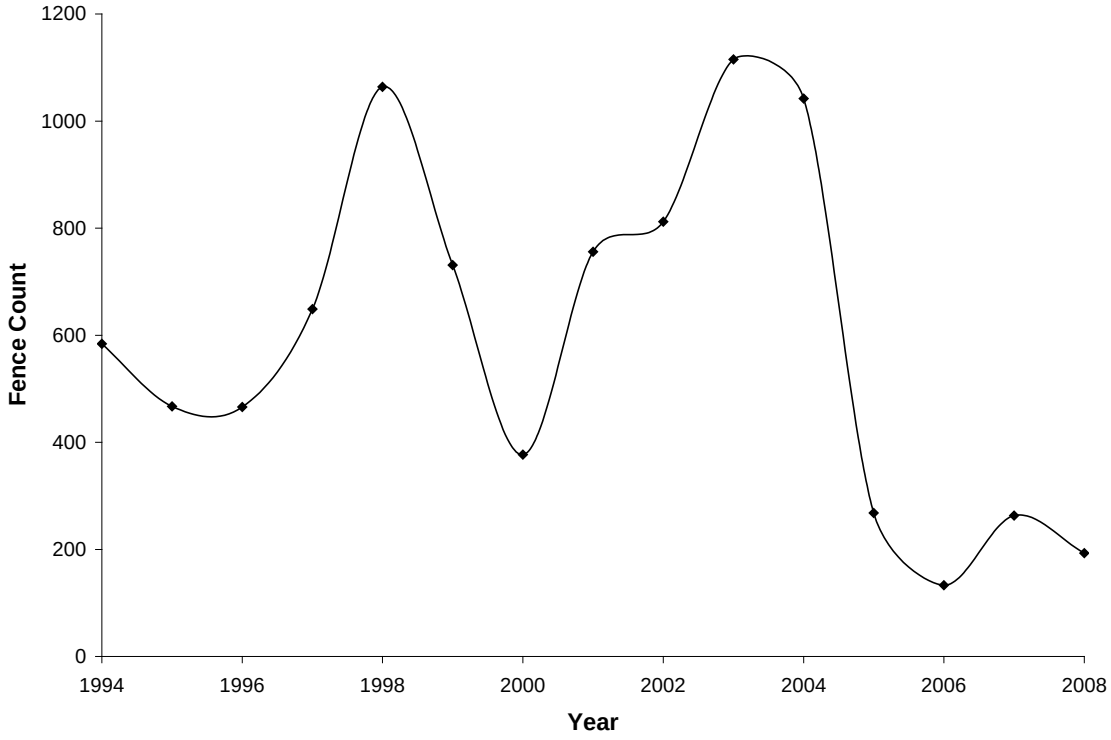


Figure 4. Annual fence count of steelhead at the upper Sustut River weir 1994-2008.

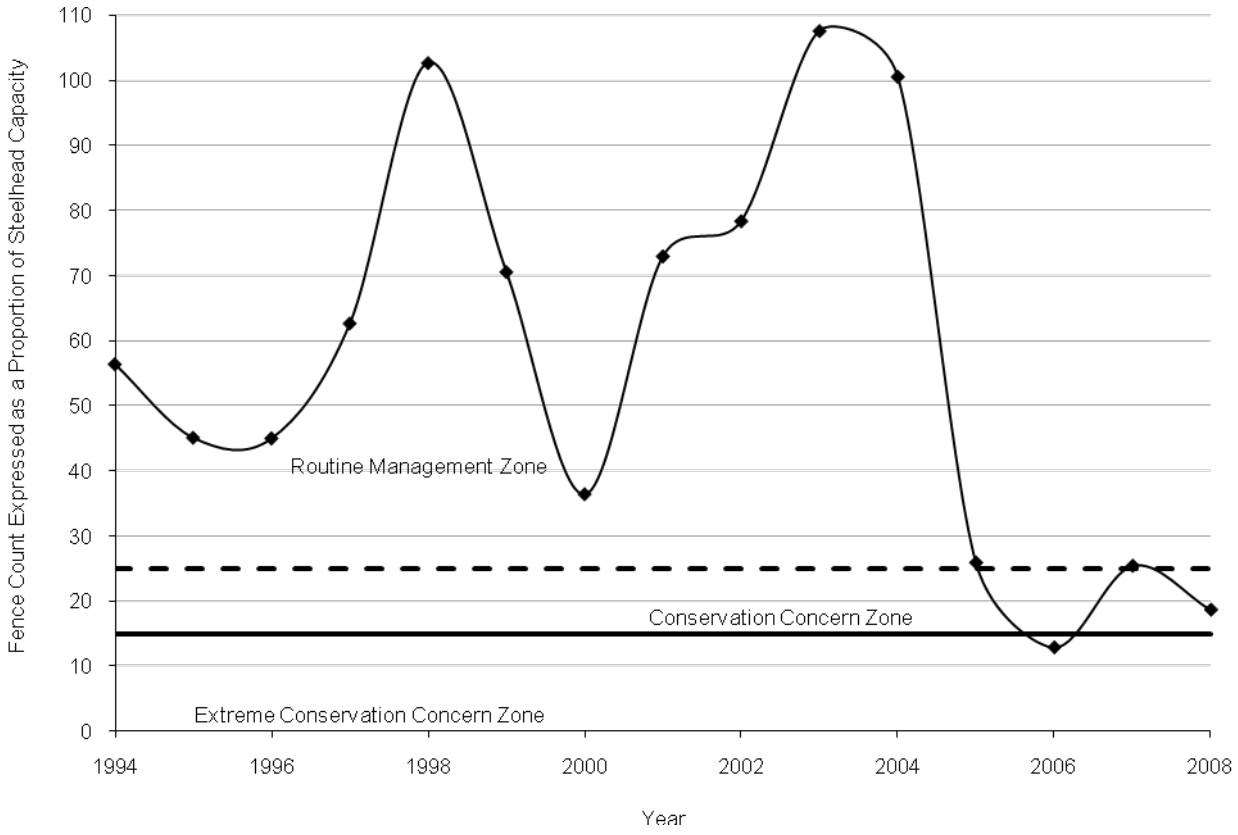


Figure 5. Annual steelhead fence count expressed as a proportion of adult steelhead capacity.

The first steelhead migrated through the fence on August 8 and by September 7, 50% of the steelhead enumerated in 2008 had passed the fence (n=97) (Fig 6). For annual comparison, the previous dates by which 50% of the migration had occurred along with the corresponding total fence counts to September 30 are recorded in Table 1 for the years 1994 to 2008. Since 1994, the date on which the first steelhead arrived has ranged between July 28 (2004) and August 17 (1999). The mean date of arrival is August 8 (SD=5.6) Information collected prior to 1994 was not included due to the variation in fence design and location.

Since 1994, the mean date at which 50% of the steelhead run had passed the fence is September 7 (SD=5.3). In comparison, since 2002, the 50% migration date has been relatively consistent. The mean 50% migration date during this time period is September 4 (SD=2.7) (Table 1).

Table 1. Dates when 50% of the steelhead migrated through the fence and the total count to September 30, for the years 1994 to 2008.

Year	Date of 50% Migration	50% Fence Count	Aggregate Fence Count	Rank
1994	Aug-29	292	584	8
1995	Sep-08	234	467	9
1996	Sep-07	233	466	10
1997	Sep-13	325	649	7
1998	Sep-07	532	1064	2
1999	Sep-17	366	731	6
2000	Sep-07	186	377	11
2001	Sep-16	378	756	5
2002	Sep-02	406	812	4
2003	Sep-02	558	1115	1
2004	Sep-03	521	1042	3
2005	Sep-03	134	268	12
2006	Sep-04	66	133	15
2007	Sep-09	132	263	13
2008	Sep-07	97	193	14
Earliest 50% Migration Date	Aug-29	Minimum Count	133	
Latest 50% Migration Date	Sep-17	Maximum Count	1115	
		Mean Count	623	

Graphical analysis of the cumulative proportional distribution of steelhead over time shows that, in 2008, almost half of the steelhead migration occurred in a three day period (Fig 6). On August 30 (n=33), September 16 (n=22) and September 19 (n=34) a total of 89 or 46% of the total index was counted. The daily steelhead count ranged from 0 to 34, and steelhead were counted on 34 days of the 61 day project. In comparison, from 2002 through 2007, the mean number of days steelhead were counted during the 61 day project was 39.1 (SD=11.73). During this time period the fence count ranged from 133 to 1115 (Table 1).

When the fence was dismantled on September 30 the fence crew estimated that 45 steelhead were present in the fence pool located downstream of the fence.

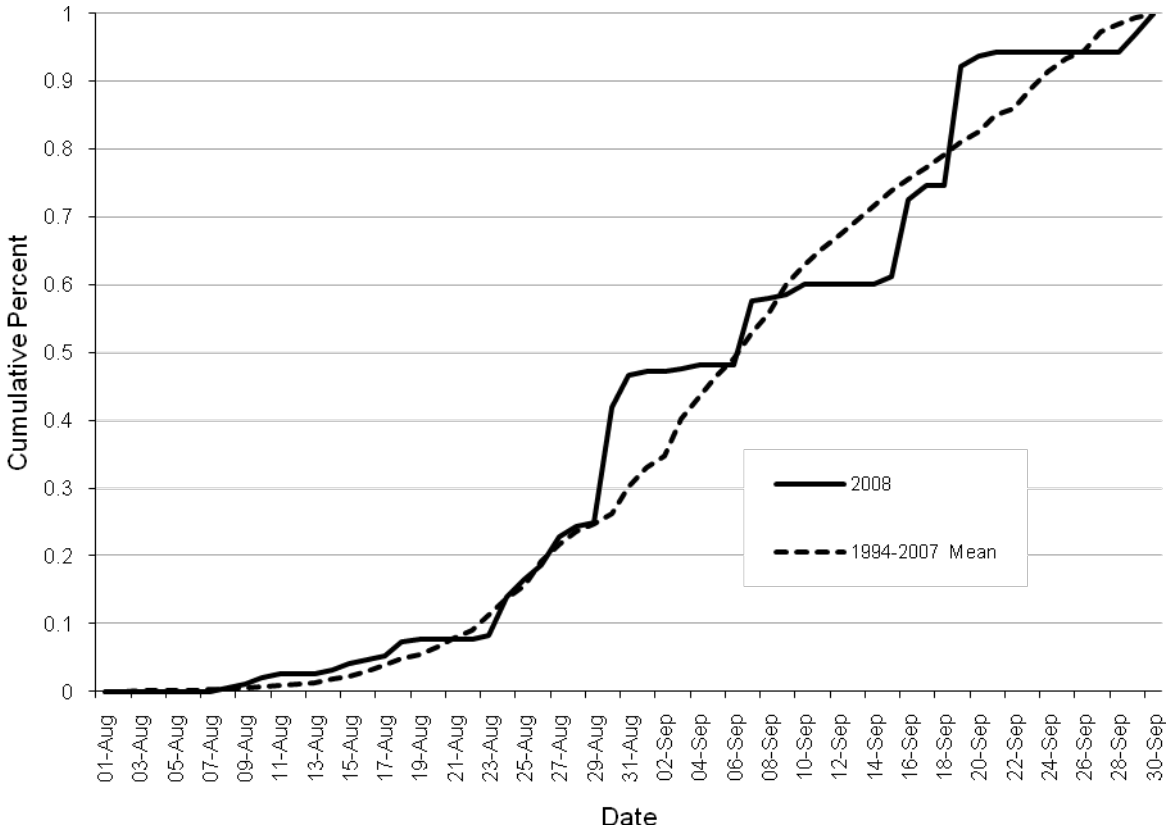


Figure 6. Daily cumulative percentage of upper Sustut River steelhead migrating past the fence.

4.2 Steelhead Ageing and Tagging Information

Prior to 2002, all steelhead captured in the trap box were marked via Anchor-T tag (Floy U.S.A.) before being released upstream of the fence. Since 2002, the tagging component of the program has been discontinued. Steelhead captured and released in Alaskan commercial fisheries, Canadian commercial fisheries, First Nation fisheries programs and the Tyee Test Fishery are sometimes tagged or marked prior to release. Steelhead enumerated at the fence are checked for marks or tags. There were no tagged or marked fish observed at the fence in 2008.

Until 2006 the fence staff attempted to collect biological information samples from approximately 20% of all steelhead captured at the fence. This information included length data and scale samples for ageing purposes. Since 2006 steelhead abundance has been below minimum requirements. Therefore, the decision has been made to suspend steelhead handling until such a time that abundance levels increase. Therefore, there is no ageing information available for the 2008 season.

4.3 Steelhead Migration and Physical Data

Daily environmental data recorded by the fence monitors are presented in Appendix Table 4. For purposes of analysis, water temperatures collected via Stowaway data loggers were utilized. The data logger recorded water temperatures from August 1 to September 30, 2008. Water temperature was recorded hourly providing 1,464 data points for analysis. Overall, the highest temperature was recorded on August 7 (16.84°C) and the lowest was recorded on September 25 (1.59°C). The mean temperature during the 2008 project was 9.11°C. The lowest mean daily water temperature recorded when a steelhead was captured was 4.58°C on September 29. Daily minimum water temperatures are shown graphically in Appendix Figure 1. Mean water temperatures in 2004, 2005, 2006, 2007 and 2008 were 9.81°C, 8.81°C, 8.71°C, 8.81°C and 9.11°C respectively. In this time period, the fence count ranged from 1042 in 2004 to 133 in 2006.

Stratified by hour, the warmest water temperatures were recorded between 17:00:00 and 18:00:00 (Fig 7). During the study period 74% (n=142) of the steelhead entering the trap box did so after the morning site visit. The remainder, 26% (n=51), entered the trap box after the crew left in the evening and before the morning site visit the following day. Since the fence staff are not at the site on a continual basis the exact hour steelhead entered the trap box cannot be determined. However, the data indicates that the majority of steelhead that entered the trap box did so in the afternoon and evening hours. This coincides with the daily time period when water temperatures are increasing or have reached their daily maximum (Fig 7).

Accumulated thermal units are defined as the cumulative daily water temperature (degrees Celsius) stratified by hour from August 1 to September 30.

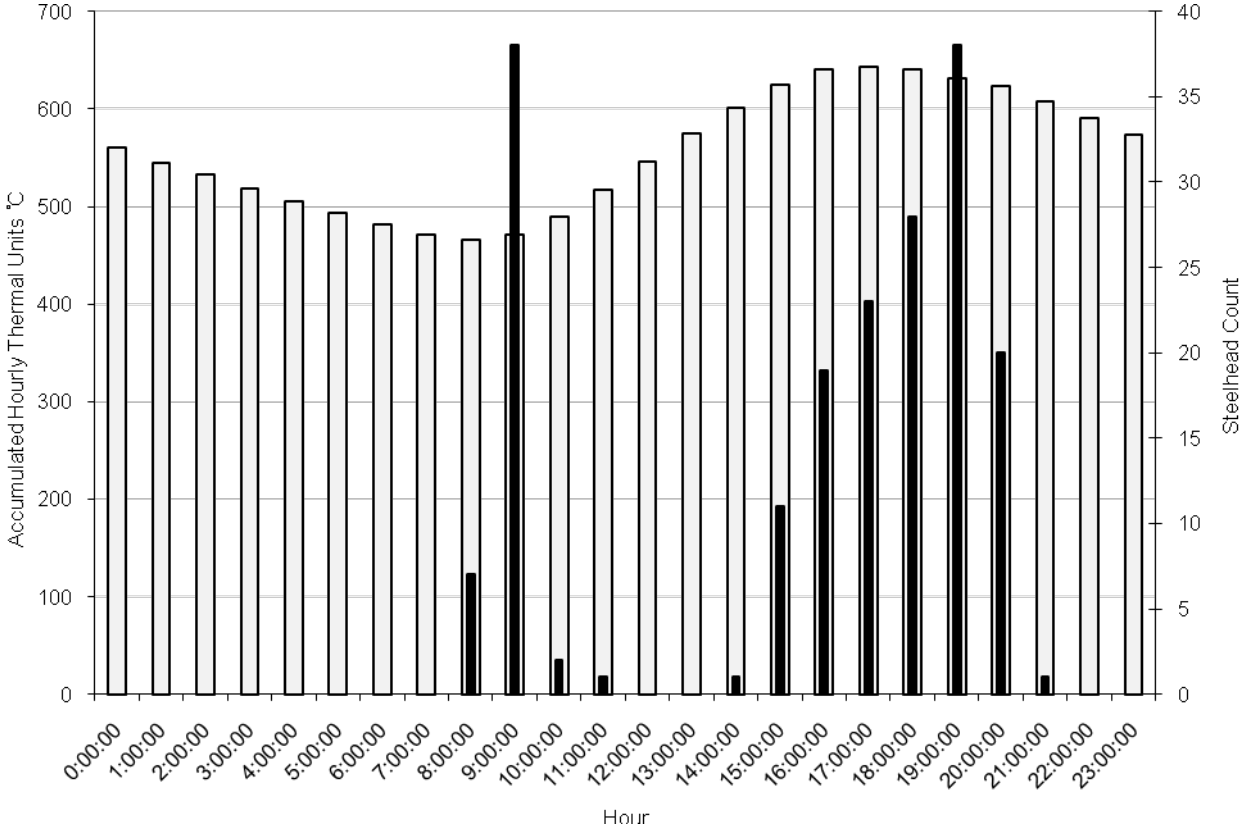


Figure 7. Water temperatures and steelhead migration stratified by hour
August 1- September 30, 2008

Water levels were recorded by fence staff twice a day. The two measurements were averaged to determine a daily level (Fig 8). Measurements were recorded from a metric staff gauge located immediately upstream of the fence. In 2008, water levels ranged between 0.14 m and 0.43 m. Steelhead entered the trap box in water levels ranging between 0.15 m and 0.43 m. The mean level was 0.23 m and the standard deviation was 0.06. The highest water level was 0.43 m measured on August 25, and the lowest level was 0.14 m measured on September 26, 27, and 28. Figure 8 shows the combined 2008 daily water levels and steelhead migration at the fence from August 1 to September 30.

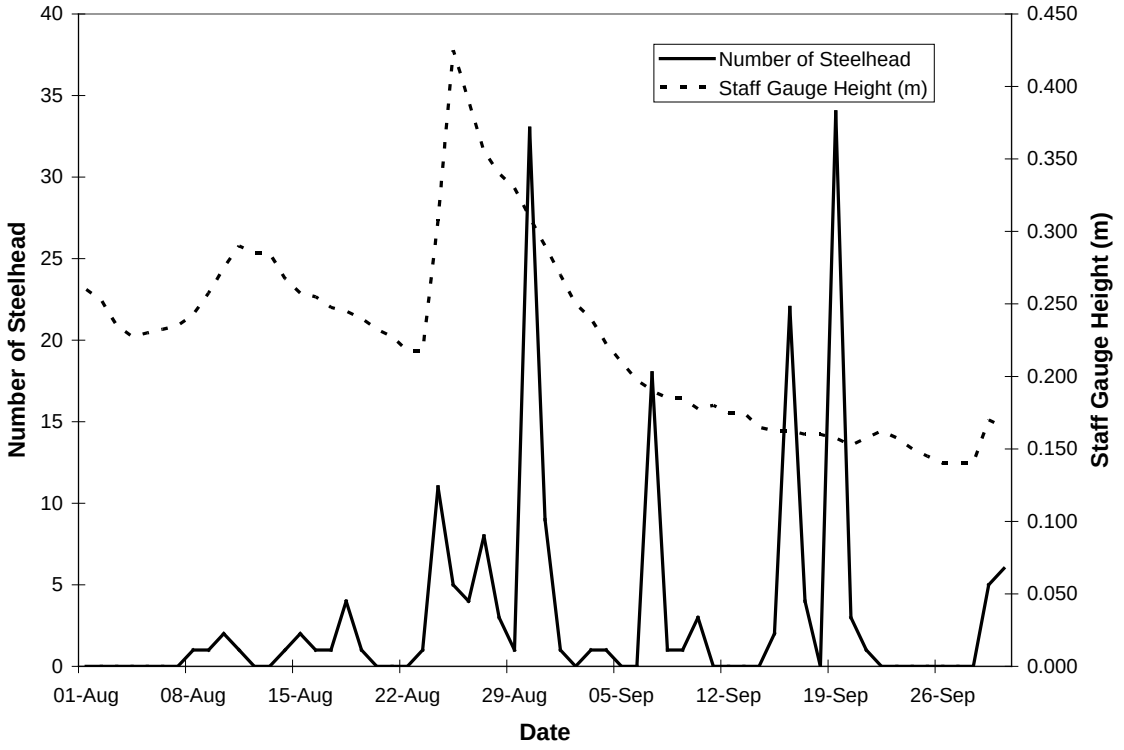


Figure 8. Daily staff gauge height and the number of steelhead migrating past the fence in 2008.

Comparing 2007 daily water level to steelhead migration into the trap box indicated a poor relationship between the variables (Fig.9). In 2008, the median water level was 0.22 m. During the project (52% n=102) steelhead entered the trap box when water levels were below 0.22 m, and (48% n=91) entered the trap box when water levels were above 0.22 m.

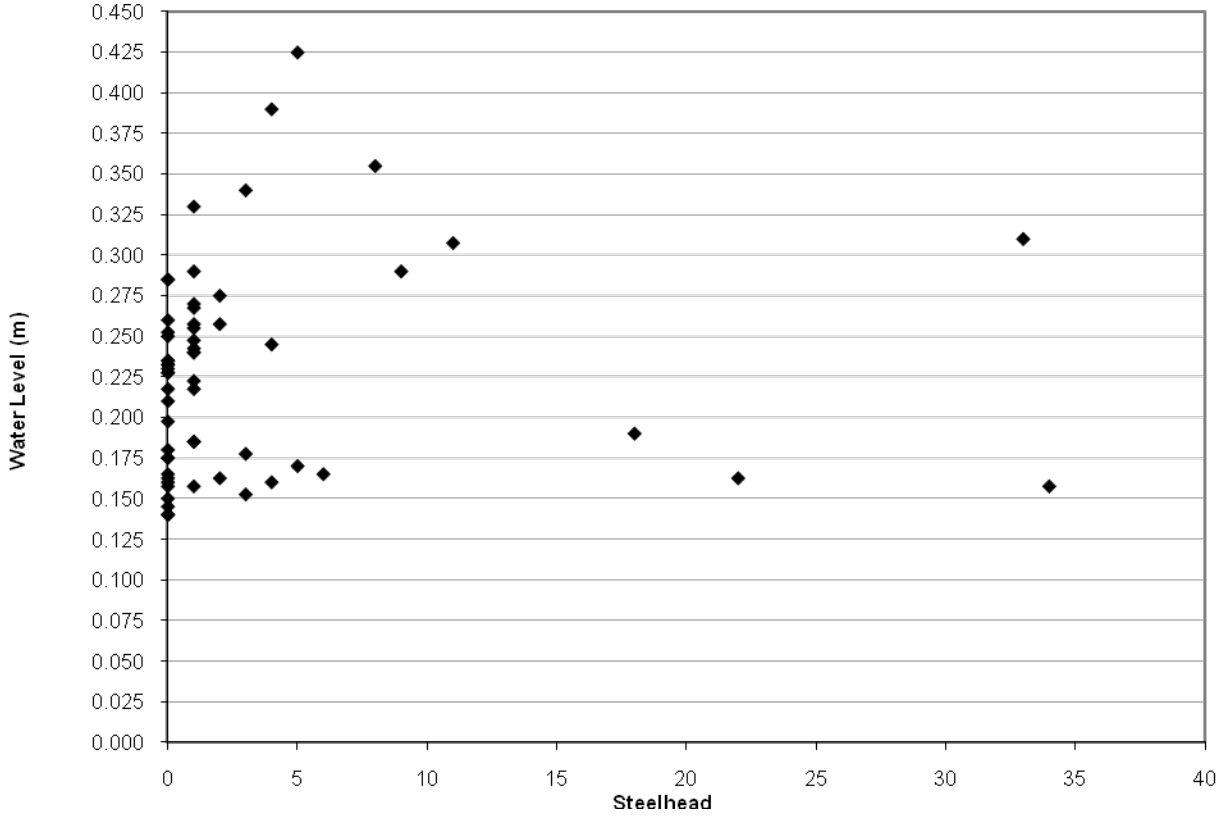


Figure 9. Water level vs. steelhead migration past the upper Sustut River enumeration weir 2008.

Since 1998 the annual mean level from August 1 to September 30 has ranged between 0.34 m (2004) and 0.16 m (2007). The mean water level in this ten year period is 0.26 m (SD=0.06). Figure 10 compares the mean annual water level and fence count. The R^2 value (0.29) indicates that there is not a significant linear relationship between annual water level and steelhead fence count.

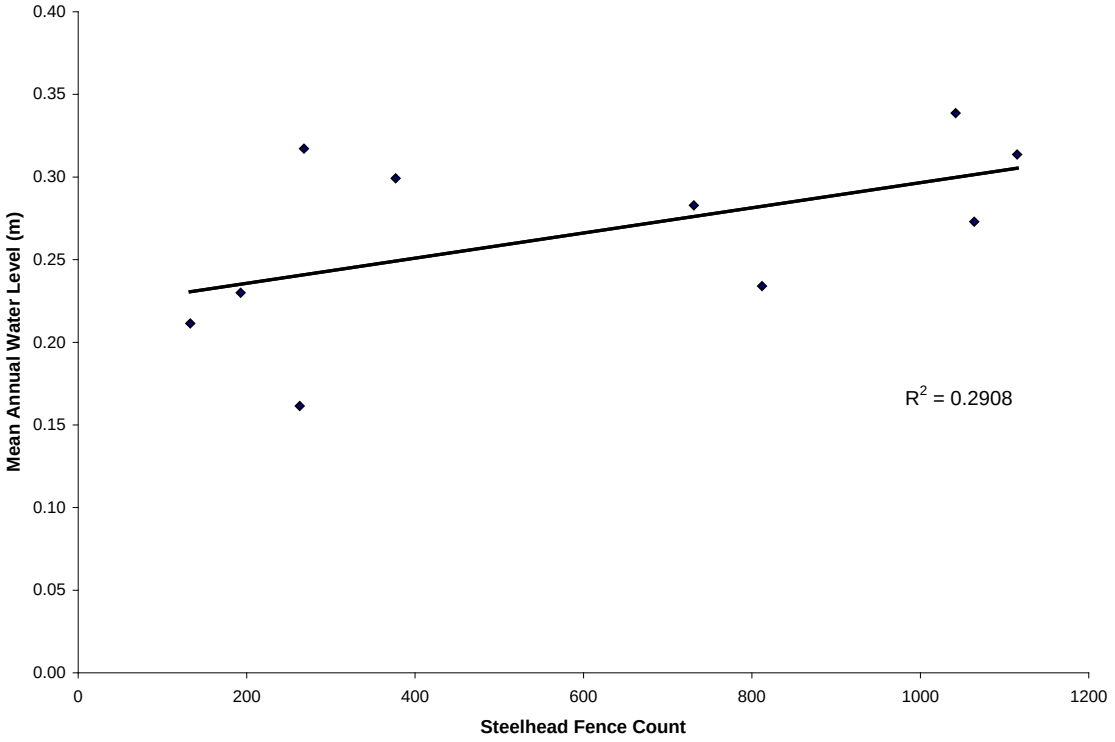


Figure 10. Annual water level vs. steelhead fence count 1998-2008.

4.4 Steelhead Sex Ratio

Of the 193 steelhead counted migrating through the fence, 66 (42%) were male and 127 (58%) were female resulting in a female to male ratio of 1.92:1. Since 2004, the female to male sex ratio has ranged between 1.39:1 (2007) and 2.01:1 (2004). The mean female to male ratio is 1.60:1 and the standard deviation was 0.22 during this time period.

4.5 Steelhead Gillnet Marks

Fence observers recorded the presence of gillnet marks on steelhead that were observed during the project. Gillnet marks were present on 3.1% (n=6) of all steelhead that migrated past the fence. Three of the steelhead observed with net marks were female and three were male.

4.6 Male and Female Steelhead Run Timing

The first female steelhead passed through the fence on August 8, and the first male steelhead migrated upstream on August 9 (Fig 11). The median migration date for males was August 31 and the median date for females was September 7. The plot of daily cumulative percentage of male and female steelhead arriving at the fence revealed a similar migration pattern for both sexes (Fig 11).

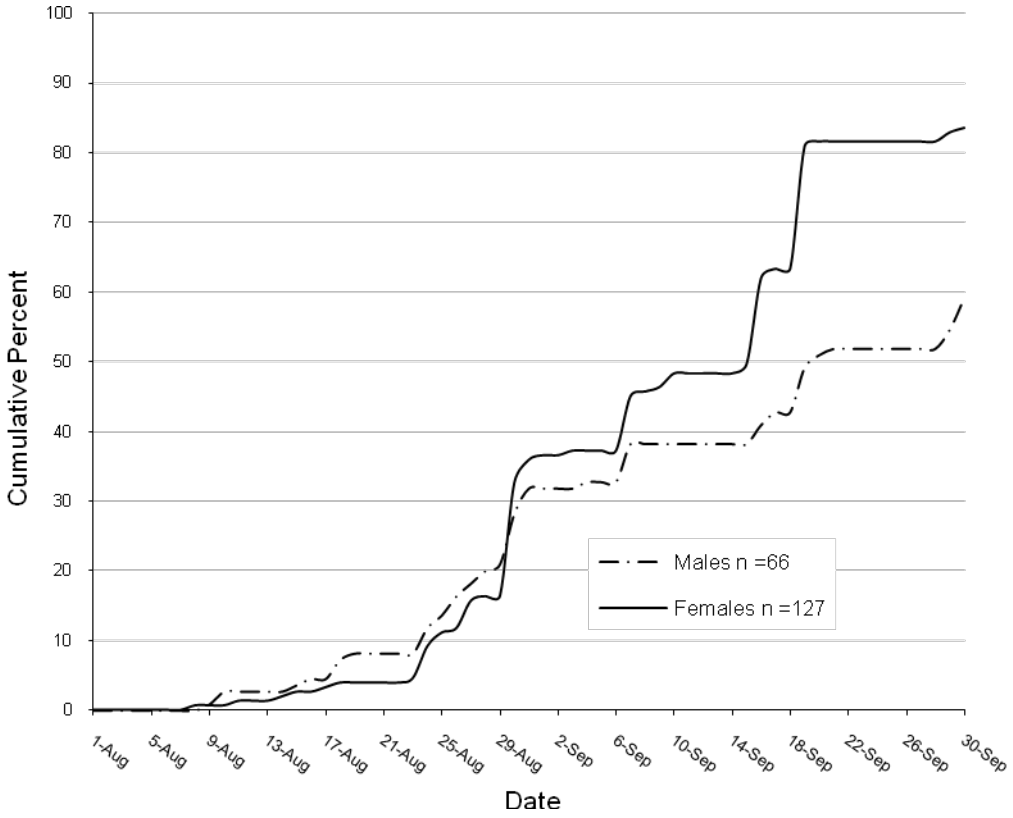


Figure 11. Daily cumulative percent of male and female steelhead migrating past the fence 2008.

5.0 Discussion

Johnston *et al.* 2002 describes a framework that establishes reference points to represent steelhead stock status. The conservation concern threshold (CCT), or precautionary threshold (PT) is identified as spawner abundance levels at 25% of maximum recruitment. Since 2005, annual fence counts combined with visual counts have resulted in aggregate counts at or near the PT. Spawner abundance below this PT is described as a conservation concern and the productivity of the population is impaired. The 2008 upper Sustut River steelhead

fence count to September 30 was 193. Early steelhead data suggested that the index could be very poor. As a result of the low numbers, ageing and length data were not collected to reduce potential handling mortalities. One hundred and ninety three represents the second lowest recorded count since methods were standardized in 1994 (Table 3). Approximately 45 steelhead were observed downstream of the fence prior to its removal. The sum of the 2008 fence count and steelhead observed downstream of the fence prior to removal, results in an abundance estimate of 238. Since 1994, annual standardized fence counts have ranged from a high of 1,115 in 2003 to a low of 133 in 2006 (Table 2).

Table 2. Historical upper Sustut River steelhead data for the years 1994 to 2008[3].

Year	Date of First Steelhead	Date of 50% Migration	Count	Average Length (cm) M	Average Length (cm) F	Repeat Spawner	% Handling Mortalities	% Gillnet Marked M	% Gillnet Marked F	% Gillnet Marked Total
1994	8-Aug	29-Aug	584	824	737					2.0
1995	8-Aug	8-Sep	467	826	746	1.2	4.0			6.0
1996	17-Aug	7-Sep	466	829	739	1.3	2.8			14.0
1997	9-Aug	13-Sep	649	814	733	0.6	1.5	9.2	17.8	15.4
1998	3-Aug	7-Sep	1064	827	749		0.8	13.4	13.8	13.7
1999	17-Aug	17-Sep	731	848	756	2.5	0.3	6.1	9.9	8.5
2000	8-Aug	7-Sep	377	827	741	0.4	0.5	10.6	16.2	14.1
2001	15-Aug	16-Sep	756	864	771	2.5	1.9	10.1	14.5	12.8
2002	9-Aug	2-Sep	812			1.9	0.5	3.6	8.4	6.3
2003	3-Aug	2-Sep	1115	780	730	1.2	0.3	8.3	14.2	11.8
2004	28-Jul	3-Sep	1042	818	745		0.3	6.0	8.8	7.7
2005	31-Jul	3-Sep	269	859	741	19	0	3.3	5.5	4.8
2006	9-Aug	4-Sep	133	N/A*	N/A*	N/A*	0	0.53	1.6	2.25
2007	9-Aug	9-Sep	263	N/A*	N/A*	N/A*	0.004	2.7	4.6	3.8
2008	8-Aug	7-Sep	193	N/A*	N/A*	N/A*	0.01	4.5	2.3	3.1
Minimum			133	780	730	0.4	0.0	0.53	1.6	2.0
Maximum			1115	864	771	19.0	4.0	13.4	17.8	15.4
Average			595	829	744	N/A*				

Two steelhead were found deceased on the upstream side upstream of the fence in 2008.

In 2008, 65% of the steelhead migrating past the fence were female and 34% were male. These results suggested a sex ratio of 1.92:1 females to males. The sex ratio in favour of females is similar to that found in previous years (Parken *et al.* 1997; Williamson 1998, 1999a, 2000; Diewert 2001, 2002, 2003, 2004; Peard 2005, 2006, 2007). The mean ratio during this time period is 1.60: 1 SD=0.22.

[3] Due to the low numbers of steelhead in 2006 and 2007 and 2008 length, ageing and genetic information was not collected.

In 2008, 3.1% of all steelhead migrating past the fence exhibited gillnet marks. This falls in the lowest end of previously recorded values which have ranged from 2.0% to 15.4% (Table 2).

5.1 The Importance of Continued Monitoring.

The upper Sustut River fence is one of two long term indexes used to estimate summer run steelhead abundance in the Skeena River watershed. It is also the only index available to monitor the abundance of upper Skeena River steelhead stocks. The long term data set collected at the site allows fisheries managers to compare annual abundance, run timing, sex ratios and age composition of adult steelhead in the upper Sustut. The ability of fisheries managers to monitor steelhead stock abundance and other important biological parameters would be severely affected if this project were to discontinue. The social, economic and ecological benefits created by the Skeena summer run steelhead stocks make this project both cost efficient and important component of the long term viability of this stock.

6.0 Recommendations

1. Enumeration of the upper Sustut River steelhead population should continue to be carried out annually. The valuable time series of data that results from this project provides fisheries managers with information on abundance trends for all early run Skeena steelhead populations and provides feedback on the impact of fisheries on these stocks.

2. Efforts to visually enumerate steelhead below the fence prior to fence removal should continue. These counts provide the basis for estimating total steelhead spawning escapement to the upper Sustut River allowing for an evaluation of stock status relative to carrying capacity. Surveys should take place bi weekly for the last two weeks of September to ensure that a count of steelhead below the fence is always available. A final count should be carried immediately prior to fence removal. How the count occurs should be standardized to maintain the long term consistency of the data.

3. Over the last three years, the values recorded at the upper Sustut River index have been poor. If 2008 fence counts are representative of the 2009 upper Sustut River steelhead spawning escapements the population may be below the routine management zone described by Johnston et al. 2002. A secondary method to estimate spawning escapement in the spring and compare to run abundance in the fall needs to be developed. In particular for the years when index counts are poor.

7.0 Acknowledgments

Ron, Wanda, Clayton, Leaf, Brome and Hawk Steffey repaired, installed and maintained the fence. Their dedication to the project was above and beyond what is asked of them; both fish and fisheries managers benefited from their hard work and thoughtful approach.

Mark Beere directed this study and provided editorial reviews and valuable comments for the final draft.

BC Conservation Foundation, Kamloops, BC provided general contracting services.

This project was funded by BC Environment's Habitat Conservation Trust Foundation and was developed by personnel of BC Environment. The Habitat Conservation Trust Foundation was created by an act of the legislature to preserve, restore and enhance key areas of habitat for fish and wildlife throughout British Columbia. Hunters, anglers, trappers and guides contribute to HCTF enhancement projects through license surcharges. Tax deductible donations to assist in the work of HCTF are welcome.

8.0 Literature Cited

Cox-Rogers, S. 1994. Description of daily simulation model for the Area 4 (Skeena) commercial gillnet fishery. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2256.

Baxter J.S. 1997. Upper Sustut, Lower Sustut, and Bear River Steelhead: Summary of Current Data and Status Review 1997. Ministry of Environment. Smithers, B.C.

Bustard, D. 1993. Adult steelhead studies in the upper Sustut River 1992. Unpublished manuscript prepared for British Columbia Ministry of Environment, Lands and Parks, Smithers, B.C.

Diewert, R.E. 2001. Enumeration of adult steelhead in the upper Sustut River 2000. British Columbia Ministry of Water, Land and Air Protection. Fisheries Branch. Skeena Fisheries Report SK#128.

Diewert, R.E. 2002. Enumeration of adult steelhead in the upper Sustut River 2001. British Columbia Ministry of Water, Land and Air Protection. Fisheries Branch. Skeena Fisheries Report SK#130.

Diewert, R.E. 2003. Enumeration of adult steelhead in the upper Sustut River 2002. British Columbia Ministry of Water, Land and Air Protection. Fisheries Branch. Skeena Fisheries Report SK#134

Diewert, R.E. 2004. Enumeration of adult steelhead in the upper Sustut River 2003. British Columbia Ministry of Water, Land and Air Protection. Fisheries Branch. Skeena Fisheries Report SK#138

McPhail, J.D. 2007. The freshwater fishes of British Columbia. The University of Alberta Press. Edmonton, Alberta, Canada. Pg 281.

McPhail, J.D. and R. Carveth. 1994. Field key. The freshwater fishes of British Columbia. British Columbia Resource Inventory Committee Publication #44.

Johnston N.T., Parkinson., E.A., Tautz., A.F. and Ward B.R 2002. A Conceptual Framework for the Management of Steelhead, Oncorhynchus mykiss. Ministry of Water, Land and Air Protection. BC Fisheries Branch Report No. RD101.

Parken, C.K., K.L. Morten, and D.Y. Atagi. 1997. Review of the escapement of adult steelhead to the upper Sustut River 1986, 1992-1996. British

Columbia Ministry of Environment, Lands and Parks. Fisheries Branch. Skeena Fisheries Report SK#107.

Peard, D.A. 2006. Enumeration of adult steelhead in the upper Sustut River, 2005. BC Min. of Environment, Fish & Wildlife Section, Skeena Region, Smithers, BC. Skeena Fisheries Report SK#147.

Peard, D.A. 2008. Enumeration of adult steelhead in the upper Sustut River, 2006. BC Min. of Environment, Fish & Wildlife Section, Skeena Region, Smithers, BC. Skeena Fisheries Report SK#150.

Peard, D.A. 2008. Enumeration of adult steelhead in the upper Sustut River, 2007. BC Min. of Environment, Fish & Wildlife Section, Skeena Region, Smithers, BC.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Bulletin No. 184, Ottawa, Ontario.

Spence, C.R., M.C. Beere and M.J. Lough. 1990. Sustut River steelhead investigations 1986. British Columbia Ministry of Environment, Lands and Parks. Smithers, B.C., Skeena Fisheries Report SK#64.

Tautz, A.F., Ward , B.R., and R.A Ptolemy. 1992. Steelhead trout productivity and stream carrying capacity for rivers of the Skeena drainage. PSARC Working Paper S92-6 and 8

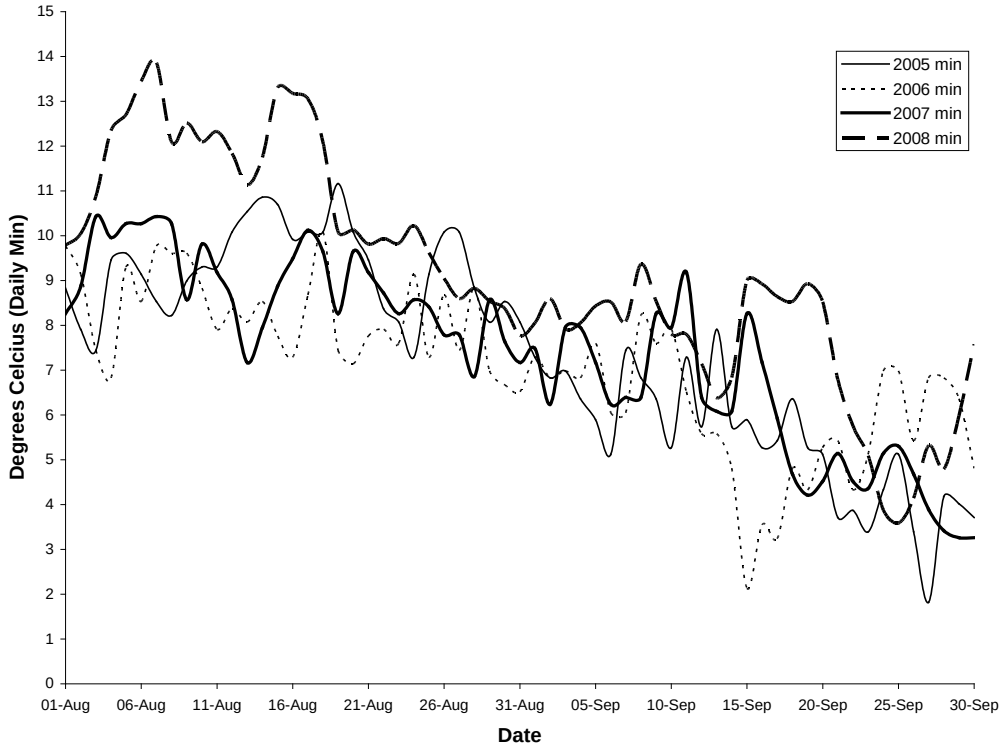
Ward, B.R., A.F. Tautz, S. Cox-Rogers and R.S. Hooton. 1993. Migration timing and harvest rates of the steelhead trout populations of the Skeena River system. PSARC Working Paper S93-06.

Williamson, C.J. 1998. Enumeration of Adult Steelhead in the Upper Sustut River 1997. British Columbia Ministry of Environment, Lands and Parks. Fisheries Branch. Skeena Fisheries Report SK #112.

Williamson, C.J. 1999a. Enumeration of Adult Steelhead in the Upper Sustut River 1998. British Columbia Ministry of Environment, Lands and Parks. Fisheries Branch. Skeena Fisheries Report SK #120.

Williamson, C.J. 2000. Enumeration of Adult Steelhead in the Upper Sustut River 1999. British Columbia Ministry of Environment, Lands and Parks. Fisheries Branch. Skeena Fisheries Report SK #126

Appendix Figures



Appendix Figure 1. Daily minimum water temperatures at the Sustut River fence 2005, 2006, 2007 and 2008.

Appendix Tables

Appendix Table 1. Daily and cumulative totals for non salmon species, 2008.

Date	ST Daily	ST Cumulative	RB Daily	RB Cumulative	BT Daily	BT Cumulative	WF Daily	WF Cumulative
1-Aug	0	0	0	0	0	0	1	1
2-Aug	0	0	0	0	0	0	0	1
3-Aug	0	0	0	0	0	0	0	1
4-Aug	0	0	0	0	0	0	0	1
5-Aug	0	1	0	0	0	0	0	1
6-Aug	0	2	0	0	0	0	2	3
7-Aug	0	4	0	0	0	0	1	4
8-Aug	1	5	0	0	0	0	0	4
9-Aug	1	5	0	0	1	1	2	6
10-Aug	2	5	0	0	0	1	0	6
11-Aug	1	6	0	0	0	1	0	6
12-Aug	0	8	0	0	0	1	0	6
13-Aug	0	9	0	0	0	1	0	6
14-Aug	1	10	0	0	0	1	0	6
15-Aug	2	14	0	0	0	1	2	8
16-Aug	1	15	0	0	0	1	0	8
17-Aug	1	15	0	0	1	2	0	8
18-Aug	4	15	0	0	0	2	0	8
19-Aug	1	15	0	0	0	2	0	8
20-Aug	0	16	0	0	0	2	0	8
21-Aug	0	27	0	0	0	2	8	16
22-Aug	0	32	0	0	0	2	2	18
23-Aug	1	36	0	0	0	2	1	19
24-Aug	11	44	0	0	0	2	3	22
25-Aug	5	47	0	0	1	3	1	23
26-Aug	4	48	0	0	0	3	2	25
27-Aug	8	81	0	0	0	3	1	26
28-Aug	3	90	0	0	0	3	0	26
29-Aug	1	91	0	0	1	4	0	26
30-Aug	33	91	0	0	0	4	0	26
31-Aug	9	92	0	0	1	5	1	27
1-Sep	1	93	0	0	0	5	0	27
2-Sep	0	93	0	0	0	5	0	27
3-Sep	1	93	0	0	0	5	0	27
4-Sep	1	111	0	0	0	5	1	28
5-Sep	0	112	0	0	0	5	3	31
6-Sep	0	113	1	1	0	5	12	43
7-Sep	18	96	0	1	0	5	1	44
8-Sep	1	100	0	1	0	5	0	44
9-Sep	1	159	0	1	0	5	1	45

Date	ST Daily	ST Cumulative	RB Daily	RB Cumulative	BT Daily	BT Cumulative	WF Daily	WF Cumulative
10-Sep	3	116	0	1	5	5	0	45
11-Sep	0	116	0	1	5	5	2	47
12-Sep	0	116	0	1	5	5	0	47
13-Sep	0	116	0	1	5	5	0	47
14-Sep	0	116	0	1	5	5	0	47
15-Sep	2	118	0	1	5	5	0	47
16-Sep	22	140	0	1	5	5	0	47
17-Sep	4	144	0	1	5	5	0	47
18-Sep	0	144	0	1	5	5	0	47
19-Sep	34	178	0	1	5	5	0	47
20-Sep	3	181	1	2	5	5	0	47
21-Sep	1	182	0	2	5	5	0	47
22-Sep	0	182	0	2	5	5	0	47
23-Sep	0	182	0	2	5	5	0	47
24-Sep	0	182	0	2	5	5	0	47
25-Sep	0	182	0	2	5	5	3	50
26-Sep	0	182	0	2	5	5	0	50
27-Sep	0	182	0	2	5	5	0	50
28-Sep	0	182	0	2	5	5	0	50
29-Sep	5	187	0	2	6	6	0	50
30-Sep	6	193	0	2	6	6	0	50

Appendix Table 2. Steelhead sampling data from the Sustut River fence, 2008.

Date	Time	Sex	GN	Comments
08-Aug	9:15	F		
09-Aug	9:15	M		
10-Aug	9:00	M		
		M		
11-Aug	9:00	F		
14-Aug	16:00	F		
15-Aug	8:30	F		
	20:30	M		
16-Aug	20:30	M		
17-Aug	20:30	F		
18-Aug	11:00	M		
	17:30	M		
		F		
	21:00	M		
19-Aug	9:00	M		
23-Aug	15:15	F		
24-Aug	9:00	M		
		M		
		M		
		F		
		F		
		F		
		F		
		F		
	14:30	F		
	15:30	M		
		F		
25-Aug	9:30	F		
		F	yes	
	15:30	M		
		M		
	20:15	M		
26-Aug	9:30	M		
		M		
		M	yes	
		F		
27-Aug	8:30	F		
		F		
		F		
	17:00	M		
		F		
		F		
	19:45	M		
		F		
28-Aug	9:30	M		
		M	yes	

Date	Time	Sex	GN	Comments
		F		
29-Aug	16:00	M		
30-Aug	9:30	M		
		M		
		F		
		F		
		F		
	18:00	M		
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		F		
		F		
		F		
31-Aug	9:00	M		
		M		
		F		
		F		
	15:30	M		
		F		
		F		
		F		
	16:30	M		
01-Sep	8:30	M		
03-Sep	8:30	F		Fungus on nose
04-Sep	15:15	M		
07-Sep	16:45	M		
		M		
		M		

Date	Time	Sex	GN	Comments
		M		
		F		
		F		
		F		
		F		
		F		Torn pectoral fin
	20:00	M		
		M		
		F		
		F		
		F		
		F		
		F		
		F		
		F		
08-Sep	19:45	F		
09-Sep	16:00	F		
10-Sep	9:30	F		
		F		
		F	yes	
15-Sep	17:15	F		
		F		
16-Sep	17:30	F		
		F		
		F		
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		F		
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	20:00	M		
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17-Sep	10:00	M		
		F		
	15:30	F		
	16:00	M		
19-Sep	17:30	F		
	19:30	M		

Date	Time	Sex	GN	Comments
		M		
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20-Sep	9:00	M		
		M		
	17:00	F		
21-Sep	8:45	M		
29-Sep	9:00	M		
	16:00	M		
		F		
	19:15	M		
		F	yes	
30-Sep	9:15	M	yes	
		M		
	16:00	M		
		M		
		M		
		F		

Appendix Table 3. Daily and cumulative total of chinook, sockeye and coho salmon migrating past the Sustut River fence, 2008.

Date	Chinook		Sockeye		Coho	
	Daily	Cum	Daily	Cum	Daily	Cum
01-Aug	38	38	0	0	0	0
02-Aug	5	43	0	0	0	0
03-Aug	22	65	0	0	0	0
04-Aug	53	118	0	0	0	0
05-Aug	149	267	0	0	0	0
06-Aug	95	362	0	0	0	0
07-Aug	104	466	7	0	0	0
08-Aug	66	532	1	0	0	0
09-Aug	76	608	18	3	0	0
10-Aug	40	648	18	8	1	1
11-Aug	38	686	32	30	1	2
12-Aug	34	720	21	57	0	2
13-Aug	6	726	11	162	1	3
14-Aug	22	748	2	288	0	3
15-Aug	18	766	28	480	0	3
16-Aug	8	774	6	702	0	3
17-Aug	9	783	2	1222	0	3
18-Aug	4	787	9	1586	1	4
19-Aug	0	787	0	1779	0	4
20-Aug	0	787	0	1881	0	4
21-Aug	0	787	1	1958	0	4
22-Aug	0	787	0	1995	1	5
23-Aug	2	789	0	2041	0	5
24-Aug	1	790	0	2058	6	11
25-Aug	0	790	38	2095	2	13
26-Aug	1	791	1	2125	0	13
27-Aug	1	792	2	2196	1	14
28-Aug	0	792	0	2250	4	18
29-Aug	0	792	2	2256	0	18
30-Aug	0	792	6	2274	0	18
31-Aug	0	792	1	2280	1	19
01-Sep	0	792	0	2288	0	19
02-Sep	1	793	1	2294	0	19
03-Sep	0	793	1	2306	0	19
04-Sep	0	793	0	2348	0	19
05-Sep	0	793	0	2355	0	19
06-Sep	0	793	0	2369	0	19
07-Sep	0	793	0	2393	0	19
08-Sep	0	793	0	2401	0	19
09-Sep	0	793	0	2419	0	19
10-Sep	0	793	0	2433	0	19
11-Sep	0	793	0	2441	0	19
12-Sep	0	793	0	2449	0	19

continued	**Chinook**		**Sockeye**		**Coho**	
	Daily	Cum	Daily	Cum	Daily	Cum
13-Sep	0	793	0	208	0	19
14-Sep	0	793	0	208	0	19
15-Sep	0	793	1	209	1	20
16-Sep	0	793	0	209	2	22
17-Sep	0	793	0	209	0	22
18-Sep	0	793	0	209	0	22
19-Sep	0	793	0	209	0	22
20-Sep	0	793	0	209	1	23
21-Sep	0	793	0	209	0	23
22-Sep	0	793	0	209	0	23
23-Sep	0	793	0	209	0	23
24-Sep	0	793	0	209	0	23
25-Sep	0	793	0	209	0	23
26-Sep	0	793	0	209	0	23
27-Sep	0	793	2	211	0	23
28-Sep	0	793	0	211	0	23
29-Sep	0	793	1	212	7	30
30-Sep	0	793	0	212	8	38

Appendix Table 4. Daily staff gauge height, air and water temperature and weather conditions for the upper Sustut River, 2008.

Date	Time	Staff	Water	Temp	Air Temp		Weather
		Gauge	Max	Min	Max	Min	
01-Aug	9:00	0.265					partly clear
	21:00	0.255	~	~	15	0	mostly clear
02-Aug	9:00	0.255					clear
	21:00	0.25	~	~	19	-2	partly clear
03-Aug	8:30	0.24					clear
	21:00	0.23	~	~	22	-3	partly clear
04-Aug	9:00	0.23					clear
	21:00	0.225	~	~	21.5	3.5	clear
05-Aug	9:00	0.23					completely clear
	21:00	0.23	~	~	25	-2	completely clear
06-Aug	9:00	0.235					completely clear
	21:15	0.23	~	~	28	-1	completely clear
07-Aug	9:15	0.235					completely clear
	20:30	0.235	~	~	27	2	completely clear
08-Aug	9:15	0.24					clear
	20:45	0.245	~	~	21	-2	partly clear, hard rain/ thunderstorms earlier
09-Aug	9:15	0.255					mostly clear, some rain overnight
	21:00	0.26	~	~	22.5	5	partly clear, thunderstorms earlier
10-Aug	9:00	0.265					overcast, light drizzle
	21:00	0.285	~	~	15	8.5	overcast
11-Aug	9:00	0.295					mostly clear
	21:15	0.285	~	~	18	3	partly clear
12-Aug	8:30	0.275					cloudy, light rain
	20:45	0.295	~	~	13	5	clear patches
13-Aug	9:30	0.295					overcast
	21:00	0.275	~	~	15	5	cloudy, light rain
14-Aug	8:30	0.27					overcast
	20:30	0.265	~	~	17	9	partly clear
15-Aug	8:30	0.26					partly clear
	20:30	0.255	~	~	23	6	mostly clear
16-Aug	9:00	0.255					completely clear
	20:30	0.255	~	~	22	3	clear
17-Aug	9:00	0.25					clear
	20:30	0.245	~	~	24	1	clear
18-Aug	9:30	0.245					mostly cloudy
	21:00	0.245	~	~	17.5	4	mostly clear, some rain earlier
19-Aug	9:00	0.24					overcast, light rain
	20:30	0.24	~	~	11.5	-1.5	overcast
20-Aug	9:15	0.235					cloudy, light rain
	21:00	0.23	~	~	11	7	overcast
21-Aug	9:00	0.23					mostly clear
	21:00	0.225	~	~	17	-0.5	cloudy
22-Aug	9:30	0.22					overcast, light rain overnight
	20:30	0.215	~	~	12	7	overcast

Date	Time	Staff	Water	Temp	Air Temp		Weather
		Gauge	Max	Min	Max	Min	
23-Aug	9:00	0.21					drizzling rain
	19:30	0.225	~	~	11.5	7	light rain
24-Aug	9:00	0.26					drizzling rain
	20:00	0.355	~	~	12	8	cloudy, light rain
25-Aug	9:30	0.435					partly clear
	20:15	0.415	~	~	11	3	partly clear
26-Aug	9:30	0.395					overcast, light rain
	19:30	0.385	~	~	10	7	partly clear, light rain
27-Aug	8:30	0.365					partly clear
	19:45	0.345	~	~	9	2	overcast, lt. rain
28-Aug	9:30	0.34					mostly cloudy
	20:30	0.34	~	~	10	4	partly clear
29-Aug	8:45	0.335					foggy, clear above
	20:15	0.325	~	~	13	-1	partly clear
30-Aug	9:30	0.315					mostly cloudy
	19:00	0.305	~	~	12	1	partly clear most of day, overcast again and lt. rain by evening
31-Aug	9:00	0.295					mostly clear
	20:00	0.285	~	~	10	-2	partly clear
01-Sep	8:30	0.275					foggy, clear above
	19:30	0.265	~	~	13	-2	overcast
02-Sep	8:30	0.255					overcast
	20:30	0.245	~	~	13	3	mostly clear
03-Sep	8:30	0.245					foggy
	20:30	0.235	~	~	12	-3	mostly clear
04-Sep	9:00	0.225					mostly cloudy
	20:30	0.22	~	~	10	0	overcast
05-Sep	9:00	0.215					clear
	19:30	0.205	~	~	14.5	0.5	mostly clear
06-Sep	9:15	0.2					clear
	20:00	0.195	~	~	16	-2	clear
07-Sep	9:30	0.195					clear
	20:00	0.185	~	~	17	-5	overcast
08-Sep	9:30	0.185					partly clear
	19:45	0.185	~	~	15	5	partly clear, lt. rain on and off all day
09-Sep	9:30	0.185					mostly clear
	20:15	0.185	~	~	8	-1	high overcast
10-Sep	9:30	0.18					overcast, lt. rain
	19:30	0.175	~	~	9	2	overcast
11-Sep	8:30	0.18					partly clear
	20:15	0.18	~	~	10.5	4.5	partly clear, lt. rain earlier
12-Sep	10:00	0.175					mostly clear
	20:30	0.175	~	~	12	0	clear
13-Sep	9:45	0.175					mostly clear
	19:15	0.175	~	~	12	-5	mostly clear
14-Sep	9:15	0.165					partly clear
	19:30	0.165	~	~	16	-2	cloudy
15-Sep	9:30	0.165					partly clear
	19:30	0.16	~	~	18	9	high cloud cover

Date	Time	Staff	Water	Temp	Air Temp		Weather
		Gauge	Max	Min	Max	Min	
16-Sep	9:30	0.16					partly clear
	20:00	0.165	~	~	18	0.5	partly clear
17-Sep	10:00	0.16					mostly clear
	19:00	0.16	~	~	18	-2	partly clear
18-Sep	8:30	0.16					mostly clear
	20:00	0.16	~	~	15	3	partly clear
19-Sep	7:30	0.16					clear
	19:30	0.155	~	~	18	2	mostly clear
20-Sep	9:00	0.155					partly clear
	19:30	0.15	~	~	17	3	clear
21-Sep	8:45	0.155					overcast, light rain
	19:00	0.16	~	~	8	-1	partly clear
22-Sep	8:30	0.165					clear
	19:30	0.16	~	~	8	-5	clear
23-Sep	9:15	0.16					foggy
	19:15	0.155	~	~	8	-5	clear
24-Sep	9:00	0.15					high clouds
	18:45	0.15	~	~	8	-9	clear
25-Sep	9:00	0.145					clear
	19:00	0.145	~	~	10	-10	clear
26-Sep	9:00	0.14					cloudy
	19:00	0.14	~	~	8	-4	overcast, light rain
27-Sep	9:00	0.14					clear patches
	19:30	0.14	~	~	7	0	partly clear
28-Sep	8:30	0.135					overcast
	19:30	0.145	~	~	4	0	overcast, rain
29-Sep	9:00	0.165					overcast, light rain
	19:30	0.175	~	~	12	2	mostly clear
30-Sep	9:15	0.175					clear
	19:30	0.155	~	~	17	-1	clear