Enumeration of Adult Steelhead in the Upper Sustut River, 2014

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Executive Summary

From August 1 to September 30, 2014, a fish fence was in operation on the upper Sustut River. This fence is used to count migrating summer-run Steelhead (*Oncorhynchus mykiss*) and provides annual monitoring information for this species. Eight hundred and ninety five Steelhead were counted crossing the fence in 2014. This is the ninth highest recorded escapement over the past twenty-one years, 23% higher than the historical average annual count for this project.

The first Steelhead migrated through the fence on August 3 and by September 20, 50% of the Steelhead had passed the fence. The last recorded fish travelled past the fence on September 30. The cumulative proportional distribution of Steelhead over time indicates that the majority (77%, *n*=689) of Steelhead counted crossed the fence in two days, on September 4 (n=295) and September 29 (*n*=394). Steelhead were counted on 38 days of this 61 day project.

Of the 895 Steelhead that migrated past the fence, 562 (63%) were female and 333 (37%) were male resulting in a female to male ratio of 1.69:1. Since 1998, the female to male sex ratio has ranged between 1.23:1 (1995) and 2.01:1 (2005) and averaged 1.60:1.

A total of 44 male and 94 female Steelhead were measured for nose-fork length. Male lengths ranged from 610 to 920 mm and female lengths ranged from 640 to 870 mm. Statistical analysis indicates that the mean length for female Steelhead ($\bar{x}$=724, SD=69, *n*=94) was significantly smaller than the mean length of male fish ($\bar{x}$=773, SD=39, *n*=44).

Gillnet marks were present on 5% (*n*=48) of Steelhead that migrated past the fence. Fish with gillnet marks arrived at the fence between September 4 and September 30, with two distinct peaks on September 4 (*n*=20) and 29 (*n*=15). During these two days, 73% of Steelhead observed with gillnet marks arrived at the fence. Twenty-seven of the Steelhead observed with net marks were female and 21 were male.

Water temperature at the fence ranged from 2.4°C (September 10) to 16.9°C (August 3) and averaged 9.3°C. Water levels ranged from 0.065 m on September 18 to 0.17 m on August 14 and averaged 0.11 m. Inter-annual comparison of mean water temperature at the Sustut fence indicates that it has been increasing over the past eight years. This may be related to decreasing water levels over the same time period. Given that stream temperature and level can negatively impact Steelhead populations, continued monitoring of these variables is warranted.

Recommendations of this report include suggestions to enhance management and conservation of the upper Sustut Steelhead population and a number of potential improvements to the design of this study.

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1.0 Introduction

Since 1994, the upper Sustut River Steelhead (*Oncorhynchus mykiss*) stock has been measured in a standardized manner at a counting fence during the months of August and September. This information provides insight into annual adult escapement for the stock and is believed to demonstrate trends in the abundance of all early summer-run Steelhead in the Skeena watershed. Perpetual concerns exist regarding the conservation of early summer-run Steelhead stocks in the Skeena watershed as their run timing coincides with marine mixed stock commercial fisheries for sockeye (*O. nerka*) and pink (*O. gorbuscha*) salmon where they are incidentally captured (Ward *et al.*, 1993; Cox-Rogers, 1994). Due to the long distance of their freshwater migration, Sustut River Steelhead are also exposed to First Nations and recreational fisheries where they are also intercepted and potentially harvested.

Upper Sustut River Steelhead are a unique population within the Skeena River watershed. Over-wintering, spawning and rearing occur at high elevations in Sustut Lake (1306 m) and Johanson Lake (1448 m). The short growth 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).

The Sustut River is designated as a Class 1 Classified Water from September 1 to October 31. Angling is prohibited from January 1 to June 15 and in a zone above the BC Railway bridge near the Bear-Sustut river confluence (all year) to protect overwintering and emigrating Steelhead. There is no access to the section of river below the railway bridge via road; anglers most commonly reach this area by helicopter or jet boat from fishing lodges on the lower Sustut River.

The objectives of the upper Sustut River enumeration project are to:

1. enumerate the upper Sustut River summer-run Steelhead population
2. examine the sex ratio of Steelhead throughout the run
3. investigate the number and distribution of gillnet marked Steelhead throughout the run
4. examine the effect of water level and temperature on Steelhead migration
5. examine the relative run timing of male and female Steelhead

Although the objectives of the project relate to Steelhead, other species are enumerated during fence operation. Data for Chinook (*O. tshawytscha*), Sockeye, Coho (*O. kisutch*), Bull trout (*Salvelinus confluentus*), Rocky Mountain Whitefish (*Prosopium williamsoni*) and Rainbow Trout are also recorded during operation of the Sustut fence. Salmon data is forwarded to Fisheries and Oceans Canada for analysis and archiving (Appendix Table 1).

2.0 Study Area

The Sustut River is a tributary of the upper Skeena River, located in north central British Columbia (Figure 1). It originates in the Omineca Mountains approximately 200 km north of Smithers, B.C. and flows for approximately 108 km from the outlet of Sustut Lake to the Skeena River. The mainstem section of river from Sustut Lake downstream to, and including, Johanson Creek form the primary spawning areas for Steelhead in the upper Sustut River (Bustard, 1993). This river drains approximately 3,574 km^2 and has seven main tributaries including 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 Steelhead, Chinook, Sockeye, Coho, Bull trout, Dolly Varden (*S. malma*), Rocky Mountain whitefish and Burbot (*Lota lota*)(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).

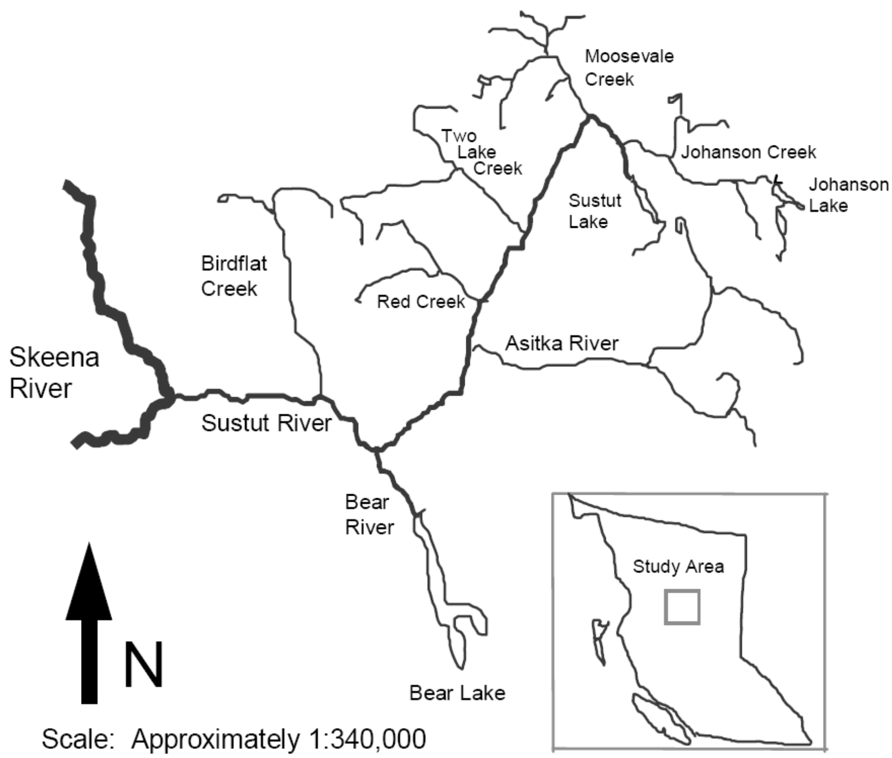

Figure 1. Sustut River and surrounding tributaries (from Saimoto, 1995).

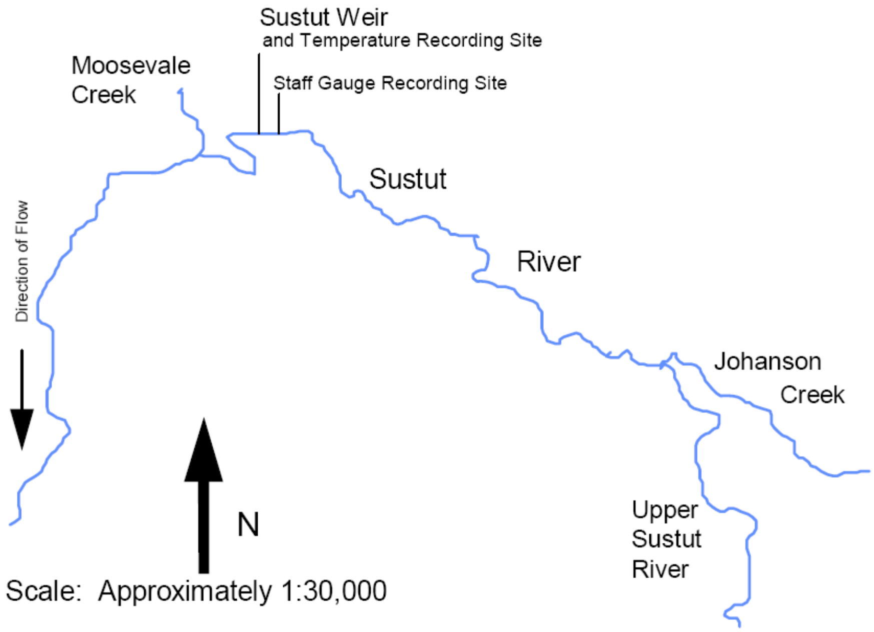

Figure 2. Weir location on the Sustut River (from Diewert, 2005).

3.0 Methods

3.1 Steelhead Enumeration

A floating fish fence constructed from 3.8 cm PVC pipe was installed in the Sustut River 500 m upstream of the Moosevale Creek confluence (Figure 2). This is approximately 97 km upstream from the confluence between the Skeena and Sustut rivers. The fence was in operation between August 1 and September 30, 2014. Upon arriving at the fence, fish were directed into an aluminum trap box where they remained until a gate was opened allowing upstream migration to continue (Figures 3 and 4).

The total count of Steelhead migrating past the fence between August 1 and September 30 has historically reflected the majority of the upper Sustut River Steelhead population that spawns upstream of the fence. The count recorded during this time period is used for comparison amongst years. This information is believed to demonstrate trends in Steelhead abundance for other upper Skeena tributaries. A count of Steelhead holding below the fence upon removal is also recorded. This information is not added to total counts as it cannot be consistently recorded. In some years, water clarify is limited and accurate visual counts are not possible.

During operation, the fence was inspected a minimum of three times a day. Debris was removed and repairs were made as necessary. The fence trap box was 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 (Ron Steffey personal communication). Therefore, the removal of debris and carcasses from the fence was limited to avoid affecting fish migration.

Figure 3. Upper Sustut Steelhead enumeration fence, looking downstream. Photo courtesy of Brome and Leaf Steffey.

Figure 4. Steelhead enumeration fence and downstream holding pool, looking upstream. Photo courtesy of Brome and Leaf Steffey.

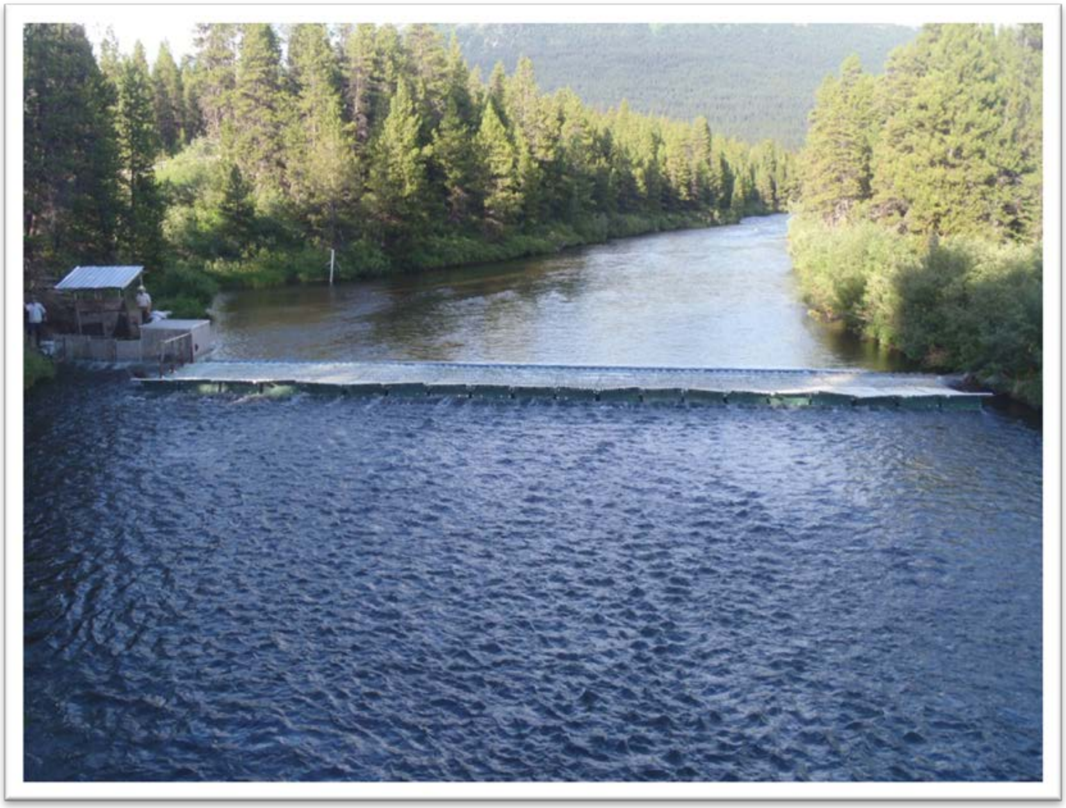

Figure 5. Steelhead enumeration fence, looking upstream. Photo courtesy of Ron Steffey.

3.2 Management Framework

The upper Sustut Steelhead stock is managed according to *A Conceptual Framework for the Management of Steelhead, Oncorhynchus mykiss* (Johnston *et al.* 2002). This framework identifies stock specific biological reference points for Steelhead conservation. These include a minimum target reference point (TRP) and a limit reference point (LRP) to describe desired and highly undesired states for fish abundance (Figure 6).

For the purposes of this study, TRP was defined as 0.25*B (the asymptotic maximum recruitment) as this value approximates the spawner abundance that produces the maximum long-term yield. If a stock falls below the TRP it is considered overfished. LRP was defined as 0.15*B, the spawner abundance from which the population will recover to the TRP in one generation in the absence of harvest.

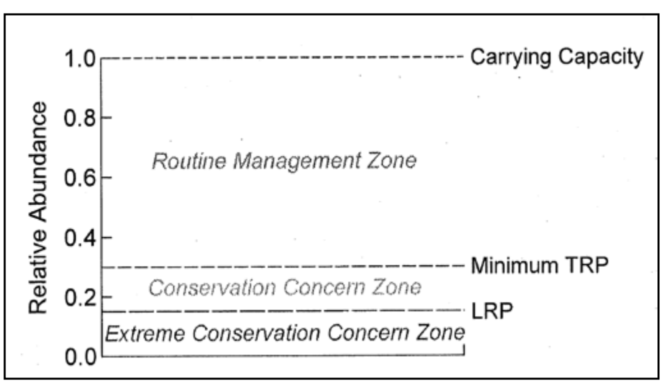

Figure 6. Management framework for the upper Sustut Steelhead population. The locations of the minimum TRP and LRP are for illustrative purposes only.

Below, between and above these thresholds are three management zones described as the Routine Management Zone, Conservation Concern Zone and the Extreme Conservation Concern Zone (Figure 6). These zones and their corresponding management actions are discussed in detail in Johnston *et al.* (2002).

Abundance estimates and Steelhead carrying capacity were determined using a habitat based productivity model developed by Tautz *et al.* (2002). This model indicates an adult production potential of 1036 Steelhead for the upper Sustut River. Annual Steelhead counts were compared to this value, enabling abundance to be assessed relative to management thresholds.

While alternate adult production estimates exist for the upper Sustut River Steelhead population (884; Lessard, 2005), the value of 1036 was selected for this report. This value yields a more conservative Target Reference Point (TRP) which enhances the ability to protect the unique attributes of the upper Sustut Steelhead stock including early run timing, distance and elevation gained during migration ("mile high" Steelhead) and the unique genetic heritage associated with these traits.

3.3 Steelhead Biological Information

Experienced personnel using the visual characteristics described in Scott & Crossman (1973) and McPhail & Carveth (1994) identified all fish passing the Sustut fence by species. This information was recorded and summarized daily. A plexiglass viewing box was used to identify fish by species and sex and to observe scars, wounds and general condition. In an attempt to reduce fish handling, approximately 20% of all male and female Steelhead passing through the fence were sub-sampled. This was conducted near the apparent end of a "run" to avoid deterring migration past the fence.

Steelhead lengths were collected by netting fish from the trap box (Figure 3) and measuring their nose-fork length (mm). For age determination, five scales were collected from sampled fish mid-laterally between the dorsal and anal fins. Mortalities recovered from the fence were also measured for nose-fork length and had scale samples collected.

For statistical analysis purposes, an independent t-test assuming unequal variances was used to determine whether a difference in nose-fork length existed between males and females sampled during the study.

3.4 Steelhead Tagging

Steelhead intercepted in Alaskan commercial fisheries, Canadian commercial fisheries, First Nation fisheries and the Tyee Test Fishery may be tagged or marked prior to release. Adult Steelhead enumerated at the Upper Sustut River fence were checked for the presence of these tags and marks. This information allows fisheries managers to assess migration rates, interception in domestic and international fisheries and survival following capture in these fisheries.

3.5 Steelhead Gillnet Marks

The presence of gillnet marks was noted for all Steelhead that migrated past the fence to the extent possible. The plexiglass viewing box allowed this information to be collected and avoided the need to handle fish. In some cases, not all fish with net marks may have been recorded due to turbid water conditions or limited observation time during high rates of migration.

3.6 Water Temperature and Level Measurement

Onset Hobo® temperature loggers were placed in the river and in the air near the fence site to record hourly water and air temperatures. The water temperature loggers were placed at the upstream and downstream sides of the trap box respectively (about 2.5 meters apart) and have been secured in consistent locations since the current fence technicians (the Steffey family) began operating the fence. Hourly data from the two water temperature loggers is typically averaged, however, this was not possible in 2014 and data from only one device was used. For backup purposes, stream water and air temperatures were recorded each day using a minimum-maximum thermometer.

Water level measurements were recorded from a metric staff gauge located immediately upstream of the fence. Levels were recorded by fence staff twice a day, typically in the morning (~0900 hrs) and evening (~2000 hrs). Fence staff also recorded air temperature and weather conditions daily. For comparison purposes, the two daily water level measurements were averaged to determine the mean daily water level. Mean daily water temperature and level were compared against daily Steelhead migration to measure potential links between these variables.

3.7 Male and Female Steelhead Run Timing

Run timing of male and female Steelhead was examined by plotting the cumulative percent of male and female Steelhead 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 Enumeration

Between August 1 and September 30, 895 Steelhead migrated past the upper Sustut River fence. This value is above the long term average (*n*=727; Table 1) and represents the ninth highest recorded Steelhead count since 1994 (Figure 7). After the fence was dismantled, the field crew observed approximately 100 Steelhead and Coho in the pool located downstream of the fence.

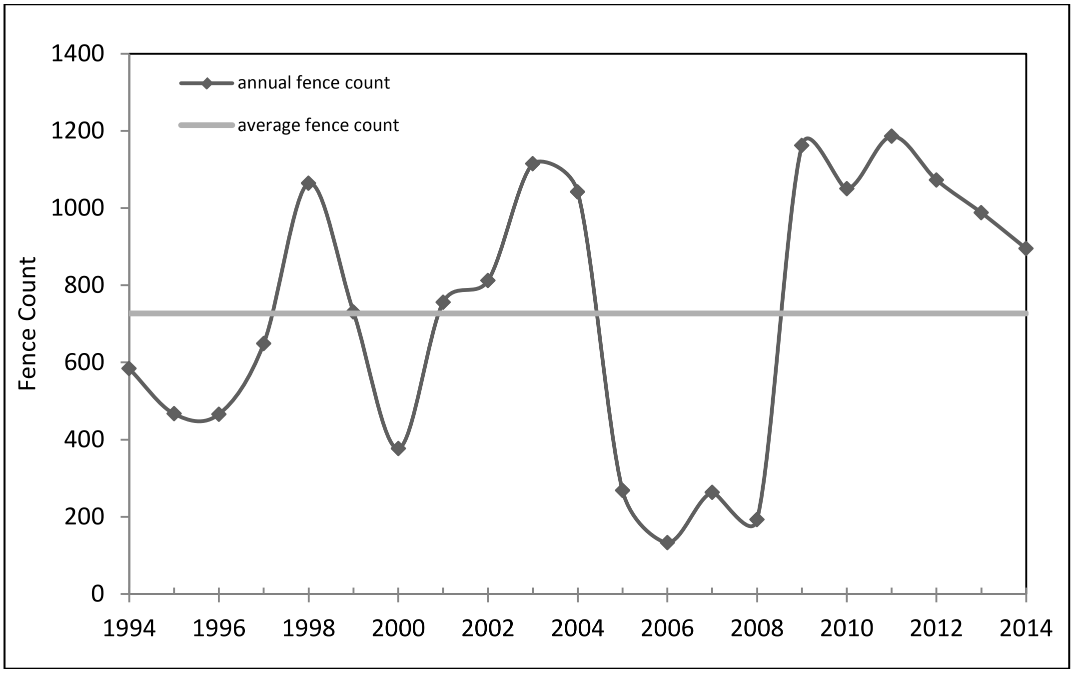

Figure 7. Annual fence count of Steelhead at the upper Sustut River weir

The first Steelhead migrated past the fence on August 3 and by September 20, 50% of the Steelhead enumerated had passed the fence (Figure 8). Since 1994, the date on which the first Steelhead arrived has ranged between July 28 and August 17. Information collected prior to 1994 was not included due to the variation in fence design and location.

Table 1. Arrival timing, total fence count and mean water temperature and level

Year	Arrival Date of First Steelhead	Date of 50% Migration	Fence Count (Aug-Sept)	Rank	Mean water temperature (°C)	Mean water level (m)
1994	08-Aug	29-Aug	584	14	-	-
1995	08-Aug	08-Sep	467	15	-	-
1996	17-Aug	07-Sep	466	16	-	-
1997	09-Aug	13-Sep	649	13	-	-
1998	03-Aug	07-Sep	1064	5	-	0.27
1999	17-Aug	17-Sep	731	12	-	0.28
2000	08-Aug	07-Sep	377	17	-	0.3
2001	15-Aug	16-Sep	756	11	-	-
2002	09-Aug	02-Sep	812	10	-	0.23
2003	03-Aug	02-Sep	1115	3	-	0.31
2004	28-Jul	03-Sep	1042	7	-	0.34
2005	31-Jul	03-Sep	268	18	8.81	0.32
2006	09-Aug	04-Sep	133	21	8.71	0.21
2007	09-Aug	09-Sep	263	19	8.81	0.16
2008	08-Aug	07-Sep	193	20	9.11	0.23
2009	06-Aug	03-Sep	1162	2	9.61	0.2
2010	03-Aug	06-Sep	1050	6	8.91	0.12
2011	13-Aug	08-Sep	1186	1	8.65	0.27
2012	11-Aug	05-Sep	1073	4	9.29	0.15
2013	03-Aug	06-Sep	988	8	10.1	0.096
2014	03-Aug	20-Sep	895	9	9.31	0.11
Minimum	28-Jul	29-Aug	133	-	8.65	0.10
Maximum	17-Aug	17-Sep	1186	-	10.10	0.34
Average	-	-	727	-	9.13	0.22

Notes:
1 - total fence count does not include fish counted in the downstream pool following weir removal
2 – staff gauge used to measure water level was replaced in 2007 or 2008.

The cumulative proportional distribution of Steelhead over time indicates that the majority (77%, n=689) of Steelhead counted crossed the fence in two days, on September 4 (n=295) and September 29 (n=394). Steelhead were counted on 38 days of this 61 day project.

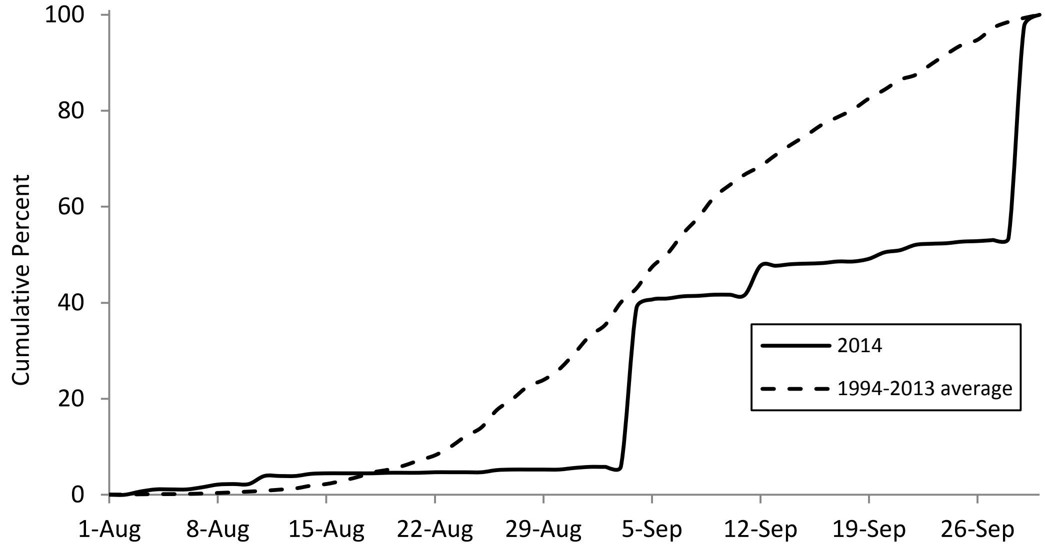

Figure 8. Daily cumulative percentage of upper Sustut River Steelhead migrating past the fence.

4.2 Management Framework

Steelhead counts at the Sustut fence have been at or above the Routine Management Zone for the last six years. This is a significant increase compared to the preceding four years when the upper Sustut spawning population was within the Conservation Concern Zone and Extreme Conservation Concern Zone (Figure 9). The 895 Steelhead that crossed the fence represents 86% of the estimated adult production potential for the upper Sustut River (*n*=1036).

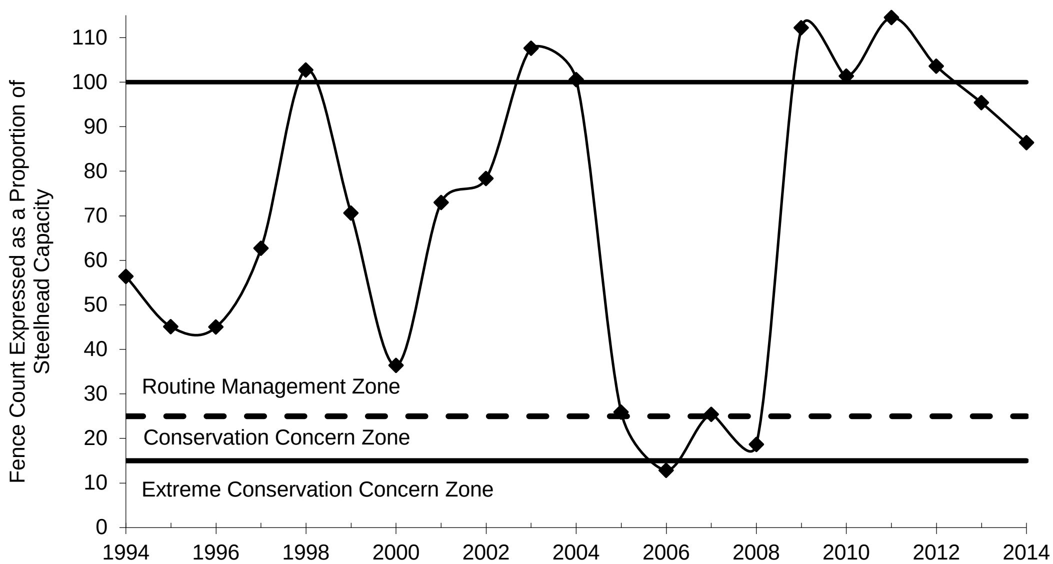

Figure 9. Annual Steelhead fence count expressed as a proportion of adult Steelhead capacity. LRP and TRP thresholds are based on Johnston *et al.* (2002) and carrying capacity is based on Tautz *et al.* (1992).

4.3 Steelhead Biological Information

4.3.1 Scale analysis and age determination

In 2014, scales were removed from 138 Steelhead that crossed the upper Sustut River fence. Relative to the total number of fish counted, this represents a sampling rate of 15.4%. These scales were analyzed to determine length of freshwater and ocean residency and incidence of spawning events. Ninety four percent of the scales (n=125) were classified as being in partially or fully readable condition (Appendix Table 2). The remaining scale samples (n=13) were not included in the analysis below as they were in poor condition or were questionable in age (Condition Code 2).

The number of freshwater annuli identified on all readable scale samples ranged from three to six. The predominant freshwater age was four and represented 83% (n=86) of the scales sampled with this information (n=103). Freshwater age three five, and six represented 7%, 9% and <1% of the sample respectively. The number of marine annuli (prior to the first spawning event) ranged from one to three. The predominant marine age was two (n=104) and represented 83% of scales sampled with this information (n=125). This is consistent with the modal ocean age of Steelhead returning to rivers throughout the province (McPhail, 2007). Maiden Steelhead (those that have not previously spawned) represented 94% (n=117) of the sample and 6% (n=8) of the scales showed evidence at least of one previous spawning event. Including all life history phases (i.e. freshwater and marine components), Steelhead sampled for this project were found to be in their 6^{th} year of life to their 11^{th} year of life. Approximately three quarters of fish (73%) with scales removed were maidens in their 7^{th} year of life.

Fish age was determined by adding freshwater and marine residency periods and spawning checks. For example, a Steelhead reported as 3.2S1 was deemed to have lived for approximately three years in freshwater, followed by two years in the ocean, it returned to spawn once, then returned to the ocean and was sampled during its second spawning migration. This adds to seven years plus the current year, and is reported as an individual in its 8^{th} year of life.

Age information from all fish sampled in 2014 is presented in Appendix Table 3.

4.3.2 Length measurement and size distribution

A total of 44 male and 94 female Steelhead were measured for nose-fork length. Male lengths ranged from 610 to 920 mm and female lengths ranged from 640 to 870 mm. The percent of the total number of Steelhead measured at the fence was plotted in 20 mm increments of nose-fork length for each sex (Figure 10).

To compare the lengths of male and female Steelhead, a two sample t-test for unequal variances was used. This statistical analysis found that the mean length for female Steelhead ($\bar{x}$=724, SD=69, n=94) was significantly smaller than the mean length of male fish ($\bar{x}$=773, SD=39, n=44), meaning that male fish measured in 2014 were on average larger than female fish; $t(56) = 4.38$, $p<0.05$.

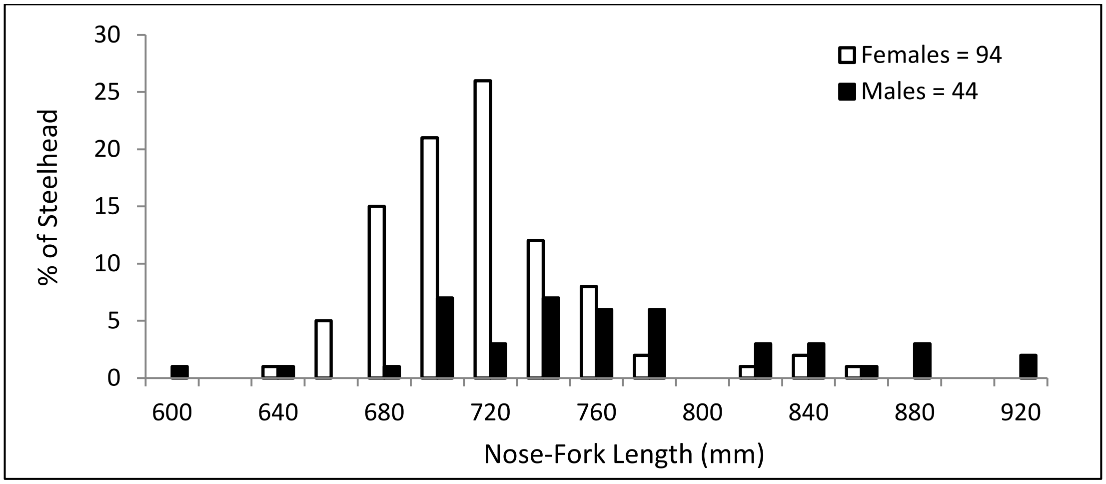

Figure 10. Percentage of male and female Steelhead by 20 mm categories of nose-fork length.

4.3.3 Sex ratio

Of the 895 Steelhead that migrated past the fence, 562 (63%) were female and 333 (37%) were male resulting in a female to male ratio of 1.69:1. Since 1998, the female to male sex ratio has ranged between 1.23:1 (1995) and 2.01:1 (2005) and averaged 1.60:1 (Table 2).

4.3.4 Mortalities

The mortality rate for Steelhead migrating past the fence in 2014 was 0.002%, which is below mean mortality rate of 0.7% (Table 2). While these fish were retrieved from the fence, their cause of death is unknown. One of the fish had visual signs of fungus on its body.

4.4 Steelhead Tagging

There were no Steelhead observed with tags at the fence in 2014.

4.5 Steelhead Gillnet Marks

Fence observers recorded the presence of gillnet marks on Steelhead to the extent possible. Gillnet marks were present on 5% (n=48) of all Steelhead that passed through the fence in 2014. Fish with gillnet marks arrived at the fence between September 4 and September 30, with two distinct peaks on September 4 (n=20) and 29 (n=15). During these two days, 73% of Steelhead observed with gillnet marks arrived at the fence.

Twenty-seven of the Steelhead observed with net marks were female and 21 were male. Given the small sample size and lack of complete length data of gillnet marked fish, additional comparisons between unmarked and marked fish were not conducted.

Table 2. Upper Sustut River Steelhead enumeration data.

Year	Average Length (mm)		Repeat Spawners (% of Total)	Mortalities (% of Total)	Gillnet Marked (% of Total)			Sex Ratio (F:M)
	M	F			M	F	Total	
1994	824	737	-	-	-	-	2.0	1.55:1
1995	826	746	1.2	4.000	-	-	6.0	1.23:1
1996	829	739	1.3	2.800	-	-	14.0	1.58:1
1997	814	733	0.6	1.500	9.2	17.8	15.4	1.43:1
1998	827	749		0.800	13.4	13.8	13.7	1.73:1
1999	848	756	2.5	0.300	6.1	9.9	8.5	1.64:1
2000	827	741	0.4	0.500	10.6	16.2	14.1	1.64:1
2001	864	771	2.5	1.900	10.1	14.5	12.8	1.63:1
2002			1.9	0.500	3.6	8.4	6.3	1.27:1
2003	780	730	1.2	0.300	8.3	14.2	11.8	1.39:1
2004	818	745	-	0.300	6.0	8.8	7.7	1.48:1
2005	859	741	19.0	0	3.3	5.5	4.8	2.01:1
2006	-	-	-	0	0.5	1.6	2.3	1.50:1
2007	-	-	-	0.004	2.7	4.6	3.8	1.39:1
2008	-	-	-	0.010	4.5	2.4	3.1	1.92:1
2009	-	-	-	0.300	0.7	1.5	1.2	1.66:1
2010	793	746	1.0	0	0.9	2.6	1.9	1.48:1
2011	824	756	10.3	0.300	3.7	8.0	6.4	1.73:1
2012	801	728	5.3	0.700	2.7	2.4	2.5	1.65:1
2013	816	752	9.2	0.600	0.5	0.5	1	1.96:1
2014	773	724	6.4	0.002	6.3	4.8	5.4	1.69:1
Minimum	773	724	0.4	0	0.5	0.5	1.0	1.23
Maximum	864	771	19.0	4.0	13.4	17.8	15.4	2.01
Mean	820	743	4.5	0.7	5.2	7.6	6.9	1.60

Note – Steelhead length, age and genetic information was not collected from 2006 to 2009 to eliminate handling stress while Steelhead abundance was in the Conservation Concern Zone.

4.6 Water Temperature

Water temperature was recorded hourly by a data logger from August 1 to September 30. Data from August 1 was removed from analysis as the range for this day (0.4°C - 16.3°C) was considered unacceptably high when compared to temperature ranges measured during the remainder of the project. The lowest temperature was recorded on September 10 at 2.4°C and the highest temperature was recorded on August 3 at 16.9°C (Figure 11). Since 2005, the average water temperature at the Sustut fence has ranged between 8.7°C and 10.1°C, averaging 9.1°C (Table 1).

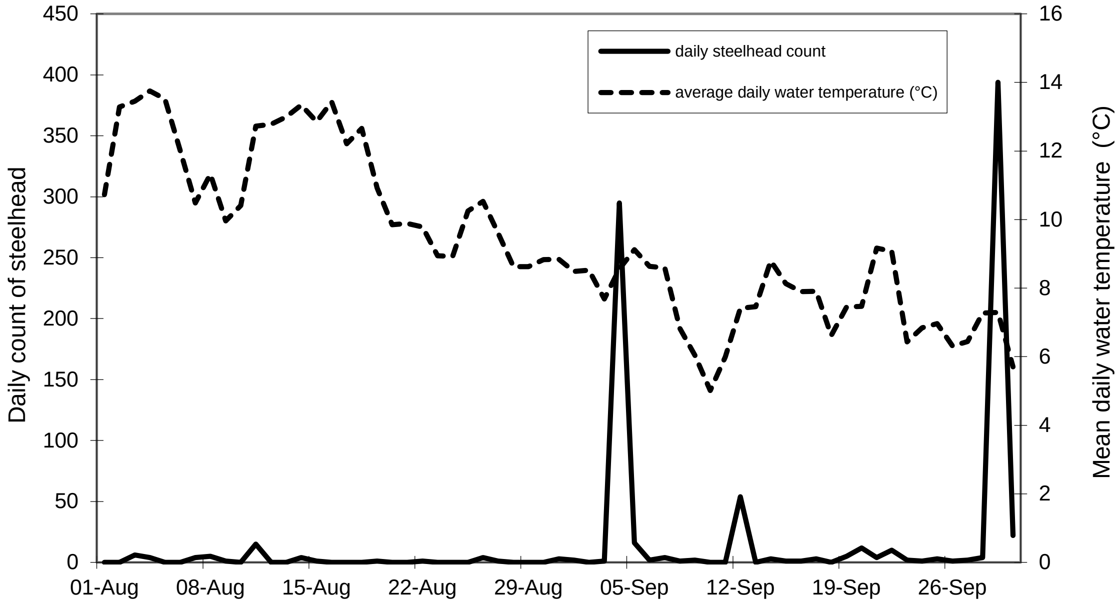

Figure 11. Mean daily water temperature and the number of Steelhead migrating past the Sustut fence.

4.7 Water Level

From August 1 to September 30, 2014, water levels ranged between 0.065 m (September 18) and 0.17 m (August 1; Figure 12). Since 1998, the annual average water level from August 1 to September 30 has ranged between 0.10 m and 0.34 m and averaged 0.22 m (Table 1).

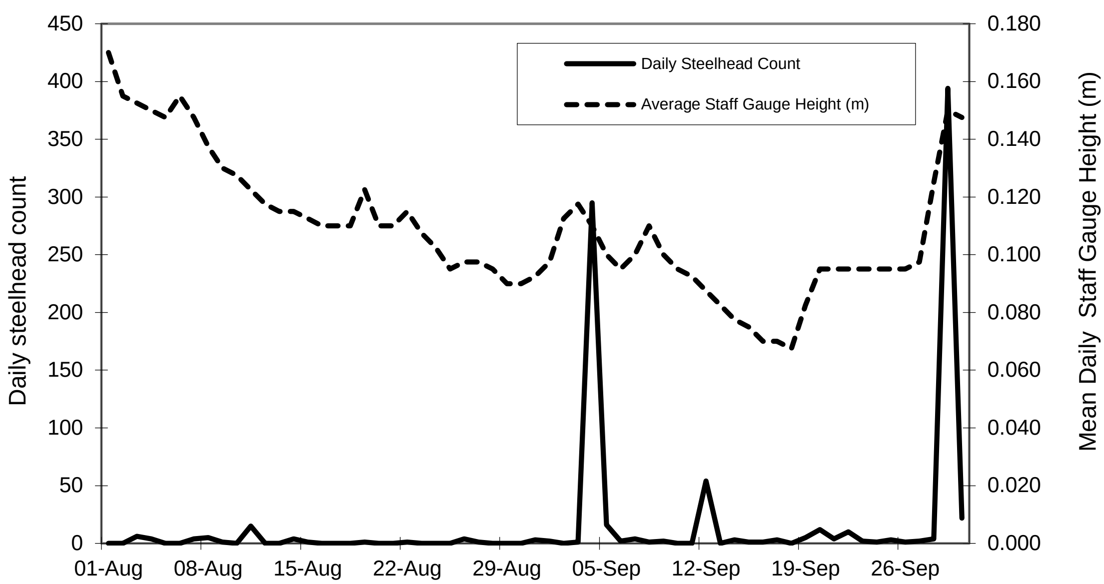

Figure 12. Mean daily staff gauge height and the number of Steelhead migrating past the Sustut fence.

4.8 Male and Female Steelhead Run Timing

The first male and female Steelhead passed through the fence on August 3. The date when 50% of male and female Steelhead had migrated past the fence was September 14 and September 21 respectively. A comparison between the cumulative percentage of male and female Steelhead crossing the fence and their arrival date indicates that males and females had similar migration timing (Figure 13).

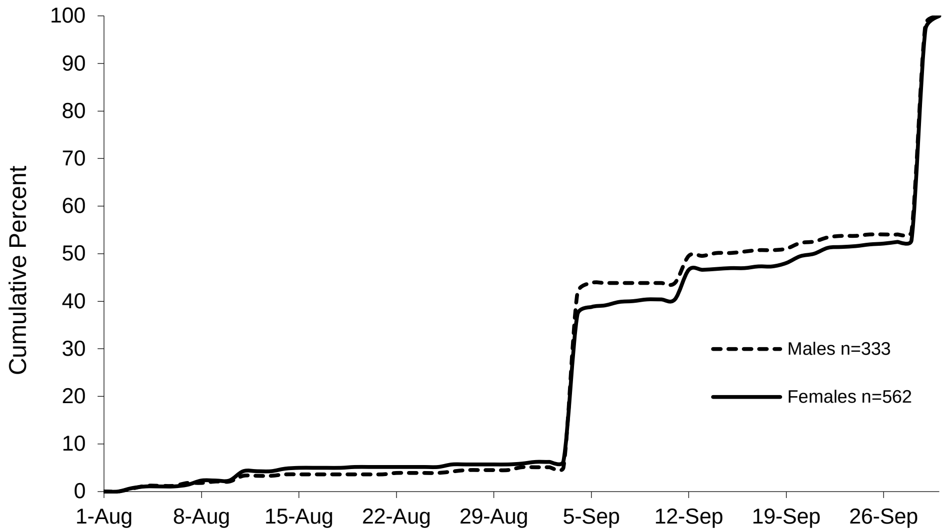

Figure 13. Daily cumulative percent of male and female Steelhead migrating past the fence.

5.0 Discussion

The objectives for this project were to enumerate the upper Sustut River summer-run Steelhead population and examine the sex ratio of Steelhead throughout the run, the effect of water level and temperature on Steelhead migration, the number and distribution of gillnet marked Steelhead throughout the run and the relative run timing of male and female Steelhead. The following section attempts to address these objectives by discussing the 2014 results and making linkages to historical findings part of this ongoing monitoring project.

5.1 Enumeration of Upper Sustut River Summer-Run Steelhead

In 2014, the upper Sustut fence Steelhead count from August 1 to October 1 was 895. This value is the ninth highest since enumeration methods were standardized in 1994. During the last 20 years, fence counts have ranged from 133 (2006) to 1186 (2011). The 2014 population index value was approximately 23% above the long term average (*n*=727).

5.2 Management Framework

According to a habitat based productivity model developed for the Skeena drainage (Tautz *et al.*, 1992) the 895 Steelhead that migrated past the upper Sustut fence in 2014 was 14% below the estimated adult production at capacity for the system (1036 Steelhead).

In the context of interpreting annual fence count data relative to adult production potential thresholds, a factor to consider is the proportional difference between escapement measured in August and September and total adult returns to the upper Sustut River. In recent years, a large number of Steelhead have been observed moving through the fence site near the end of the project. For example, in 2014, 44% (*n*=394) of all Steelhead counted crossed the fence in the second to last day of this project. Additionally, in 2010 and 2012, 24% and 17% of all Steelhead counted crossed the fence in the last 10 days of September, which raises questions regarding the number of Steelhead that enter the upper Sustut after the fence is removed on October 1. Comparisons made between annual fence counts and adult production capacity estimates (Tautz *et al.*, 1992; Figure 8) rely on the assumption that fence counts represent total escapement into the Upper Sustut watershed. If this assumption is being significantly violated, attempts should be made to assess the proportion of Steelhead entering the upper Sustut after fence removal. This may be achieved by extending fence operations into October annually in years when environmental conditions allow this to occur.

Since 1994, increases in Steelhead abundance have been followed by declines. Low returns during the 2005 to 2008 period fell within the conservation concern and extreme conservation concern zones (Figure 8). In light of this variability, management approaches must exercise caution. Potential impacts from climate change (Tydemers and Ward, 2001), shifts in freshwater and/or marine survival (Smith and Ward, 2000), interception in commercial salmon fisheries and losses from overwintering mortality (estimated at 11%; Beere, 1999) may lead to future fluctuations in Steelhead abundance. For these reasons, it is crucial that conservative approaches are taken by managers to support the long term sustainability of this unique and vulnerable Steelhead stock.

5.3 Sex Ratio and Relative Run Timing of Male and Female Steelhead

Of the 895 Steelhead that migrated past the fence, 562 were female and 333 were male, resulting in a female to male ratio of 1.69:1. This value is slightly higher than the long term trend of 1.60:1 (Table 2). While this skewed sex ratio in favor of females is consistent with observations at the Sustut fence since 1994, it is higher than sex ratios reported for other major Steelhead bearing tributaries in the Skeena watershed (Parken and Morten, 1996).

The skewed sex ratio observed at the Sustut River is of management concern and may be linked to natural and/or anthropogenic selective pressures. This topic has been discussed in previous versions of this report, most recently in Hirshfield (2011).

5.4 Distribution of Gillnet Marked Fish throughout the Run

Net marks were identified on 5.4% (*n*=48) of Steelhead migrating past the Sustut fence in 2014. This value is below the long term average of 6.9% (Table 2) and may be correlated with decreases in commercial gillnet fishing effort in the tidal approach waters of the Skeena River. Given few net marked fish had length measurements taken (5 males and 10 females), insufficient samples size exists to compare the length or sex of marked and unmarked fish.

5.5 Effect of Water Level and Temperature on Steelhead Migration

During the project, water level at the upper Sustut fence generally declined throughout the study period (Figure 11), with a notable increase during the last 10 days of the project. Levels ranged from 0.065 m on September 18 to 0.17 m on August 14 and averaged 0.11 m. Relative to the average water level, 15% (n=136) of Steelhead entered the trap box when water levels were below this level and 85% (n=759) entered when water levels were above. This is consistent with previous observations which found the majority of Steelhead migrated past the fence during above average water levels.

The average water level in the upper Sustut River has been generally decreasing since 1998. Over the same period, the average water temperature measured at the fence has been increasing (Appendix Figure 2). While the correlation coefficient for water level and time (R^2=0.54) indicates a stronger linear relationship than water temperature and time (R^2=0.34), continued and/or increased monitoring of these variables is recommended. For example, if further decreases in average flow are observed, Steelhead migration may become restricted during periods of low water level. This may result in fish impoundment within deeper sections of river (pools), increased vulnerability to in-river fisheries and stress-related mortality from elevated water temperatures.

As for temperature related impacts, the average water temperature during the project in 2014 was 9.31°C , which is well below the upper lethal limit of 27°C for rainbow trout (McPhail, 2007). Research has proven, however, that increases in stream temperature can negatively impact Steelhead populations (Sloat & Osterback, 2013). As such, continued monitoring of stream temperature during this project is warranted. In addition to monitoring temperature during fence operation, it would be advantageous to monitor maximum stream temperature within juvenile rearing habitat. This is a sensitive life history stage and shallow water environments have an elevated probability of experiencing temperature fluctuations.

5.6 The Importance of Continued Monitoring

The upper Sustut River counting 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. This long term data set allows fisheries managers to compare variables among and between years including annual abundance, effect of water level and temperature on migration, the number and distribution of gillnet marked Steelhead throughout the run, the relative run timing of male and female Steelhead, sex ratios and age composition. The ability to detect changes in these parameters and establish linkages to natural and human-related impacts is vital to protecting the social, economic and ecological benefits Skeena Steelhead provide now and into the future.

6.0 Recommendations

1. Enumeration of the upper Sustut River Steelhead population should continue to be conducted annually. The long term monitoring data from this project provides fisheries managers with valuable information on abundance trends for all early run Skeena Steelhead populations and feedback on the impact of fisheries on these stocks.

2. The current minimum Target Reference Point (TRP) of 25% carrying capacity should be evaluated to determine if it will conserve the upper Sustut Steelhead population above the Limit Reference Point and yield a precautionary approach to Steelhead management.
3. Agreement must be reached between BC and Canada as to the plan when the upper Sustut Steelhead stock falls below the TRP. This plan should be reflected through the Steelhead objectives section of the North Coast Integrated Fisheries Management Planning process. Management actions described in Johnston *et al.* (2002) should be put forward to federal agencies for consultation. In the latter part of this decade, multiple fence counts at or below the TRP have not resulted in the development of any plans or agreements that would mitigate commercial fishery impacts on this population.
4. Adult production estimates for the upper Sustut River should be reconciled (Lessard, 2005; Tautz *et al.*, 1992) and the smolt-to-adult survival rates used for these studies (14%) should be updated to reflect the most current and regionally relevant estimates.
5. Efforts to visually count Steelhead below the fence should continue. This should be undertaken when the fence is removed, and also on a daily basis. Counts of Steelhead holding below the fence each day would provide beneficial information for assessing the correlation between flow and temperature and Steelhead migration. This would allow the data to be standardized to fish counted vs. fish available (i.e. holding in pool downstream) and provide insight into how Steelhead respond to differing flow and temperature regimes.
6. Future emphasis should be placed upon the approach taken when investigating the role environmental factors (water flow and temperature) have upon Steelhead migration. An explicit modeling approach capable of dealing with overdispersed data (Richards, 2008) may help better understand Steelhead migration patterns and links to environmental variables.
7. A review of enumeration results at the Sustut fence should be undertaken every five years. Comparison of results inter-annually would provide useful insight into changing environmental factors (water supply, ocean and climatic conditions) and anthropogenic impacts (in river and ocean fisheries, resource development etc) as they relate to conserving the upper Sustut Steelhead population.
8. Data loggers measuring water temperature should be placed in the water at least one day (preferably longer) prior to study commencement. This will allow instrumentation to properly adjust to water temperature following transport to the fence site. Furthermore, monitoring water temperature during summer months is recommended to evaluate maximum steam temperatures and potential impacts to young of the year Steelhead.
9. The target where 20% of Steelhead crossing the Sustut fence are sampled should be investigated. A power analysis should be conducted to determine whether the current sampling target is adequate to detect changes in sampled parameters. Consideration regarding the sampling methodology is also warranted to assess assumptions and explore changes which may increase the ability to collect samples which are representative of Steelhead crossing the upper Sustut counting fence. It is

recommended that the sample rate be as consistent as possible throughout migration past the fence to minimize any bias associated with migration timing.

10. The objectives of this report should be broadened to include Steelhead length and age investigation. Presenting an analysis of these parameters annually would increase the ability to monitor changes over time as they relate management of the upper Sustut Steelhead population. Also, all efforts should be made to ensure that sex and length information is recorded for all fish that have scale samples removed and all fish exhibiting gillnet marks. This will allow analysis between these factors to be conducted.
11. If large relative proportions of Steelhead are observed crossing the Sustut fence at the end of September (e.g. 2010, 2014), or if significant numbers of Steelhead are counted below the fence prior to removal (e.g. 2012), consideration should be given to operating the fence into October as weather conditions allow. This would assist in accurately enumerating the upper Sustut Steelhead population and monitoring future changes to Steelhead migration timing.

7.0 Acknowledgments

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

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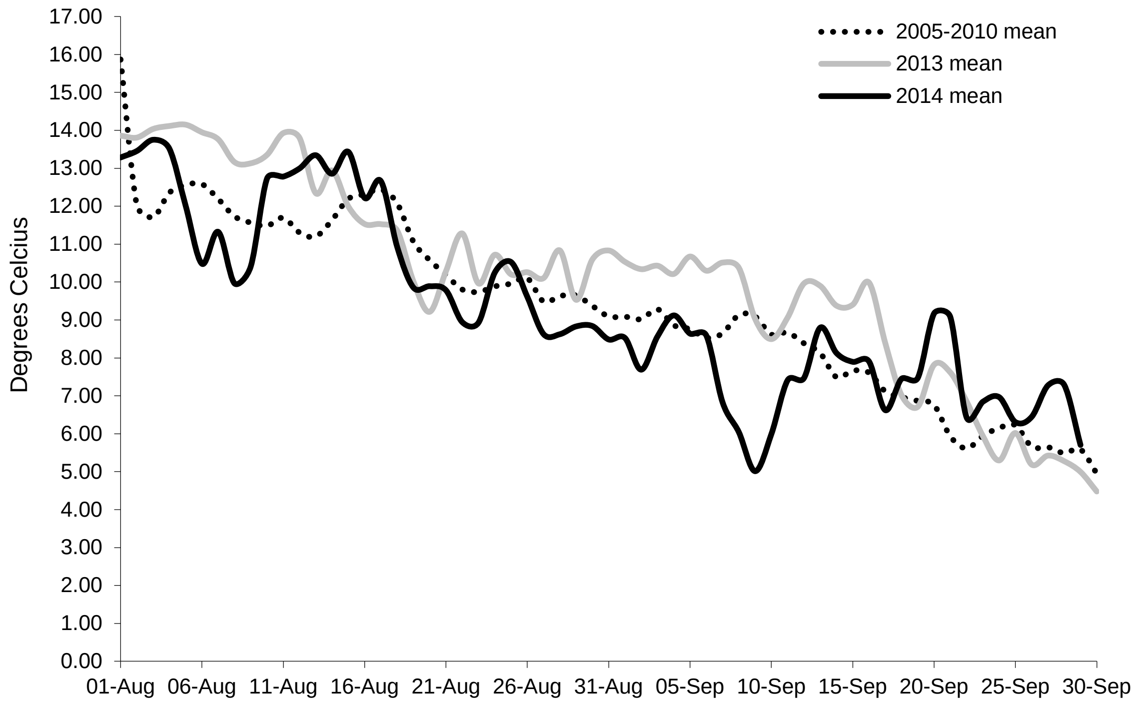
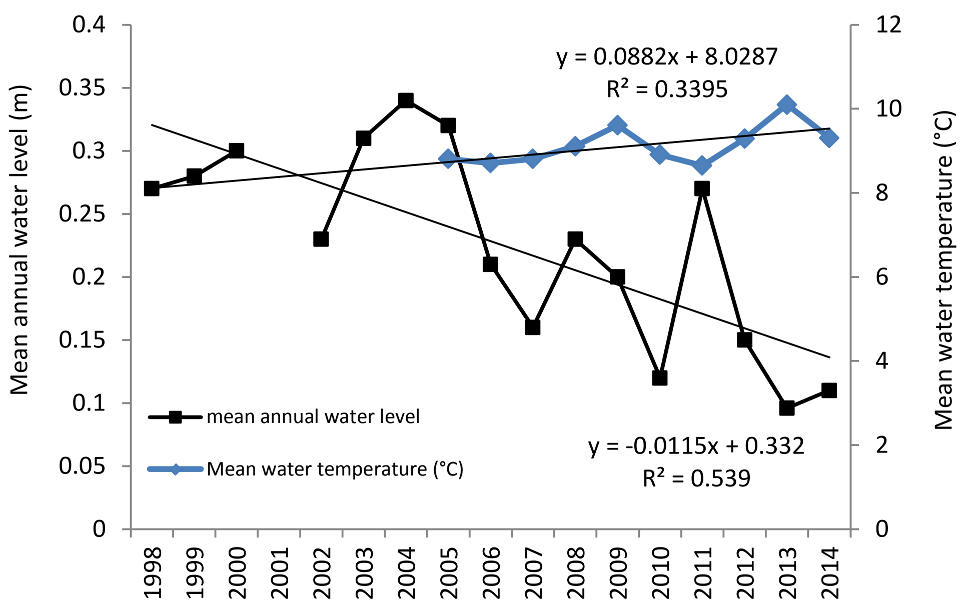
9.0 Appendices

Appendix Figures



Appendix Figure 1. Mean daily water temperature at the Sustut River fence



Appendix Figure 2. Mean annual water level at the Sustut River fence in September and October annually

Appendix Tables

Appendix Table 1. Daily and cumulative totals for all fish species enumerated at the Upper Sustut River weir.

Date	Chinook		Sockeye		Steelhead		Coho		Bull Trout		Whitefish		Rainbow Trout	
	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum	Daily	Cum
01-Aug-14	10	10	24	24	0	0	0	0	0	0	1	1	0	0
02-Aug-14	14	24	122	146	0	0	0	0	0	0	0	1	0	0
03-Aug-14	23	47	102	248	6	6	0	0	0	0	1	2	0	0
04-Aug-14	0	47	0	248	4	10	0	0	0	0	0	2	0	0
05-Aug-14	6	53	114	362	0	10	0	0	0	0	2	4	0	0
06-Aug-14	15	68	15	377	0	10	0	0	0	0	0	4	0	0
07-Aug-14	12	80	59	436	4	14	0	0	0	0	2	6	0	0
08-Aug-14	0	80	99	535	5	19	0	0	0	0	3	9	0	0
09-Aug-14	5	85	25	560	1	20	0	0	0	0	0	9	0	0
10-Aug-14	15	100	14	574	0	20	0	0	0	0	0	9	0	0
11-Aug-14	4	104	89	663	15	35	0	0	0	0	1	10	0	0
12-Aug-14	0	104	5	668	0	35	2	2	0	0	0	10	0	0
13-Aug-14	1	105	28	696	0	35	2	4	0	0	0	10	0	0
14-Aug-14	5	110	22	718	4	39	9	13	0	0	2	12	0	0
15-Aug-14	2	112	1	719	1	40	1	14	0	0	1	13	0	0
16-Aug-14	1	113	20	739	0	40	0	14	0	0	1	14	0	0
17-Aug-14	3	116	1	740	0	40	3	17	0	0	0	14	0	0
18-Aug-14	3	119	2	742	0	40	4	21	0	0	0	14	0	0
19-Aug-14	2	121	0	742	1	41	0	21	0	0	0	14	0	0
20-Aug-14	0	121	0	742	0	41	0	21	0	0	0	14	0	0
21-Aug-14	0	121	0	742	0	41	0	21	0	0	0	14	0	0
22-Aug-14	0	121	0	742	1	42	0	21	0	0	0	14	0	0
23-Aug-14	0	121	0	742	0	42	0	21	0	0	0	14	0	0
24-Aug-14	0	121	0	742	0	42	0	21	0	0	0	14	0	0
25-Aug-14	0	121	0	742	0	42	0	21	0	0	0	14	0	0
26-Aug-14	0	121	11	753	4	46	2	23	0	0	5	19	1	1
27-Aug-14	0	121	2	755	1	47	0	23	0	0	1	20	0	1
28-Aug-14	0	121	0	755	0	47	0	23	0	0	0	20	0	1
29-Aug-14	0	121	0	755	0	47	0	23	0	0	3	23	0	1
30-Aug-14	0	121	0	755	0	47	0	23	0	0	0	23	0	1
31-Aug-14	0	121	1	756	3	50	0	23	0	0	1	24	0	1
01-Sep-14	0	121	1	757	2	52	0	23	0	0	0	24	0	1
02-Sep-14	0	121	0	757	0	52	0	23	0	0	0	24	0	1
03-Sep-14	0	121	21	778	1	53	1	24	0	0	3	27	0	1
04-Sep-14	0	121	255	1033	295	348	108	132	0	0	2	29	0	1
05-Sep-14	0	121	0	1033	16	364	1	133	0	0	0	29	0	1
06-Sep-14	0	121	2	1035	2	366	0	133	0	0	3	32	0	1

07-Sep-14	0	121	0	1035	4	370	0	133	0	0	1	33	0	1
08-Sep-14	0	121	0	1035	1	371	0	133	0	0	2	35	0	1
09-Sep-14	0	121	0	1035	2	373	0	133	0	0	0	35	0	1
10-Sep-14	0	121	0	1035	0	373	0	133	0	0	4	39	0	1
11-Sep-14	0	121	0	1035	0	373	0	133	0	0	1	40	0	1
12-Sep-14	0	121	9	1044	54	427	29	162	0	0	1	41	0	1
13-Sep-14	0	121	1	1045	0	427	0	162	0	0	0	41	0	1
14-Sep-14	0	121	1	1046	3	430	9	171	0	0	0	41	0	1
15-Sep-14	0	121	1	1047	1	431	0	171	0	0	0	41	0	1
16-Sep-14	0	121	1	1048	1	432	1	172	0	0	2	43	0	1
17-Sep-14	0	121	0	1048	3	435	2	174	0	0	0	43	0	1
18-Sep-14	0	121	0	1048	0	435	0	174	0	0	0	43	0	1
19-Sep-14	0	121	0	1048	5	440	7	181	0	0	2	45	0	1
20-Sep-14	0	121	5	1053	12	452	16	197	1	1	1	46	0	1
21-Sep-14	0	121	0	1053	4	456	17	214	0	1	0	46	0	1
22-Sep-14	0	121	1	1054	10	466	9	223	1	2	0	46	0	1
23-Sep-14	0	121	0	1054	2	468	1	224	0	2	0	46	0	1
24-Sep-14	0	121	0	1054	1	469	0	224	1	3	0	46	0	1
25-Sep-14	0	121	0	1054	3	472	0	224	1	4	0	46	0	1
26-Sep-14	0	121	0	1054	1	473	1	225	0	4	0	46	0	1
27-Sep-14	0	121	0	1054	2	475	0	225	0	4	0	46	0	1
28-Sep-14	0	121	0	1054	4	479	11	236	0	4	0	46	0	1
29-Sep-14	0	121	5	1059	394	873	87	323	2	6	2	48	0	1
30-Sep-14	0	121	3	1062	22	895	2	325	1	7	1	49	0	1

Appendix Table 2. Condition code definitions and abbreviation descriptions.

Condition Code	**Definition**
1	Good condition
2	Poor condition or questionable age
3	Freshwater age unreadable (eg. U.2)
4	Unreadable (eg. U.U)
5	Starting to regenerate (freshwater age may be under-estimated)
5a	Starting to regenerate, wide focus (freshwater age not under-estimated)
6	Regenerated (eg. R.2)
7	Missing
8	Resorption (eg. last marine annulus on edge of scale)
9	First freshwater annulus very vague, but must be present due to high circuli count and spacing relative to other freshwater annuli
Abbreviation	**Definition**
ann.	annulus
est.	estimate
fw	freshwater

fwa	freshwater annulus
fws	freshwater stress
ma	marine annulus
ms	marine stress
p/c	poor condition
pg zone	zone of closely spaced circuli immediately following last freshwater annulus; may resemble another year of freshwater growth
rg	regenerated
sp. ch.	spawning check

Appendix Table 3. Steelhead sampling data from the Sustut River fence in 2014

Fish Number	Date	Time	Sex	Nose Fork Length (cm)	Gill Net Mark	Fish Age	Scale Condition Code	Scale Analysis Comments
1	03-08-2014	8:00	M		no			
2	03-08-2014	8:00	F	76	no	5.2	1	
3	03-08-2014	14:30	F		no			
4	03-08-2014	15:15	F		no			
5	03-08-2014	15:15	F		no			
6	03-08-2014	17:45	M		no			
7	04-08-2014	8:00	F	76	no	R.2	6	estimate at least 4.2
8	04-08-2014	8:00	M	88	no	4.3	9	1st fwa not visible
9	04-08-2014	8:00	M	85	no	3.3	1	
10	04-08-2014	16:30	F		no			
11	07-08-2014	15:00	M		no			
12	07-08-2014	15:30	F		no			
13	07-08-2014	16:45	F		no			
14	07-08-2014	17:15	M		no			
15	08-08-2014	15:15	F		no			
16	08-08-2014	15:15	F		no			
17	08-08-2014	16:15	F		no			
18	08-08-2014	16:15	F		no			
19	08-08-2014	16:45	F		no			
20	09-08-2014	16:45	M		no			
21	11-08-2014	8:00	M	78.5	no	4.2	1	
22	11-08-2014	15:30	M		no			
23	11-08-2014	15:30	M		no			
24	11-08-2014	15:30	F		no			
25	11-08-2014	15:30	F		no			
26	11-08-2014	15:30	F		no			
27	11-08-2014	15:30	F		no			
28	11-08-2014	15:30	F		no			
29	11-08-2014	15:30	F		no			

30	11-08-2014	15:30	F		no			
31	11-08-2014	15:45	M		no			
32	11-08-2014	15:45	F		no			
33	11-08-2014	16:15	F		no			
34	11-08-2014	16:15	F		no			
35	11-08-2014	17:15	F		no			
36	14-08-2014	14:00	F		no			
37	14-08-2014	14:00	F		no			
38	14-08-2014	14:00	F		no			
39	14-08-2014	17:00	M		no			
40	15-08-2014	8:00	F	76	no	4.2	1	
41	19-08-2014	13:30	F		no			
42	22-08-2014	8:30	M		no			
43	26-08-2014	18:30	M		no			
44	26-08-2014	18:30	F		no			
45	26-08-2014	18:30	F		no			
46	26-08-2014	19:00	F	70.5	no	4.2	1	
47	27-08-2014	8:00	M	77.5	no	3.2	5a	
48	31-08-2014	8:00	M	65	no	4.2	2	fw in p/c; 1st fwa barely visible
49	31-08-2014	8:00	F	69	no	R.2	6	estimate at least 4.2
50	31-08-2014	16:30	M		no			
51	01-09-2014	20:00	F		no			
52	01-09-2014	20:00	F		no			
53	03-09-2014	13:30	F		no			
54	04-09-2014	8:30	F	70.5	no	4.2	1	
55	04-09-2014	14:00	F		no			
56	04-09-2014	14:00	F		no			
57	04-09-2014	14:00	F		no			
58	04-09-2014	15:00	M		yes			
59	04-09-2014	15:00	M		no			
60	04-09-2014	15:00	M		no			
61	04-09-2014	15:00	M		no			
62	04-09-2014	15:00	M		no			
63	04-09-2014	15:00	M		no			
64	04-09-2014	15:00	M		no			
65	04-09-2014	15:00	M		no			
66	04-09-2014	15:00	M		no			
67	04-09-2014	15:00	M		no			
68	04-09-2014	15:00	M		no			
69	04-09-2014	15:00	M		no			
70	04-09-2014	15:00	M		no			
71	04-09-2014	15:00	M		no			
72	04-09-2014	15:00	M		no			

73	04-09-2014	15:00	M		no				
74	04-09-2014	15:00	M		no				
75	04-09-2014	15:00	M		no				
76	04-09-2014	15:00	M		no				
77	04-09-2014	15:00	M		no				
78	04-09-2014	15:00	M		no				
79	04-09-2014	15:00	M		no				
80	04-09-2014	15:00	M		no				
81	04-09-2014	15:00	M		no				
82	04-09-2014	15:00	M		no				
83	04-09-2014	15:00	F		no				
84	04-09-2014	15:00	F		no				
85	04-09-2014	15:00	F		no				
86	04-09-2014	15:00	F		no				
87	04-09-2014	15:00	F		no				
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345	04-09-2014	18:00	M		no			
346	04-09-2014	18:00	F		no			
347	04-09-2014	18:00	F		no			
348	04-09-2014	19:30	F		no			
349	05-09-2014	16:00	M	77.5	no	4.2	1	
350	05-09-2014	16:00	M	88.5	no	R.3	6	estimate at least 4.3
351	05-09-2014	16:00	F	70.5	yes	4.2	1	
352	05-09-2014	17:00	F	72.5	no	4.2	9	1st fwa barely visible
353	05-09-2014	18:00	F	75	no	4.3	1	
354	05-09-2014	18:00	M	68	yes	4.2	1	
355	05-09-2014	18:00	F	71.5	no	4.2	5a	
356	05-09-2014	19:15	M	84	no	4.2	1	
357	05-09-2014	19:15	M	86	no	4.3	2	fw in p/c
358	05-09-2014	19:15	F	73	no	4.2	1	
359	05-09-2014	19:15	F	75	no	4.2	1	
360	05-09-2014	19:15	F	69	no	R.2	6	estimate at least 4.2
361	05-09-2014	19:15	M	83	no	3.3	1	
362	05-09-2014	19:15	M	79.5	no	4.2	1	
363	05-09-2014	19:15	F	68	no	4.2	9	1st fwa barely visible
364	05-09-2014	19:15	F	74	no	5.2	9	1st fwa not visible
365	06-09-2014	8:30	F	67	no	4.2	5a	
366	06-09-2014	8:30	F	76.5	no	R.2	6	estimate 4.2
367	07-09-2014	8:30	F	74	no	4.2	5a	
368	07-09-2014	8:30	F	72	no	4.2	1	
369	07-09-2014	19:00	F	69.5	no	R.2	6	estimate at least 3.2
370	07-09-2014	19:00	F	67	no	5.2	2	fw in p/c
371	08-09-2014	8:00	F	68	no	R.2	6	estimate at least 4.2
372	09-09-2014	8:00	F	70	no	4.1S1	2	vague spawning check
373	09-09-2014	8:00	F	76.5	no	5.2	1	

374	12-09-2014	8:00	F	68	no	4.2	9	1st fwa barely visible
375	12-09-2014	6:45	F		no			
376	12-09-2014	17:00	M		no			
377	12-09-2014	17:00	M		no			
378	12-09-2014	17:00	M		no			
379	12-09-2014	17:00	M		no			
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384	12-09-2014	17:00	F		no			
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387	12-09-2014	17:00	F		no			
388	12-09-2014	17:00	F		no			
389	12-09-2014	17:00	F		no			
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391	12-09-2014	17:00	F		no			
392	12-09-2014	17:00	F		no			
393	12-09-2014	17:00	F		no			
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409	12-09-2014	18:00	F		no			
410	12-09-2014	18:00	F		no			
411	12-09-2014	19:30	M	89.5	no	4.3	8	
412	12-09-2014	19:30	F	69.5	no	4.2	1	
413	12-09-2014	19:30	F	74.5	no	5.2	9	1st fwa not visible
414	12-09-2014	19:30	F	87	no	3.2S1	8	vague spawning check
415	12-09-2014	19:30	F	71.5	no	4.1S1	2	vague spawning check
416	12-09-2014	19:30	F	69.5	yes	4.2	1	

417	12-09-2014	19:30	M	92	no	4.4	9	1st fwa not visible; marine age est.
418	12-09-2014	19:30	F	72	no	5.2	2	fw in p/c; age estimate
419	12-09-2014	19:30	F	70.5	no	5.2	9	1st fwa not visible
420	12-09-2014	19:30	F	73	no	4.3	2	p/c; age estimate
421	12-09-2014	19:30	M	74.5	no	4.2	9	1st fwa barely visible
422	12-09-2014	19:30	F	73	no	4.2	2	fw in p/c
423	12-09-2014	19:30	F	73.5	no	4.2	2	fw stress in 3rd year; others rg
424	12-09-2014	19:30	F	71	no	4.2	9	1st fwa not visible
425	12-09-2014	20:00	F	71	yes	4.2	9	1st fwa barely visible; vague 3rd fwa
426	12-09-2014	20:00	F	74.5	no	4.1S1	1	
427	12-09-2014	20:00	F	67	no	4.2	1	
428	14-09-2014	8:00	M	75.5	no	4.3	9	1st fwa barely visible
429	14-09-2014	19:00	M		no			
430	14-09-2014	19:00	F		no			
431	15-09-2014	8:00	F	71.5	no	R.2	6	estimate at least 4.2
432	16-09-2014	19:30	M	84	no	4.3	8	possible 4.3S1; resorption
433	17-09-2014	8:00	F	72.5	no	5.1S1	8	vague spawning check
434	17-09-2014	18:45	F	77.5	no	4.3	8	
435	17-09-2014	18:45	M	72	no	4.2	9	1st fwa not visible
436	19-09-2014	8:00	M	78	no	4.2	1	
437	19-09-2014	8:00	F	69	no	R.2	6	
438	19-09-2014	8:00	F	72	no	4.2	9	1st fwa barely visible
439	19-09-2014	17:00	F	66.5	no	4.2	1	
440	19-09-2014	17:00	F	69	no	3.2	1	
441	20-09-2014	8:00	F	74.5	no	R.2	6	
442	20-09-2014	8:00	F	73	yes	R.2	6	estimate at least 3.2
443	20-09-2014	8:00	M	75	yes	4.2	5	may be lacking 1st fwa (ie. 5.2)
444	20-09-2014	8:00	M	71	no	R.1S1	6	vague spawning check
445	20-09-2014	14:30	F	69	yes	4.2	1	
446	20-09-2014	14:30	M		no			
447	20-09-2014	14:30	F		no			
448	20-09-2014	14:30	F		no			
449	20-09-2014	16:00	F	73	no	4.2	1	
450	20-09-2014	16:00	F		no			
451	20-09-2014	17:30	M	75	no	4.2	9	1st fwa barely visible
452	20-09-2014	19:15	F	68	no	4.2	5a	
453	21-09-2014	8:00	M	70.5	yes	4.2	1	
454	21-09-2014	8:00	F	72.5	no	4.2	1	
455	21-09-2014	8:00	F	73	no	4.2	1	
456	21-09-2014	8:00	F	71.5	no	4.2	9	1st fwa not visible
457	22-09-2014	8:00	M	70.5	yes	4.2	1	
458	22-09-2014	8:00	F	76	no	R.2	6	
459	22-09-2014	8:00	F	74	no	4.2	5	

460	22-09-2014	8:00	F	73.5	no	R.2	6	
461	22-09-2014	8:00	M	70	no	4.2	1	
462	22-09-2014	15:00	F	72	no	5.2	1	
463	22-09-2014	17:00	F	71	no	U.2	3	estimate 4.2
464	22-09-2014	19:00	M	76.5	no	4.2	1	
465	22-09-2014	19:00	F	71.5	no	4.2	1	
466	22-09-2014	19:00	F	72	no	4.2	5a	
467	23-09-2014	8:00	M	72.5	no	4.2	9	1st fwa not visible
468	23-09-2014	8:00	F	71	no	3.2	1	
469	24-09-2014	8:30	F	73	no	U.2	3	fw distorted; estimate at least 4.2
470	25-09-2014	8:00	M	71	no	4.2	1	
471	25-09-2014	8:00	F	70	no	4.2	1	
472	25-09-2014	8:00	F	69	yes	4.2	9	1st fwa barely visible
473	26-09-2014	8:00	F	76.5	no	R.2	6	
474	27-09-2014	8:00	F	72	no	4.2	9	1st fwa barely visible
475	27-09-2014	8:00	F	74.5	no	4.2S1	1	
476	28-09-2014	8:00	M	76.5	no	4.2	1	
477	28-09-2014	8:00	M	78	no	3.3	8	
478	28-09-2014	8:00	F	70	no	4.2	5	
479	28-09-2014	14:00	F		no			
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481	29-09-2014	8:00	M	79.5	no	4.2	1	
482	29-09-2014	8:00	F	75.5	no	5.2	2	vague 4th fwa
483	29-09-2014	8:00	M	75	no	4.2	1	
484	29-09-2014	8:00	F	72	no	4.2	1	
485	29-09-2014	8:00	M	92	no	4.4	2	p/c; marine age estimate
486	29-09-2014	8:00	F	71.5	no	4.2	1	
487	29-09-2014	8:00	M	82	no	4.2S1	1	
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489	29-09-2014	8:00	F	74.5	no	4.2	1	
490	29-09-2014	8:00	F	72	yes	4.2	9	1st fwa barely visible
491	29-09-2014	8:00	M	61	no	R.1	6	
492	29-09-2014	8:00	F	83	no	4.3	2	fw in p/c
493	29-09-2014	8:00	F	68	no	4.2	2	fw in p/c
494	29-09-2014	8:00	M	78.5	no	4.2	8	
495	29-09-2014	8:00	F	73	no	U.2	3	estimate 5.2
496	29-09-2014	8:00	M	75.5	no	4.2S1	9	1st fwa barely visible
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498	29-09-2014	8:00	F	72	no	4.2	1	
499	29-09-2014	8:00	M	71	yes	4.3	9	1st fwa not visible
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874	30-09-2014	8:30	F	78	no	6.2S1	1	
875	30-09-2014	8:30	F	70	no	4.2	1	
876	30-09-2014	8:30	M	72	no	4.2	1	
877	30-09-2014	8:30	M	77	no	4.2	5	
878	30-09-2014	8:30	F	74	no	4.2	5a	
879	30-09-2014	8:30	F	73	no	4.2	1	
880	30-09-2014	8:30	F	73	no	4.2	1	
881	30-09-2014	8:30	F	67	yes	4.2	5	
882	30-09-2014	8:30	M	71	no	5.2	5a	
883	30-09-2014	8:30	F	68	no	4.2	1	
884	30-09-2014	8:30	F	79	no	4.3	5	
885	30-09-2014	8:30	F	84	no	4.3	1	
886	30-09-2014	8:30	F	85	yes	R.3	6	estimate 4.3
887	30-09-2014	8:30	F	64	no	4.2	1	
888	30-09-2014	8:30	F	70	no	4.2	1	
889	30-09-2014	8:30	F	71	yes	4.2	1	

890	30-09-2014	8:30	M		no			
891	30-09-2014	15:00	F		no			
892	30-09-2014	16:30	M		no			
893	30-09-2014	16:30	M		no			
894	30-09-2014	16:30	F		no			
895	30-09-2014	16:30	F		no			
896	01-10-2014	11:00	F		no			
897	01-10-2014	11:00	F		no			

Appendix Table 4. Staff gauge height, water and air temperature and weather conditions recorded at the Upper Sustut River Weir.

Date	Time (hrs)	Staff Gauge Height (m)	Water Temperature (°C)		Air Temperature (°C)		Weather Conditions
			Max	Min	Max	Min	
01-Aug-14	8:00	0.170					clear, hard frost last night
01-Aug-14	19:30	0.170	9	7	27.8	-	clear
02-Aug-14	8:00	0.155					clear
02-Aug-14	20:00	0.155	12	9	28.5	-1.5	clear
03-Aug-14	8:00	0.155					clear
03-Aug-14	20:00	0.150	12	9	29.5	-1	clear
04-Aug-14	8:00	0.150					clear
04-Aug-14	20:00	0.150	12	9	29	0	high clouds
05-Aug-14	20:00	0.150	11	9	26.5	6.5	clear, thunderstorms in the afternoon
05-Aug-14	8:00	0.145					cloudy
06-Aug-14	8:00	0.155					mostly cloudy
06-Aug-14	20:00	0.155	11	9	15	4	mostly clear
07-Aug-14	8:00	0.150					clear
07-Aug-14	20:00	0.145	11	9	16	-2	mostly cloudy
08-Aug-14	8:00	0.140					mostly cloudy
08-Aug-14	20:00	0.135	11	9	19	6	clear
09-Aug-14	8:00	0.130					mostly cloudy
09-Aug-14	20:00	0.130	11	8	15	1	mostly cloudy
10-Aug-14	8:00	0.130					cloudy
10-Aug-14	20:00	0.125	11	8	17	8.5	overcast, light rain
11-Aug-14	20:15	0.125	12	9	27.2	9.3	clear
11-Aug-14	8:00	0.120					clear
12-Aug-14	8:00	0.120					partly cloudy
12-Aug-14	20:00	0.115	12	9	28.5	1.5	mostly clear
13-Aug-14	8:00	0.115					mostly clear
13-Aug-14	19:30	0.115	12	9	26.5	0.5	clear
14-Aug-14	8:00	0.115					clear
14-Aug-14	20:00	0.115	12	9	27.5	1.1	clear
15-Aug-14	8:00	0.115					clear
15-Aug-14	20:00	0.110	12	9	25	1.5	mostly cloudy
16-Aug-14	8:00	0.110					mostly clear
16-Aug-14	20:00	0.110	12	9	25	5	clear
17-Aug-14	8:00	0.110					mostly cloudy
17-Aug-14	20:00	0.110	12	9	24	1	high cloud cover
18-Aug-14	8:00	0.110					cloudy
18-Aug-14	20:00	0.110	12	9	18.5	9	clear
19-Aug-14	8:00	0.130					partly clear
19-Aug-14	20:00	0.115	12	9	16	3.5	clear
20-Aug-14	8:00	0.115					clear
20-Aug-14	20:00	0.105	12	8.4	18.5	-4	partly clear
21-Aug-14	8:00	0.110					cloudy
21-Aug-14	20:00	0.110	12	8.6	14	1.5	mostly cloudy

22-Aug-14	8:30	0.115					clear
22-Aug-14	19:30	0.115	12	9	18	-2.5	mostly clear
23-Aug-14	8:30	0.110					cloudy
23-Aug-14	20:00	0.105	12	9	15	-3	partly clear
24-Aug-14	8:00	0.105					completely clear
24-Aug-14	20:00	0.100	12	9	20	-4	overcast
25-Aug-14	8:00	0.095					cloud, light rain overnight
25-Aug-14	20:00	0.095	13	9	18	9	cloudy
26-Aug-14	20:00	0.100	13	10	17	7	partly clear
26-Aug-14	8:00	0.095					overcast, rain
27-Aug-14	8:00	0.100					partly cloudy
27-Aug-14	20:30	0.095	13	9.4	16	4	clear
28-Aug-14	8:00	0.095					clear
28-Aug-14	20:00	0.095	13	7.5	18.5	-5	partly clear
29-Aug-14	8:00	0.090					light rain
29-Aug-14	20:00	0.090	12	7.5	15.5	-0.5	overcast
30-Aug-14	8:00	0.090					overcast, drizzle
30-Aug-14	20:00	0.090	12	9	11	4.5	partly clear
31-Aug-14	8:00	0.095					cloudy; drizzle
31-Aug-14	20:00	0.090	10	10	14	4	mostly cloudy
01-Sep-14	20:00	0.100	9	7.5	8	2.6	cloudy
01-Sep-14	8:00	0.095					overcast
02-Sep-14	20:00	0.115	11	8.5	14.7	4.1	mostly cloudy
02-Sep-14	8:00	0.110					overcast, drizzle
03-Sep-14	8:00	0.120					mostly cloudy
03-Sep-14	20:00	0.115	8	7	13.8	-3.7	mostly cloudy
04-Sep-14	8:00	0.110					partly cloudy
04-Sep-14	20:00	0.110	12	9	18	0	partly cloudy
05-Sep-14	8:00	0.100					mostly cloudy
05-Sep-14	20:00	0.100	11	9	20.3	2.7	partly cloudy
06-Sep-14	8:00	0.095					cloudy
06-Sep-14	20:00	0.095	11	8.5	15.5	3.8	cloudy
07-Sep-14	19:30	0.105	11	8	12.3	4.3	overcast; rain
07-Sep-14	8:00	0.095					overcast; rain overnight
08-Sep-14	8:00	0.110					cloudy
08-Sep-14	19:30	0.110	8	8	5	-0.5	overcast
09-Sep-14	8:00	0.105					overcast
09-Sep-14	20:00	0.095	6	4.5	8.6	-0.7	mostly clear
10-Sep-14	8:00	0.095		2			clear
10-Sep-14	20:00	0.095	6		12	-11	partly cloudy
11-Sep-14	8:00	0.095		4			cloudy
11-Sep-14	20:00	0.090	7		11.5	-1	mostly cloudy
12-Sep-14	8:00	0.090		5			fog
12-Sep-14	20:00	0.085	8		14.3	0	partly cloudy
13-Sep-14	8:00	0.085		5			cloudy
13-Sep-14	20:00	0.080	8.5		20	-2.5	partly cloudy
14-Sep-14	8:00	0.080		6			clear
14-Sep-14	19:45	0.075	10		23.5	-1.3	clear
15-Sep-14	8:00	0.075		5			clear
15-Sep-14	20:00	0.075	9		22	-4	partly cloudy

16-Sep-14	8:00	0.070		5			high overcast
16-Sep-14	20:00	0.070	9		21.5	-4.2	cloudy
17-Sep-14	8:00	0.070		5			mostly cloudy
17-Sep-14	20:00	0.070	9		20.5	-3	partly cloudy
18-Sep-14	19:00	0.070	8		11	-3.5	light rain
18-Sep-14	8:00	0.065		5			cloudy
19-Sep-14	19:30	0.090	8		9.3	4.3	cloudy
19-Sep-14	8:00	0.075		6			light rain
20-Sep-14	8:00	0.095		6			drizzle
20-Sep-14	19:30	0.095	8.5		12.5	3.5	cloudy
21-Sep-14	8:00	0.095		7			partly cloudy
21-Sep-14	19:30	0.095	10		22.5	2.7	partly cloudy
22-Sep-14	8:00	0.095		7.5			mostly cloudy
22-Sep-14	19:30	0.095	9		16.5	4	mostly cloudy
23-Sep-14	8:00	0.095		4			partly cloudy
23-Sep-14	19:30	0.095	7		15.5	-6	partly cloudy
24-Sep-14	8:30	0.095		6			light rain
24-Sep-14	19:30	0.095	7		8.5	1.5	cloudy
25-Sep-14	8:00	0.095		5			mostly cloudy
25-Sep-14	19:30	0.095	7		14	0.5	mostly cloudy
26-Sep-14	8:00	0.095		4			mostly cloudy
26-Sep-14	19:15	0.095	6.5		12	-2.5	mostly cloudy
27-Sep-14	19:15	0.100	6.5		8.5	1.5	cloudy
27-Sep-14	8:00	0.095		5.5			mostly cloudy
28-Sep-14	18:30	0.130	7.5		12	6	overcast; drizzle
28-Sep-14	8:00	0.120		6.5			cloudy; rain overnight
29-Sep-14	8:00	0.150		6			partly cloudy
29-Sep-14	19:15	0.150	6.5		9.8	1.8	mostly cloudy
30-Sep-14	19:00	0.150	6		7.5	-1.5	mostly cloudy
30-Sep-14	8:30	0.145		5.5			mostly cloudy