REVIEW OF THE ESCAPEMENT OF ADULT STEELHEAD TO THE UPPER SUSTUT RIVER 1986, 1992 - 1996

C.K. Parken
K.L. Morten
and
D.Y. Atagi

British Columbia
Ministry of Environment, Lands and Parks
Fisheries Branch
Skeena Region
Smithers, B.C.
V0J 2N0

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Abstract

The upper Sustut River steelhead (*Oncorhynchus mykiss*) population was enumerated from August 3 to October 1, 1996, for the fifth consecutive year. One fence, approximately 500 m upstream of the confluence of the Sustut River with Moosevale Creek, was used for enumeration. Four hundred and sixty-six (466) steelhead passed through the fence between August 3 and September 30. An additional 49 steelhead were counted downstream of the fence to the Moosevale Creek confluence, but included fish that were previously counted as they migrated upstream through the fence and were then able to migrate downstream over the fence during the freshet in late September. This estimate also included steelhead counted at the fence and released downstream. The fall escapement was above the estimated number of spawners required for maximum sustainable yield, but substantially below carrying capacity. The steelhead mortality rate due to handling at the fence was 2.8 percent. In 1996, 14 percent of steelhead had gillnet marks and 11 percent had predator scars. Between August 4 and September 30, a total of 3,368 sockeye salmon (*O. nerka*), 33 coho salmon (*O. kisutch*) and 8 bull trout (*Salvelinus confluentus*) were counted at the fence. The first steelhead arrived at the fence on August 17 and by September 7, 50 percent of steelhead had passed the fence. Of the eight steelhead recaptured in 1996, six were repeat spawners (2.0 percent of those tagged in 1994) and two were tagged earlier in 1996. At least 1.3 percent of the 1996 steelhead run were repeat spawners, as evidenced by Floy tags from previous years. In 1996, increases in steelhead migration did not coincide with changes in water temperature, but did coincide with an increase in river height. Male steelhead (mean = 82.9 cm) were significantly larger than female steelhead (mean = 73.9 cm; Student's t-test = 16.32, $P < 0.0005$). About 10 to 30 sockeye salmon heads and 6 steelhead heads were in the Sustut River between the Junction Pool and the fence, indicating low Native harvest.

From 1986 to 1996 the abundance of upper Sustut River steelhead fluctuated little and ranged from a high of 823 in 1986 to a low of 476 in 1993. The fall escapement of steelhead exceeded the minimum spawning requirements for conservation in all years examined, but were substantially below the estimated carrying capacity. From a review of all years of tagging data, tagged upper Sustut River steelhead were estimated to migrate by Tyee between June 25 and August 10 (mean = July 25), whereas tagged lower Sustut River steelhead were estimated to migrate by Tyee between July 16 and September 7 (mean = August 15). The significantly different timing of tagged upper and lower Sustut River steelhead indicated two separate populations (Mann-Whitney U test = 32.0, $P < 0.0005$). The upper Sustut River population index was positively correlated (Pearson Correlation R = 0.81, $P = 0.025$) and significantly related (ANOVA F = 7.61, $P = 0.051$) to the cumulative steelhead index at Tyee test fishery on August 10. The fork lengths of 1996 male and female steelhead were significantly larger than the 1992 steelhead run, but similar to 1993, 1994 and 1995 steelhead. The mean fork lengths of male and female steelhead with gillnet marks were significantly different than male (Student's t-test = 2.22, $P = 0.027$) and female (Student's t-test = 2.06, $P = 0.039$) steelhead without gillnet marks, although the magnitude of differences was small.

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1.0.0 Introduction

Early run steelhead (*Oncorhynchus mykiss*) are of special concern to fisheries managers in the Skeena Region. The timing of early run steelhead migration coincides with the commercial fishery for more abundant sockeye (*O. nerka*) and pink (*O. gorbuscha*) salmon (Cox-Rogers 1994). The intensity of the commercial fishery may cause the strength of early run steelhead to be compromised, since steelhead are incidentally caught with sockeye and pink salmon (Ward *et al*. 1993; Cox-Rogers 1994). Fisheries managers have used upper Sustut River steelhead as an index population for other early run steelhead in the Skeena Region since 1986 (Spence *et al*. 1990; Bustard 1993; Saimoto 1994; Saimoto 1995; Parken and Morten 1996). Enumeration of the upper Sustut River steelhead population has provided fisheries managers with yearly population index values and time series data to help determine the relative abundance and population trends of early run Skeena River steelhead.

Prior enumeration and investigation suggested two steelhead populations existed in the Sustut River that differed in run timing and overwintering areas (Spence *et al*. 1990; Ward *et al*. 1993). Bustard (1993; 1994) reported that upper Sustut River steelhead entered the Skeena River in July and August during the commercial fishery and overwintered in Sustut and Johanson lakes. In comparison, the lower Sustut River population was reported to enter the Skeena River in August and early September and overwinter in Bear Lake, Bear River and in the Sustut River downstream of the Bear River confluence (Spence *et al*. 1990).

Spence *et al*. (1990) suggested upper and lower Sustut River steelhead may be separate populations because they differed by their in-river distribution, size and age. In September and October 1986, Spence *et al*. (1990) found steelhead bimodally distributed in the upper and lower river, with only one steelhead located in a 70 km section between Bear River and Moosevale Creek (Figure 1). In September and October 1986, Spence *et al*. (1990) Floy anchor tagged 387 steelhead in the lower Sustut River and only recovered one of them in the upper Sustut River. Furthermore, none of the steelhead tagged in the lower river were among approximately 250 steelhead observed at the Sustut-Johanson confluence (Spence *et al*. 1990). Spence *et al*. (1990) suggested the bimodal distribution and low migration rates indicated both populations were near their respective overwintering areas. Also, Spence *et al*. (1990) reported lower Sustut River steelhead were significantly larger than upper Sustut River steelhead. They suggested the differences in fork length may be a result of shorter ocean residency for upper Sustut River steelhead, since they probably entered the Skeena River earlier to facilitate the longer migration. Scale analysis indicated upper Sustut River steelhead had longer freshwater residency than lower Sustut River steelhead (Spence *et al*. 1990). Spence *et al*. (1990) suggested steelhead parr in the upper Sustut River took longer to attain smolt size because of the shorter growing season in the upper river with respect to the lower river. Thus, both populations demonstrated local adaptations of evolutionary importance (Waples 1995).

Ward *et al*. (1993) proposed two populations may exist in the Sustut River with different run timing. Ward *et al*. (1993) analyzed tagged Sustut River steelhead as a single population and found the mode migration date passed Tyee was 9 days before the mean. In 1992, Ward *et al*. (1993) also found over half of the upper Sustut River steelhead were in the river prior to the date when Bustard (1993) observed tagged steelhead in the system. Thus, a significant portion of the upper Sustut River steelhead population was thought to have migrated passed Tyee before tagging in the commercial fishery began in the last week of July (Bustard 1993; Ward *et al*. 1993). Furthermore, the nine day discrepancy between mean migration dates passed Tyee, as determined by racial analysis of scales (Aug. 4; Cox-Rogers 1986) and Floy tag recoveries (Aug. 13), may reflect the early (upper) and late (lower) components of Sustut River steelhead (Ward *et al*. 1993).

The objectives of the 1996 enumeration program were:

1. to enumerate the upper Sustut River steelhead population,

2. to examine the sex, number, and size distribution of previously tagged steelhead that returned in 1996,

3. to examine the relationship between steelhead migration through the fences and physical parameters such as water temperature and river height,

4. to examine the size distribution of male and female steelhead, and

5. to estimate the population of sockeye heads in the Sustut River upstream of the fence.

The objectives of the review of 1986, 1992 - 1996 were:

1. to standardize and compare previous abundance estimates of upper Sustut River steelhead,

2. to examine the sex, number, size distribution and growth of recaptured upper Sustut River steelhead,

3. to examine the run timing of tagged upper and lower Sustut River steelhead passed Tyee,

4. to examine the relationship between the upper Sustut River steelhead population index and the cumulative steelhead index at Tyee test fishery on August 10,

5. to examine the length distributions of male and female steelhead between years, and

6. to examine the frequency and distribution of gillnet marks for all years of data collection.

2.0.0 Study Area

The Sustut River is an upper Skeena River tributary in northern central British Columbia (Figure 1). From Sustut and Johanson lakes, the Sustut River flows southwest for approximately 100 km to its confluence with 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. The common fish species in the upper Sustut River are steelhead, chinook salmon (*O. tshawytscha*), sockeye salmon, coho salmon (*O. kisutch*), bull char (*Salvelinus confluentus*), Dolly Varden char (*S. malma*), and Rocky Mountain whitefish (*Prosopium williamsoni*; Bustard 1993; Saimoto 1994; Saimoto 1995). The physical boundary for the upper Sustut River steelhead population is the Sustut River upstream of the Moosevale Creek confluence, including Johanson Creek and Sustut and Johanson lakes (Spence *et al*. 1990; Figure 1). Whereas, the physical boundary for 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).

3.0.0 Methods

3.1.0 1996 Enumeration Program

3.1.1 Steelhead Enumeration

One 3.8 cm P.V.C. floating fish counting fence was placed in the Sustut River, 500 m upstream of the confluence with Moosevale Creek and 70 km upstream of the confluence with Bear River (Figures 2, 3). The fence was operated from August 3 to October 1, 1996. On September 30, a stream - side survey was conducted to count steelhead holding below the fence to the Moosevale Creek confluence pool (500 m; Figure 2). The fence was inspected for openings and cleaned of debris daily whereas fish traps were emptied at least every two hours. An upper fence was not constructed in 1996.

All fish were identified to species using visual characteristics described in Scott and Crossman (1973) and for bull and Dolly Varden char, species were distinguished using branchiostegal counts (Haas and McPhail 1991). Prior to September 1, contract personnel for Fisheries and Oceans identified the sex, Floy anchor tagged and measured the fork length of every fifth steelhead. From September 1 through September 30, sex, fork length and the presence of gillnet or predator scars were recorded for all steelhead. Coloured and numbered Floy anchor tags were applied below the dorsal fin on 55 percent of all steelhead. From

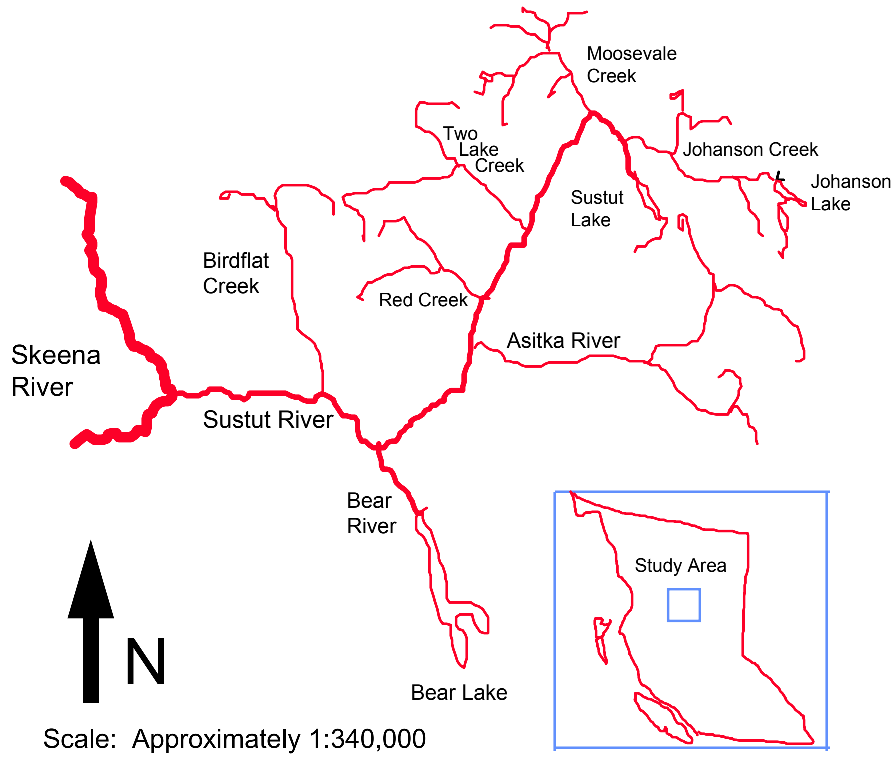

Figure 1. The Sustut River and major tributaries (from Saimoto 1995).
The physical boundary for the upper Sustut River steelhead population is the Sustut River upstream of the Moosevale Creek confluence, including Johanson Creek and Sustut and Johanson Lakes (Spence *et al*. 1990). The physical boundary for 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).

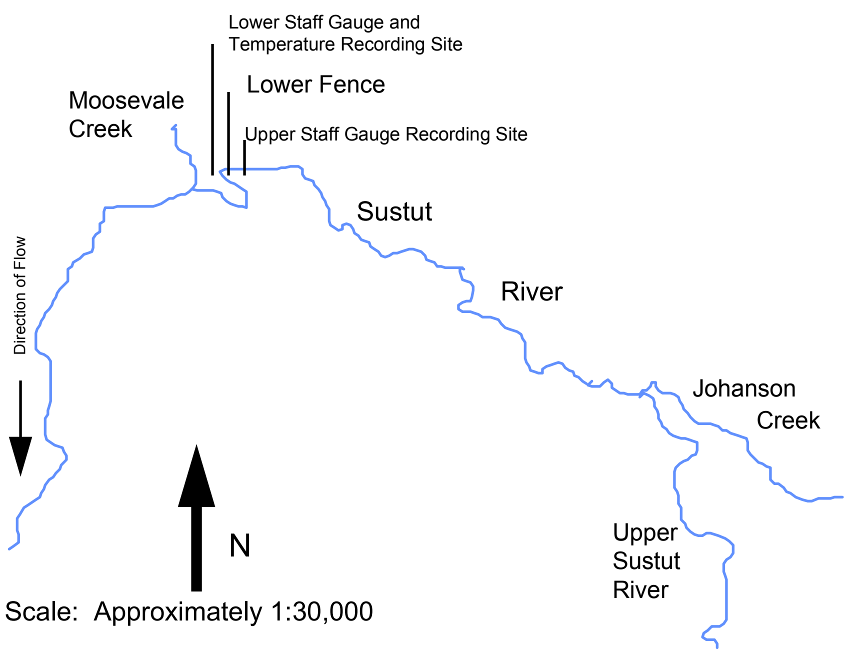

Figure 2. Detailed map of the study area (from Saimoto 1995).

a

b

Figure 3. Aerial photograph of the steelhead enumeration fence looking downstream (a) and photograph of the fence from the trail on the right bank (b) of the Sustut River, 1996.

50 steelhead, 10 scales were collected between the lateral line and dorsal fin for aging and stock identification studies (laser ablation). From the same 50 steelhead, adipose fin samples were collected for genetic analysis and stock identification. Steelhead mortalities due to handling were recorded at the fence.

3.1.2 Steelhead Recaptures

Sex, fork length and the presence of gillnet marks or predator scars were recorded for previous tagged steelhead (identified by Floy tag presence). Floy tag colour and number were recorded and compared to the Ministry of Environment, Lands and Parks Skeena Region TAGS database.

3.1.3 Steelhead Migration and Physical Parameters

The total number of steelhead that passed through the fence was recorded daily and compared to daily maximum water temperatures and staff gauge readings. Two staff gauges, one above and one below the fence were used to measure river height (Figure 2). Water temperature was measured with a Brannan min-max thermometer at the fence. Water temperature and river height data were collected by Ministry of Environment representatives from September 1 through September 30. J.O. Thomas and Associates (1370 Kootenay St., Vancouver, B.C.) provided water temperature from data loggers located near the fence for the period of May to September, 1996. River height data were not available from August 3 to August 31 when Fisheries and Oceans operated the fence (Dr. Cole Shirvell; personal communication).

3.1.4 Steelhead Length Distributions

Steelhead fork lengths were measured to the nearest 0.1 cm with an Evazote lined measuring tray. Fork lengths of male and female steelhead were compared using length-frequency histograms and mean fork lengths were compared with a Student’s t-test.

3.1.5 Sockeye Heads

To rudimentally quantify the extent of the Native subsistence fishery, sockeye salmon heads were collected from the fence, given a unique mark daily and then released that evening at the Junction Pool (11.2 km downstream of Sustut Lake), from August 30 to September 1, 1996. Sockeye heads were marked by clipping upper or lower maxilla or by clipping the left or right operculum. The Junction Pool was documented as the main Native fishing area in the upper Sustut River (Spence *et al*. 1990; Bustard 1993; Saimoto 1994) and was also the main site in 1996. The proximate areas to the Junction Pool were inspected for gut piles (Bustard 1993), but none were found and all evidence of fish cleaning indicated waste was discarded into the river. Native fishing activities ended at the Junction Pool on August 30.

The population of sockeye salmon heads in the Sustut River, between the Junction Pool and the fence, was estimated using a Schnabel mark-recapture method (Ricker 1975; Van Den Avyle 1993). Confidence limits (95 percent) were calculated using a Poisson approximation for few recaptures (Ricker 1975). The micro-computer program SCHNABEL (see appendix 2.3 in Krebs (1989) for source code) was used for calculations. The Schnabel estimate was chosen over the Schumacher - Eschmeyer estimate because we violated either of the Schumacher - Eschmeyer assumptions of a closed population or of constant catchability (Krebs 1989). Travel times and travel rates were also calculated for sockeye heads. We assumed all sockeye salmon heads retained their distinguishable marks until the end of the study, all marked heads were identified in the recapture sample, marked and unmarked heads were randomly mixed and equally vulnerable to capture on the fence, and that Native fishing had ended by the start of the study (Ricker 1975; Van Den Avyle 1993).

3.2.0 Review of 1986, 1992 - 1996

3.2.1 Steelhead Enumeration

Enumeration methods were described for each year to clarify how the total fall escapement was estimated. The estimated fall escapement of upper Sustut River steelhead were compared between years and to the adult abundance at maximum sustainable yield and carrying capacity estimated by Tautz *et al*. (1992).

3.2.2 Steelhead Recaptures

Sex and growth rate were analyzed for all tagged and recaptured upper Sustut River repeat spawners. Steelhead were classified as part of the upper Sustut River population if they were tagged or recovered in the upper Sustut River (Figure 1).

3.2.3 Timing of Tagged Steelhead

The timing of tagged upper and lower Sustut River steelhead that migrated by the Tyee test fishery (Figure 4) were calculated using tag data from the Tyee test fishery, commercial fishery, Native fishery, Skeena River bar fishery, lower Sustut River sport fishery, and upper Sustut River steelhead enumeration program (Appendix Tables 2, 3). Steelhead were classified as part of the upper Sustut River population if they were tagged or recovered in the upper Sustut River (Figure 1). Similarly, steelhead were classified as part of the lower Sustut River population if they were tagged or recovered in the lower Sustut River during September or

October (Figure 1). The methods of estimating timing passed Tyee differed for steelhead caught in the ocean and those caught in the Skeena River.

For ocean caught steelhead, we estimated the number of days to reach the Tyee test fishery by estimating the distance between the capture location and Tyee (Figure 4) and dividing by the estimated travel rate (Table 1). For steelhead caught in specific statistical fishing areas, we estimated the distance to Tyee by assuming steelhead were captured at a centroid within the statistical fishing area (Figure 4). For steelhead reported from Area 4 with no sub area, we assumed they were captured at the centroid in the area labeled 4-?? (Figure 4). We assumed ocean caught Sustut River steelhead traveled at the mean travel rate reported by Koski *et al*. (1995) for Sustut River steelhead migrating off the mouth of the Skeena River (10.2 km/d). Koski *et al*. (1995) measured the travel rates for Sustut River steelhead tagged in the commercial fishery off the mouth of the Skeena River to a radio transmitter recorder located at the confluence of the Exchamsiks River and Skeena River (57.6 km upstream of Tyee).

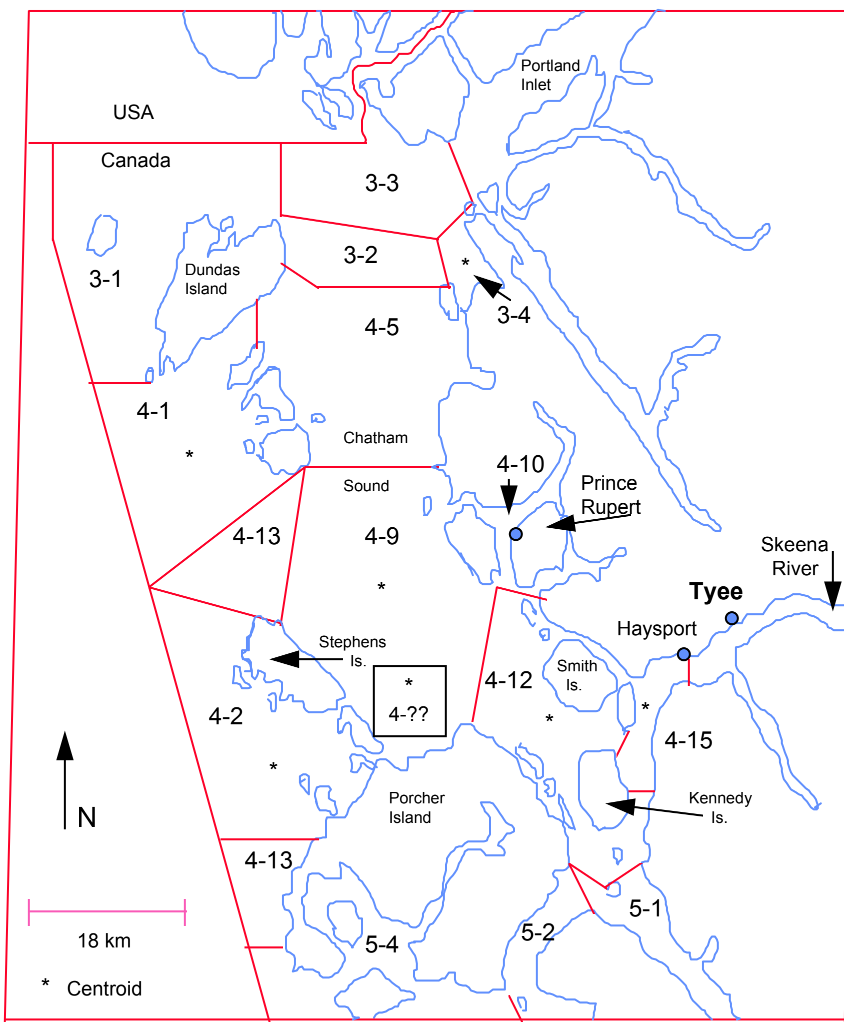

Figure 4. Map of statistical fishing areas and centroids for statistical areas where tagged steelhead were captured in the ocean. Areas without centroids had no tagged steelhead reported.

Table 1. Distance and travel rate estimates used to calculated travel time from statistical fishing areas (Figure 2) to Tyee for ocean caught steelhead.
Travel rate for Sustut River steelhead from Koski *et al*. (1995).

Capture Location	Distance to Tyee (km)	Travel Rate (km/d)	Travel Time to Tyee (d)
Area 4-15	15	10.2	1.47
Area 4-12	25	10.2	2.45
Area 4-09	53	10.2	5.20
Area 4-02	58	10.2	5.69
Area 4-??	47	10.2	4.61
Area 3-04	93	10.2	9.12

For steelhead caught in the Skeena River, the date of passage by the Tyee test fishery was estimated using reported travel rates and travel times for Sustut River steelhead and by estimating the distances to capture locations (Table 2; Figure 5). To estimate the travel time from Tyee, the Skeena River was divided into the sections used by Koski *et al*. (1995). Koski *et al*. (1995) reported mean travel rates and travel times for Sustut River steelhead migrating upstream through each section (Table 2). To estimate the travel time of steelhead captured within a section, we estimated the distance traveled in that section and divided by the travel rate for that section, reported by Koski *et al.* (1995). The estimated travel time in the section was then added to the sum of the travel times for the downstream sections to produce an estimate of the total travel time from Tyee. For example, a Sustut River steelhead caught at Esker Island (Figure 5) was estimated to have traveled 12 km upstream of the previous section (Exchamsiks River downstream to Tyee) at a travel rate of 16.2 km/d (Table 2). Thus, the estimated travel time from the previous section was 0.74 days. We estimated a Sustut River steelhead took 6.39 days to travel from the Tyee test fishery to Esker Island, since Sustut River steelhead were estimated to travel for 5.65 days from Tyee to the Exchamsiks River and 0.74 from the Exchamsiks River to Esker Island. Therefore if a Sustut River steelhead was caught on September 11 at Esker Island, we estimated it would have traveled passed the Tyee test fishery on September 4. The distances in Table 2 were estimated from figures in Koski *et al*. (1995). Travel time and travel rates were assumed to be similar to those reported by Koski *et al*. (1995) for Sustut River steelhead.

Table 2. Distance, travel rate and travel time estimates used to calculate travel time from the capture location to Tyee test fishery for steelhead caught in the Skeena River. Note, * indicates results from Koski *et al*. (1995) and N/A indicates not applicable. Skeena River locations are in Figure 5.

	Distance (km)	Travel Time (days)*	Travel Rate (km/d)*	Estimated Travel Time (d)	Estimated Travel Time From Tyee (d)
Tyee to Exchamsiks R.	57.6	N/A	10.2	5.65	5.65
Exchamsiks R. to Delta Cr.	5	N/A	16.2	0.30	5.95
Exchamsiks R. to Esker Island	12	N/A	16.2	0.74	6.39
Exchamsiks R. to Old Remo	55.1	N/A	16.2	3.40	9.05
Exchamsiks R. To Zymoetz R.	N/A	4.4	16.2	4.4	10.05
Zymoetz R. to Kitselas Fish Wheel	16	N/A	15.3	1.05	11.10
Zymoetz R. to Price Cr.	N/A	5.6	15.3	5.6	15.65
Price Cr. to Bulkley R.	N/A	2.3	19.8	2.3	17.95
Bulkley R. to 4 Mile Canyon	8	N/A	12.8	0.63	18.58
Bulkley R. to 1 Mile Upstream of Kispiox	27.2	N/A	12.8	2.13	20.08

The timing of tagged upper and lower Sustut River steelhead by Tyee were examined by date and by statistical week as defined in Appendix Table 1. The timing of tagged upper and lower Sustut River steelhead at Tyee was tested with a Mann-Whitney U-test. Run timing curves were not estimated for upper and lower Sustut River steelhead populations because the commercial fishery data were partially a reflection of steelhead abundance, the timing of commercial fishing openings, the amount of commercial fishing effort and the non random distribution of tags. Steelhead recapture data were pooled among years for upper and lower Sustut River steelhead populations because we assumed migration timing was similar between years, although the run timing for individual steelhead populations was estimated to vary up to 8.5 d between years (Ward *et al*. 1993).

Travel time through the commercial fishery was estimated by assuming Sustut River steelhead entered the fishery near Dundas Island (centroid in Area 4-01; Figure 4) and traveled 78 km to Tyee at a rate of 10.2 km/d (Koski *et al*. 1995).

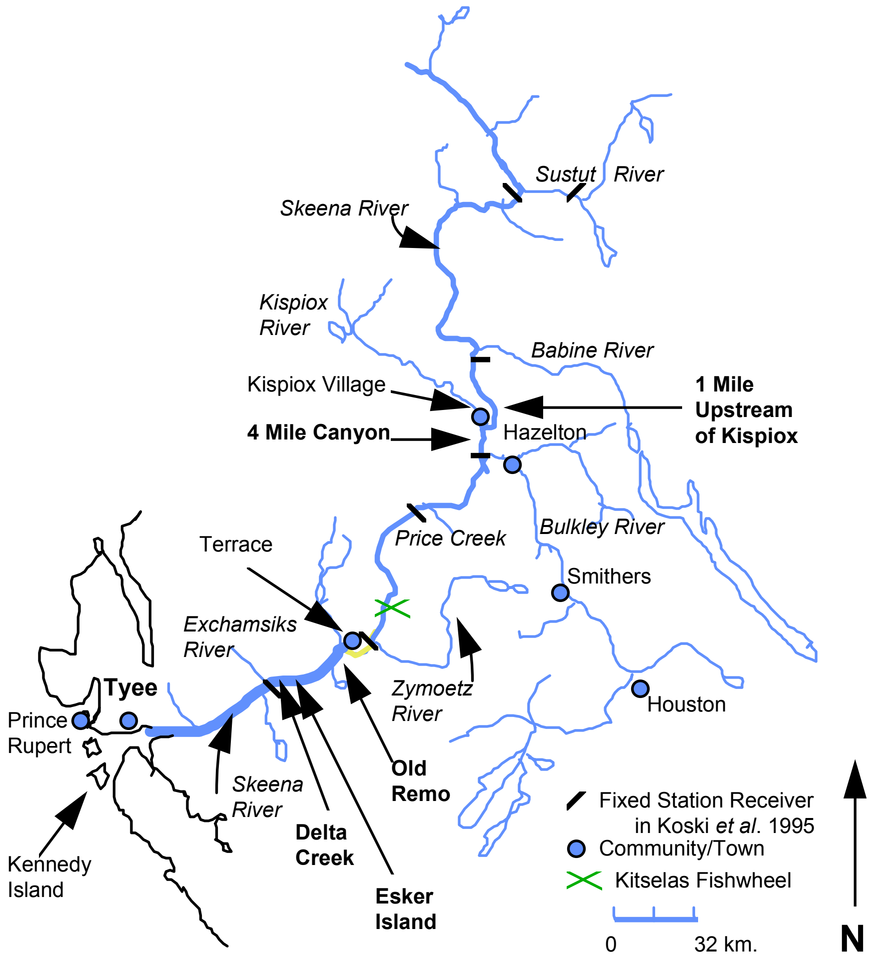

Figure 5. Map of Skeena River and locations from Table 2.

3.2.4 Upper Sustut River and Tyee Test Fishery Indexes

The cumulative steelhead index at Tyee test fishery has been used to indicate the relative abundance of steelhead and salmon migrating into the Skeena River (Cox-Rogers and Jantz 1993; Ward *et al*. 1993; Cox-Rogers 1994; Koski *et al*. 1995; Labelle *et al*. 1995). The cumulative steelhead index on August 10 was used to indicate the relative abundance of early run Skeena River steelhead (upper Sustut River steelhead). For tagged upper Sustut River steelhead, August 10 was the latest date to migrate passed the Tyee test fishery.

The relative abundance of upper Sustut River steelhead was standardized into a population index to reduce the variability resulting from the different enumeration methods. For 1986, the angling mark-recapture estimate was the standardized population index because it was the only method (Spence *et al*. 1990). For 1992, the snorkel mark-recapture estimate was chosen because it estimated the total population whereas the upper Sustut fence only estimated the number of steelhead migrating to Sustut Lake. For 1993 to 1996, the fence totals to the date nearest to September 30 were used as index values. Thus, for 1993 the upper Sustut and Johanson fence totals on September 28 were used. For 1994, the lower Sustut fence total on September 26 total was used. For 1995 and 1996, the lower fence totals on September 30 were used. Snorkel observations were excluded for 1994 and 1995 as none were available for 1996.

The relative abundance of upper Sustut River steelhead was based on fence counts for 1993 to 1996 because of the variable enumeration methods used. The relationship between the upper Sustut River steelhead population and the cumulative steelhead index at Tyee on August 10 was examined with correlation analysis and simple linear regression (Zar 1984; Ott 1993). Correlation analysis was used to determine if both indexes were positively correlated. Simple linear regression was then used *a posteri* to determine whether or not the cumulative steelhead index at Tyee test fishery on August 10 was useful as a predictor of the upper Sustut River steelhead population index.

3.2.5 Steelhead Length Distributions

The mean fork lengths of male and female steelhead were compared between years with a one way ANOVA. In order to compare mean fork lengths between years, a Levene test for homogeneity of variances between years was performed. Additional Bonferonni and Tukey HSD *post hoc* tests were used to determine which years were significantly different from each other.

Tukey box plots were constructed to graphically display male and female steelhead fork lengths between years. The extent of the box represented the 25th and 75th percentiles, the lines (whiskers) extending from the boxes were 10th and 90th percentiles and the circles were 5th and 95th percentiles. The dashed and solid lines within the box represented the mean and median fork lengths, respectively (Tilling *et al*. 1994).

3.2.6 Steelhead Gillnet Marks

Gillnet marks on steelhead were recorded at the fence in 1996 and compared to records of gillnet marks from 1992 (Bustard 1993), 1993 (Saimoto 1994), 1994 (Saimoto 1995) and 1995 (Parken and Morten 1996). The percentage of gillnet marks in each 2 cm fork length category was plotted by sex and year. A Student's t-test was used to compare the mean fork lengths of male and female steelhead with gillnet marks to male and female steelhead without gillnet marks.

4.0.0 Results

4.1.0 1996 Enumeration Program

4.1.1 Steelhead Enumeration

Before October 1, 1996, 466 steelhead passed through the Sustut River fence. An additional 49 steelhead were observed in the 500 m downstream of the fence to the Moosevale Creek confluence pool. However, some of the 49 steelhead may have already been included in the fence total as a number of steelhead were observed migrating downstream over the fence during a period of high river discharge between September 26 and 29, 1996. Also, steelhead that exhibited repetitive downstream migration behavior were released downstream of the fence. Another limitation in the estimate of steelhead downstream of the fence was that some steelhead may not have been observed. Between August 4 and September 30, 1996, 3,368 sockeye salmon, 33 coho salmon, and 8 bull trout were counted through the fence.

The first steelhead arrived at the fence on August 17, 1996 and by September 7, 50 percent of steelhead had passed by the fence (Figure 6; Table 3). The handling mortality rate at the fence was 2.8 percent (13 steelhead). Eleven (11) percent of steelhead had predator scars and 14 percent had gillnet marks.

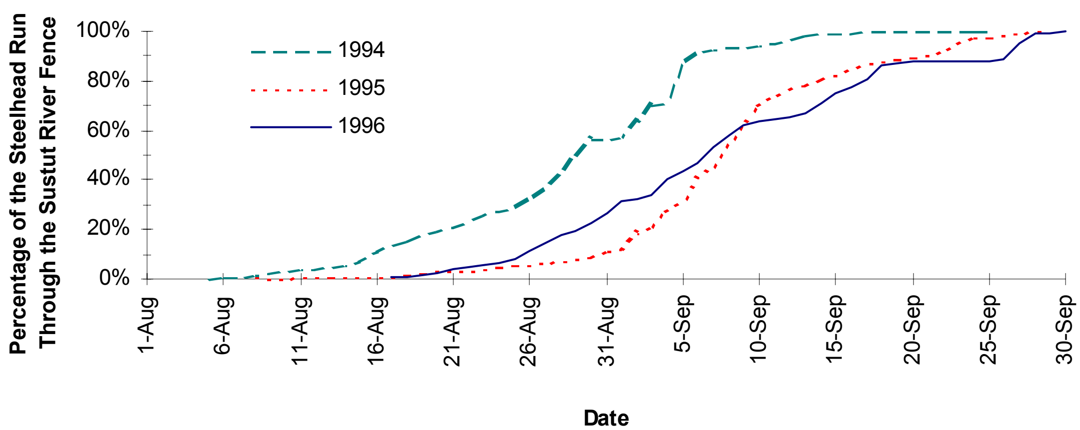

Figure 6. 1994, 1995 and 1996 daily cumulative percentages of the upper Sustut River steelhead run through the fence.

Table 3. Dates when 50 percent of steelhead migrated through the upper and/or lower fences on the upper Sustut River.

Year	Date 50 percent of steelhead run had passed: Upper Fence	Lower Fence
1993	August 28	N/A
1994	September 15	August 29
1995	September 10	September 8
1996	N/A	September 7

4.1.2 Steelhead Recaptures

Eight previously tagged steelhead were recaptured in 1996 (1.7 percent of the run; Table 4). Five steelhead were tagged in 1994 and two were tagged earlier in 1996. The steelhead tagged with the blue tag (row 3, Table 4) may have been a repeat spawner from 1994 or 1992, since no Skeena River steelhead were given blue tags in 1996 (Ron Tetreau; personal communication). Two (2.0) percent of steelhead tagged through the fences in 1994 returned in 1996. Thus, at least 1.3 percent of steelhead in 1996 were repeat spawners. Both steelhead tagged in 1996 were caught in the ocean by a tidal seine fisher. Of the eight fish recaptured, two were male, five were female and the other was unknown. Four of the five repeat spawners were female, although for two steelhead there was a discrepancy in the sex recorded at recapture and initial tagging.

Table 4. Summary of tag recoveries at the fence 1996.

Recaptures at Sustut Fence 1996			Tagging Information			
Date (yy/mm/dd)	Sex	Length (cm)	Date (yy/mm/dd)	Length (cm)	Sex	Location
960901	m	84.4	940916	74.0	f	upper fence
960901	f	83.0	940827	76.0	f	lower fence
960904	steelhead with a blue tag that escaped before data were recorded					
960908	f	79.1	940912	74.0	f	Sustut River
960909	m	84.5	96????	caught in the ocean by a tidal seine		
960911	f	82.7	940915	75.0	f	upper fence
960914	f	69.8	96????	caught in the ocean by a tidal seine		
960914	f	82.1	940827	79.0	m	lower fence

4.1.3 Steelhead Migration and Physical Parameters

Maximum daily water temperature and staff gauge height were plotted with steelhead migration at the fence for 1996 (Figures 7, 8). As temperature increased on September 17 a coincidental increase in steelhead migration occurred. Overall, no clear increases in steelhead migration occurred with fluctuations in water temperature. Daily minimum, maximum and mean water temperatures at the fence were plotted in Appendix Figure 1. A minor increase in steelhead migration coincided with a minor increase in river height on September 7 and a stronger increase in migration coincided with a fall freshet between September 26 and 29.

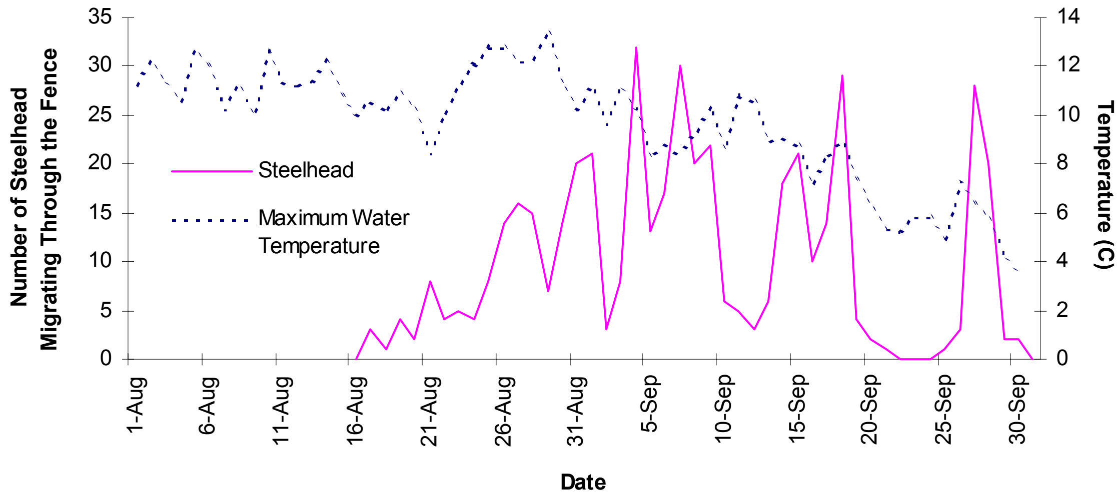

Figure 7. Daily maximum water temperature and the number of steelhead migrating at the fence. Maximum water temperature data from J.O. Thomas and Associates.

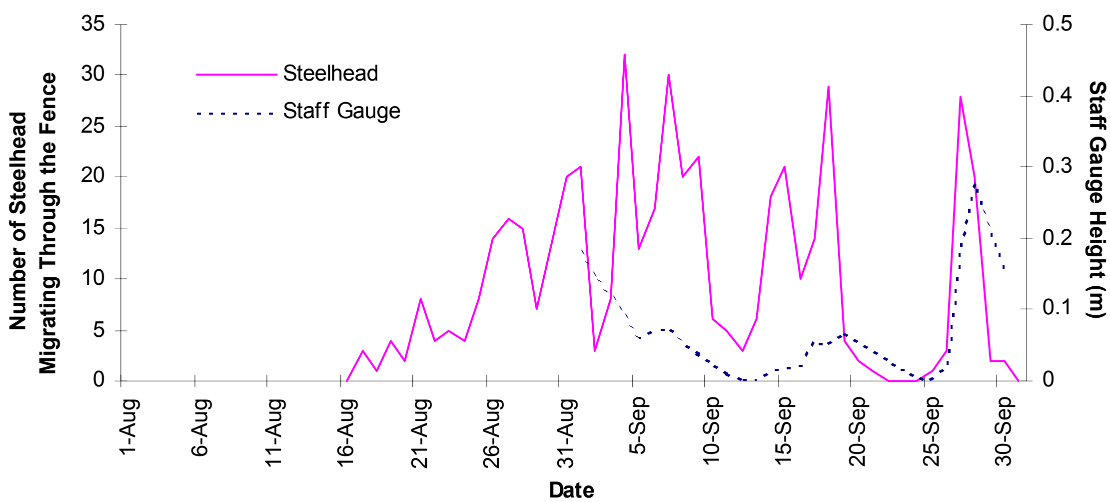

Figure 8. Daily staff gauge height and the number of steelhead migrating at the fence. Staff gauge height data were not available from August 1 to August 31.

4.1.4 Steelhead Length Distributions

In 1996, 356 steelhead were identified for sex and measured at the fence on the Sustut River. A total of 218 (61.2 percent) were female while 138 (38.8 percent) were male. Thus, the ratio of female to male steelhead was 1.58 : 1. The mean fork length of female steelhead was 73.9 cm whereas the mean fork length of male steelhead was 82.9 cm. The length distribution of male and female steelhead, as grouped by 2 cm categories, illustrated that males were generally larger than females (Figure 9). Statistically, the mean fork length of male steelhead was significantly larger than the mean fork length of female steelhead (Student's t-test = 16.320, $P < 0.0005$).

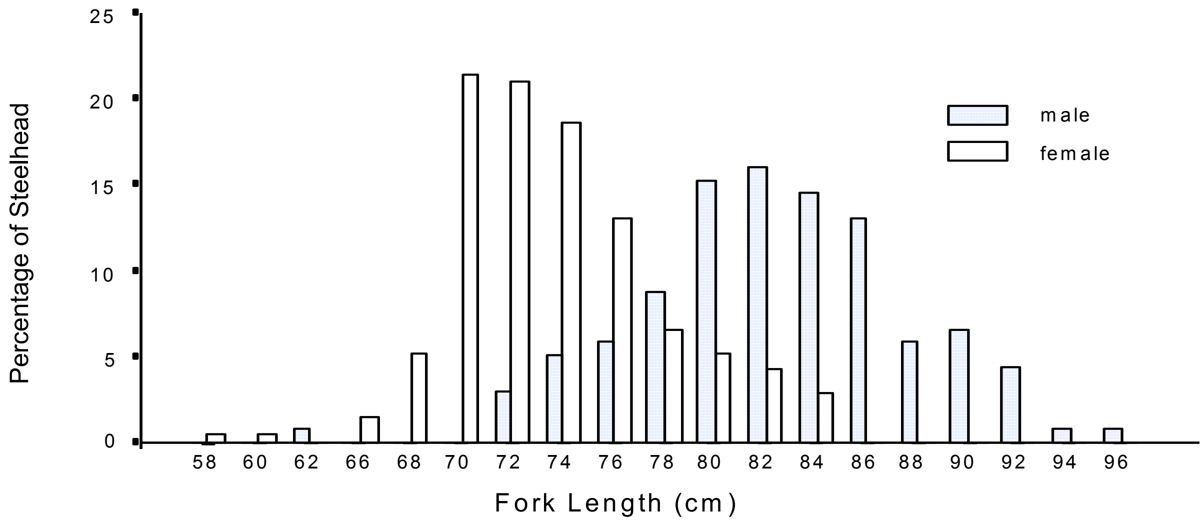

Figure 9. Percentage of male and female steelhead by categories of fork length (cm).

4.1.5 Sockeye Heads

Ten unmarked sockeye salmon heads were collected from the fence and given unique marks (Table 5). The Schnabel estimate was 12.2 sockeye heads (95 percent confidence limits: 10, 31.0 heads) between the Junction Pool and the fence between August 30 and September 1, 1996. For the sockeye salmon heads recovered, all took one day to reach the fence and traveled at 4.5 km/d. In total, 15 sockeye heads were released into the Sustut River and 5 were recovered at the fence. Thus, 33 percent of marked sockeye salmon heads were recovered at the fence (range: 0 to 100 percent). Assuming simple random sampling, ratio estimation (Scheaffer *et al*. 1990) indicated as many as 30 sockeye salmon heads were present in the Sustut River based on the 10 unmarked sockeye heads recovered. Two steelhead heads were collected from the fence prior to August 30 (Heather Steffey; personal communication). Assuming steelhead heads were similar to sockeye heads, ratio estimation indicated as many as six steelhead heads were present in the Sustut River, based on the two steelhead heads recovered.

Table 5. Summary of sockeye salmon head mark-recapture data.

	Number of Sockeye Heads Captured			Percentage of Marked Heads
Date	**Marked (R)**	**Unmarked**	**Total (C)**	**Recovered From Previous Night**
August 30	0	7	7	N/A
August 31	2	1	3	29
September 1	3	2	5	100
September 2	0	0	0	0

4.2.0 Review of 1986, 1992 - 1996

4.2.1 Steelhead Enumeration

As a result of the different enumeration methods used from 1986 to 1996, time series comparisons were difficult because the inter-annual variability in population size may have been confounded by the variability in enumeration methods (Table 6). For 1986, angling mark-recapture was used to estimate the population size (823; Spence *et al*. 1990). In 1992, a fence on the Sustut River upstream of the Johanson Creek confluence and a snorkel mark-recapture method was used to estimate the total population (487; Bustard 1993). In 1993, a snorkel survey and enumeration fences on Johanson Creek and on the Sustut River upstream of the confluence of Johanson Creek were used for population estimation (Saimoto 1994). The total population estimate (476) was the sum of the number of steelhead observed by snorkeling downstream of the fences (276) and the total fence counts (200). In 1994, a fence upstream of the Moosevale Creek confluence and another upstream of the Johanson Creek confluence, plus a snorkel survey downstream of the fences were used for enumeration (Saimoto 1995). The population estimate (598) was the sum of the lower fence total on September 26 (584) and the snorkel survey downstream of the fence (14). In 1995, two fences and a snorkel survey were used for enumeration, similar to the methods in 1994 (Parken and Morten 1996). The total population estimate (658) was the sum of the lower fence (465) and a snorkel survey on September 29 (193). As previously stated, in 1996 the sum of the fence total (466) and a stream side survey (49) was used for population estimation (515; Table 6). The 1996 population estimate may be biased by double counting of steelhead counted at the fence and the ability of the method to distinguish or observe all steelhead.

The total population estimates ranged from a high of 823 in 1986 to a low of 476 in 1993 (Figure 10). From 1992 to 1996, the total population estimates fluctuated little (range, 487-658) and indicated partial stability of fall escapement. For 1992, 1993 and 1996, population estimates were similar and were within a range of 39. All fall escapement estimates were substantially below carrying capacity (K = 1036; Tautz *et al*. 1992), and in three of six years the fall escapement was approximately half of carrying capacity (1992, 1993, and 1996, Table 6). In all years, the total population estimate was higher than the number of spawners required at maximum sustainable yield (P_s = 418; Tautz *et al*. 1992).

Table 6. Summary of fall escapement data from 1986 to 1996.

Year	Upper Sustut Fence	Lower Sustut Fence	Johanson Fence	Snorkel Survey Down-stream of Fence	Stream Walk Survey	Handling Mortality (percent)	Total Estimated Fall Escapement	Percentage of Carrying Capacity (1036; Tautz *et al*. 1993)	Standardized Population Index	Source	Methods for Standardizing Index Values
1986	NA	NA	NA	NA	NA	NA	**823**	79	**823**	Spence *et al*. 1990	Schumacher-Eschmeyer mark recapture estimate based on angling in the upper Sustut River during Sept. and Oct.[1]
1992	150	NA	NA	NA	NA	2.0	**487**	47	**487**	Bustard 1993	Corrected snorkel observation for tagged to untagged fish
1993	26	NA	182	276	NA	0	**476**	46	**208**	Saimoto 1994	Total steelhead that passed the Johanson and upper Sustut River fences
1994	154	584	NA	14	NA	0.5	**598**	58	**584**	Saimoto 1995	Total steelhead that passed the lower Sustut River fence by Sept. 26
1995	202	467	NA	193	NA	4.3	**658**	64	**467**	Parken & Morten 1996	Total steelhead that passed the lower Sustut River fence by Sept. 30
1996	NA	466	NA	NA	49	2.8	**515**	50	**466**	Parken *et al*. 1996	

1. Schumacher-Eschmeyer mark recapture estimate was chosen over Schnabel and Chapman mark-recapture estimates because it is considered more reliable (Krebs 1989).

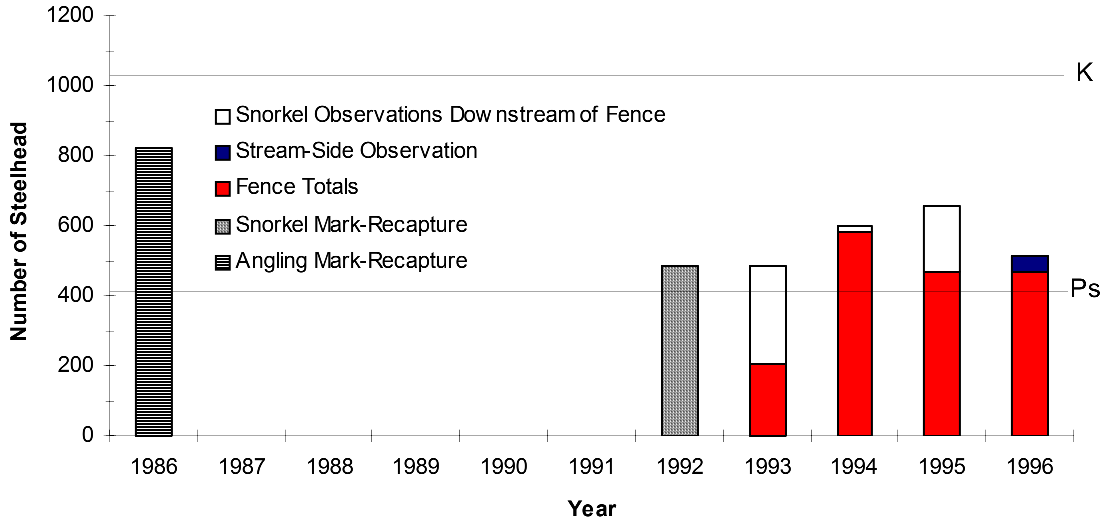

Figure 10. Time series of the upper Sustut River steelhead population. The differential shading indicates the enumeration methodology, whereas the horizontal lines labeled K and P_s indicate the number of spawners at carrying capacity and the number of spawners at maximum sustainable yield, respectively (Tautz *et al*. 1992).

4.2.2 Steelhead Recaptures

For all years, fifty-four recaptured steelhead were identified as upper Sustut River steelhead (Appendix Table 3). Twenty-six were tagged and recaptured in the same year during the spawning migration. Twenty-two had two years between the tag and recapture date and were considered to be repeat spawners. Five were recaptured less than one year after their spawning migration (kelts). Another steelhead (male, 84 cm) was tagged at the lower fence in 1994 and then passed through the upper fence in 1995 and apparently did not leave the upper Sustut River. Of the 22 repeat spawners, 1 was a male, 15 were female, 3 were unidentified and 3 had discrepancies of sex identification between tag and recapture. Eight of the 22 repeat spawners had fork lengths recorded when they were tagged and recaptured. Seven steelhead were used to calculate a mean growth of 6.9 cm in two years (3.45 cm/year). One of the eight steelhead had a negative growth of 7 cm and it was excluded from growth calculations because it was assumed to be a recording error.

4.2.3 Timing of Tagged Steelhead

The distribution of tagged upper and lower Sustut River steelhead indicated the populations differed in timing passed Tyee by statistical week (Figure 11). At Tyee, the timing for tagged upper Sustut River steelhead ranged from statistical week 6-4 to 8-1 and was highest in week 7-4, whereas tagged lower Sustut River steelhead ranged from statistical week 7-3 to 9-1 and was highest in weeks 8-1 and 8-2. Tagged upper Sustut River steelhead were estimated to migrate passed Tyee between June 25 and August 10 (mean = July 25, median = July 23), whereas tagged lower Sustut River steelhead were estimated to migrate passed Tyee between July 16 and September 7 (mean = August 15, median = August 14). Further analysis found tagged upper Sustut River steelhead migrated by Tyee before tagged lower Sustut River steelhead (Mann-Whitney U test = 32.0 , $P < 0.0005$). The mean date for pooled upper and lower Sustut River steelhead migrating passed Tyee was August 4. The mean date passed Tyee may not necessarily represent the peak date in migration because data were not corrected for commercial fishing effort. We estimated Sustut River steelhead took eight days to migrate through the commercial fishery from Area 4-1 to Tyee. Thus, the mean date that tagged upper and lower Sustut River steelhead entered Area 4 was July 17 and August 7, respectively.

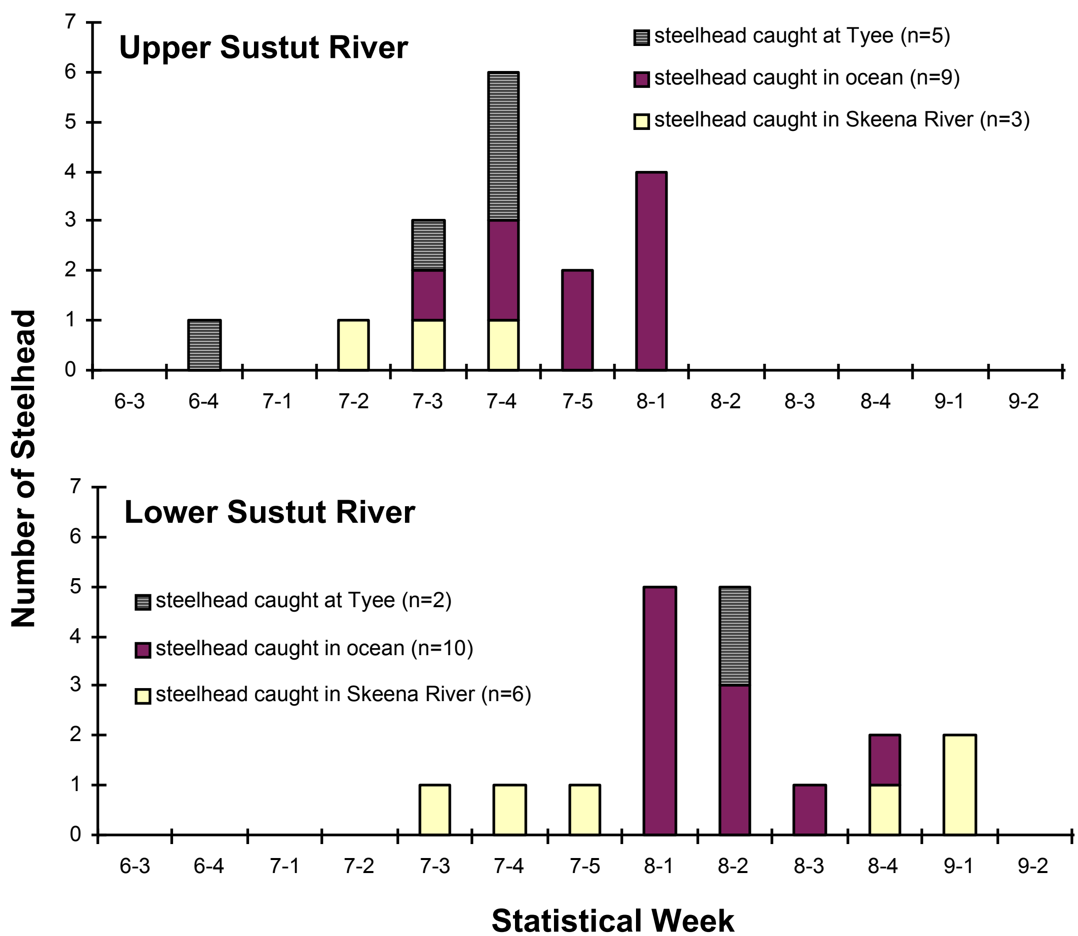

Figure 11. Timing of tagged upper and lower Sustut River steelhead populations passed the Tyee test fishery.

Upper and lower Sustut River steelhead kelts were grouped by their capture location (Table 7). Steelhead kelts were caught in Area 4 from June 18 to August 9. Overall, kelts were caught most frequently during the last week of June. The date when kelts migrated downstream passed Tyee was not calculated because downstream steelhead migration rates were unknown.

Table 7. Dates of steelhead kelts recaptured in the Skeena River and statistical areas for upper and lower Sustut River steelhead populations.

Sustut River Steelhead	Kelt Recapture Location						
	Tyee Test Fishery	Area 4-15	Area 4-12	Area 4-9	Area 4-1	Area 4-??	4 Mile Canyon
Upper Sustut	June 21 June 28 June 29	June 27					June 15
Lower Sustut	July 5	June 18	June 17 July 2	June 26	June 29	July 8 Aug. 9	

4.2.4 Upper Sustut River and Tyee Test Fishery Indexes

The upper Sustut River steelhead population index (Table 6) was positively correlated to the cumulative steelhead index at Tyee test fishery on August 10 (Pearson Correlation R = 0.81, P = 0.025; Figure 12). Thus, as the cumulative steelhead index values at Tyee on August 10 increased, upper Sustut River steelhead population index also increased. The upper Sustut River steelhead population index was significantly related to the cumulative steelhead index at Tyee on August 10 (ANOVA F = 7.610, P = 0.051), but was dependent upon the 1986 data point. Thus, the cumulative steelhead index at Tyee on August 10 was useful in predicting the upper Sustut River population index values.

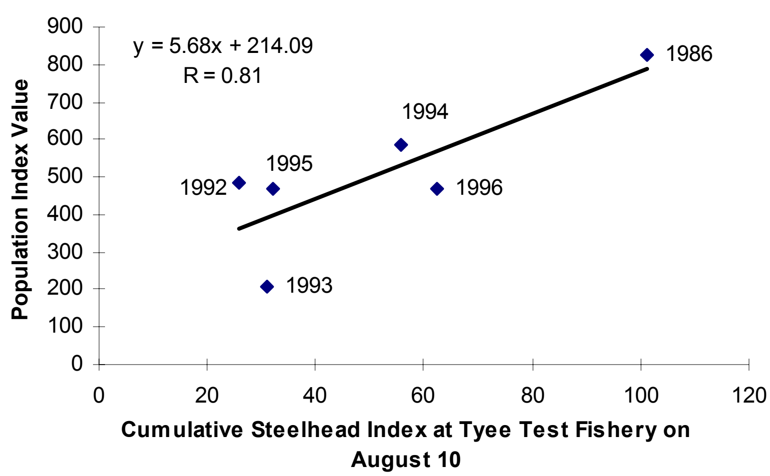

Figure 12. Linear relationship between the upper Sustut River steelhead population index and the cumulative steelhead index at Tyee test fishery on August 10.

4.2.5 Steelhead Length Distributions

The mean fork lengths of 1996 male and female steelhead were within the range established by previous years (Table 8). A one way ANOVA determined male and female[1] fork lengths differed significantly between 1992, 1993, 1994, 1995 and 1996 (ANOVA F = 12.561, $P < 0.0005$ and ANOVA F= 11.294 $P < 0.0005$, respectively). This result indicated at least one of the years (and not necessarily all the years) was different from another year. Further *post hoc* tests (Bonferonni and Turkey HSD) indicated the fork lengths of 1992 male and female steelhead were significantly smaller than those from 1993, 1994, 1995 and 1996 steelhead. All other years were not significantly different from each other.

Table 8. A summary of the mean, standard error and range in fork lengths for male and female steelhead in 1992, 1993, 1994, 1995 and 1996.

	1992	**1993**	**1994**	**1995**	**1996**	***ANOVA P* values**
Female						
Mean fork length (cm)[1]	72.1	74.9	73.7	74.6	**73.9**	< 0.0005[2]
Standard Error (cm)	0.19	0.48	0.43	0.31	**0.29**	
Size range (cm)	65-82	66-87	65-84	58-90	**58-85**	
Male						
Mean fork length (cm)[1]	77.7	84.8	82.4	82.6	**82.9**	< 0.0005
(Standard Error) (cm)	0.66	0.66	0.75	0.38	**0.45**	
Size range (cm)	69-91	53-94	71-99	71-100	**63-96**	
t-test *P* values	<0.0005	<0.0005	<0.0005	<0.0005	**<0.0005**	

[1] The mean lengths reported for 1992, 1993 and 1994 differ slightly from the results of the original reports because the complete data sets were unavailable. [2]From *post hoc* tests, the mean fork length of male and female 1992 steelhead were significantly smaller than other years.

The significant differences between 1992 steelhead fork lengths and other years, and between the male and female fork lengths were also evident when box plots were examined (Figure 13). The proximity of the mean and median lines on each of the box plots indicated the distribution of fork lengths within years and sex were not heavily skewed.

[1] Although the female populations of fork length did not have equal variances, as determined by the Levene statistic, a one way ANOVA was performed because of the robustness of the test when slight departures from the assumption of equal variances exist (Zar 1984).

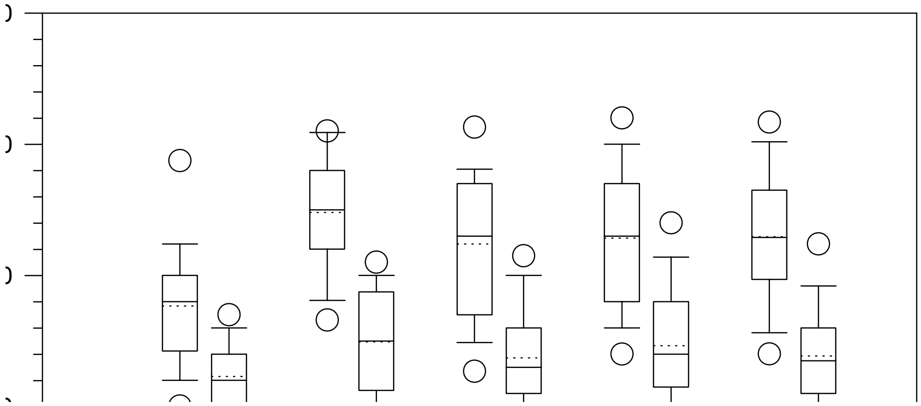

Figure 13. Tukey box plots of steelhead lengths (male and female) by year. Note, * indicates 1992 fork lengths were significantly different from other years. The extent of the box represented the 25th and 75th percentiles, the lines (whiskers) extending from the boxes were 10th and 90th percentiles and the circles were 5th and 95th percentiles. The dashed and solid lines within the box represented the mean and median fork lengths, respectively (Tilling *et al*. 1994).

4.2.6 Gillnet Marks

The percentage of steelhead with gillnet marks in 1996 (14 percent) was within the range of gillnet marks for other years (Table 9). The percentage of steelhead with gillnet marks was not related to the number of gillnet boat days up to statistical week 8-1 (Pearson Correlation R = 0.38; ANOVA F = 0.50, P = 0.53). For all years of steelhead enumeration, 11.4 percent (159 steelhead) had gillnet marks and ranged in length from 58 to 90 cm (Figure 14). Male steelhead with gillnet marks (mean = 80.3 cm) were significantly different than male steelhead without gillnet marks (mean = 82.5 cm, Student's t-test = 2.220 P = 0.027). Similarly, female steelhead with gillnet marks (mean = 73.1 cm) were significantly different than females without gillnet marks (mean = 73.9 cm, Student's t-test = 2.064, P = 0.039), however the magnitude of the differences was small. The size distribution of male and female steelhead with gillnet marks followed the same size distribution as the total population (Figure 14). However in 1994 and 1995 when a significant proportion of the population consisted large steelhead (> 86 cm), no large steelhead were observed with gillnet marks (Figure 15)

The size distribution of steelhead with gillnet marks was similar for all years (range of 66 to 90 cm; Figure 15). From 1994 to 1996, steelhead with gillnet marks were more frequent among smaller steelhead. However, for 1992 and 1993 steelhead with gillnet marks were more evenly distributed throughout the population.

Table 9. Percentage of steelhead with gillnet marks and gillnet boat days up to statistical week 8-1 by year of enumeration project.

Year	Percentage of Steelhead with Gillnet Marks (%)	Gillnet Boat Days up to Statistical Week 8-1
1992	23	10, 057
1993	11	9, 961
1994	2	7, 450
1995	6	11, 472
1996	14	12, 802

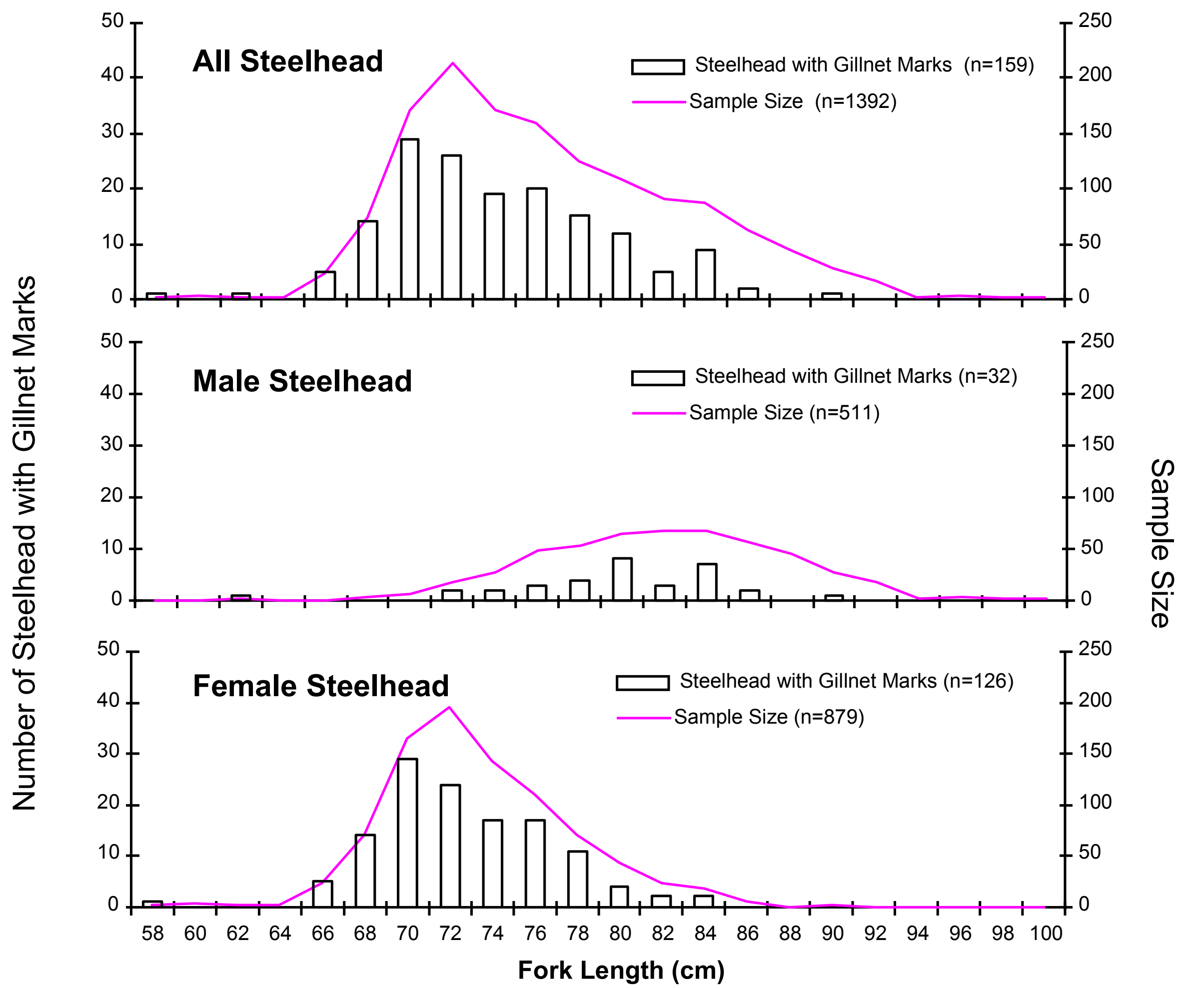

Figure 14. The percentage of steelhead with gillnet marks in each 2 cm fork length category and sample sizes for all steelhead, all male steelhead and all female steelhead.

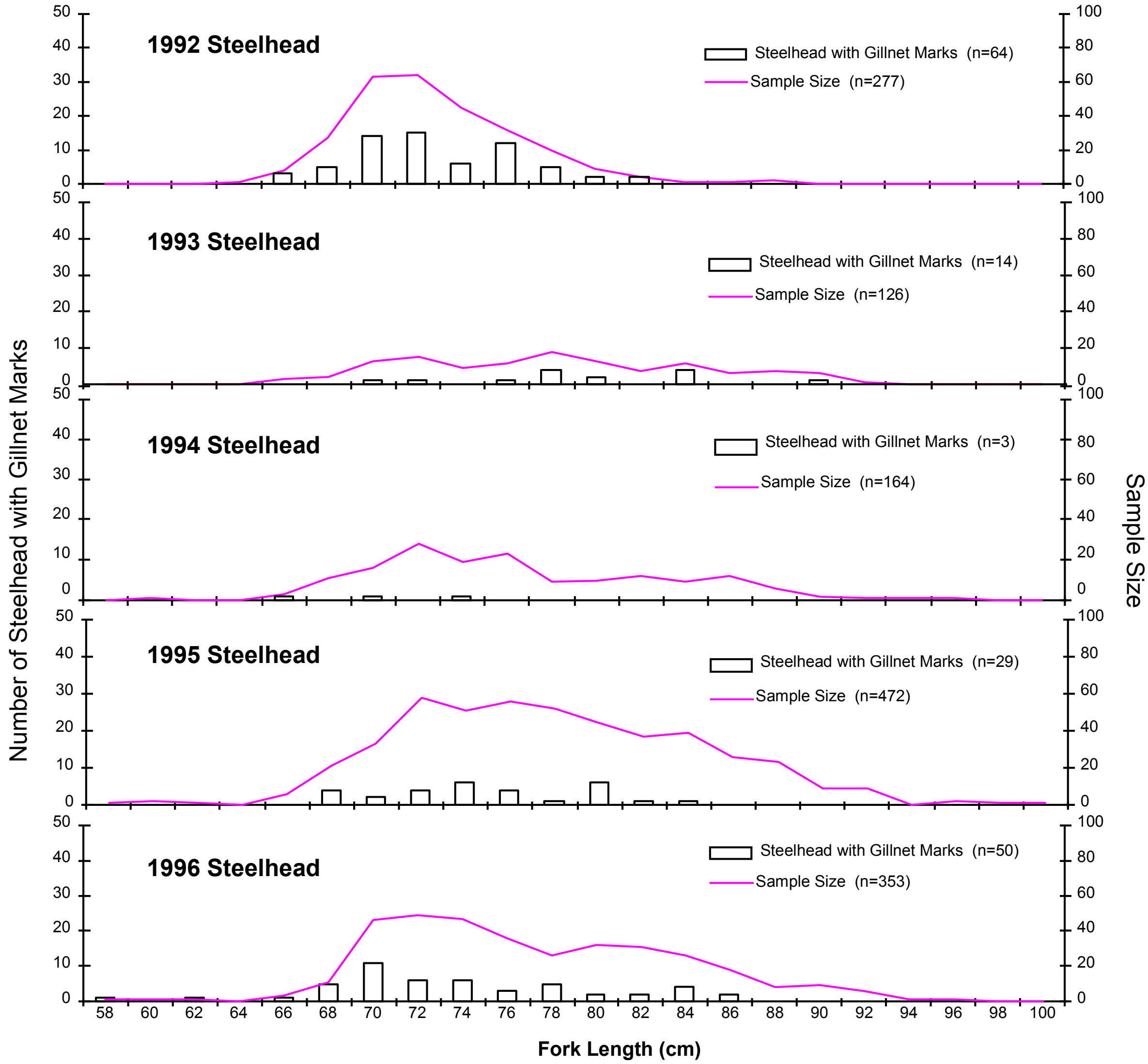

Figure 15. The percentage of steelhead with gillnet marks in each 2 cm fork length category and sample sizes for 1992, 1993, 1994, 1995 and 1996.

5.0.0 Discussion

5.1.0 1996 Enumeration Program

Steelhead enumeration on the upper Sustut River has taken place for six years. In 1996, the fall escapement (515) was lower than the results of 1986 (823; Spence *et al*. 1990), 1994 (598; Saimoto 1995) and 1995 (658; Parken and Morten 1996), but higher than the results of 1992 (487; Bustard 1993) and 1993 (476; Saimoto 1994). The fall escapement estimates indicated some variability in the number of spawners returning to the upper Sustut River (467 to 823), but for three of six years the values were similar (476 to 515). The variability in population estimates may in part be a reflection of the different enumeration methods, since different methods were used in each of the six years.

In 1996, the 50 percent cumulative proportion date of upper Sustut River steelhead through the fence (September 7) was similar to previous results for upper Sustut River steelhead. In 1995, the 50 percent cumulative proportion date through the fence was one day later than 1996 (September 8; Parken and Morten 1996), but in 1994, the 50 percent cumulative proportion date 50 percent was over a week earlier (August 29; Saimoto 1995). In 1996, the first steelhead arrived at the fence on August 17, later than the two previous years. In 1995, the first steelhead arrived over a week earlier (August 8; Parken and Morten 1996) and in 1994 the first steelhead arrived almost two weeks earlier (August 5; Saimoto 1995).

The steelhead mortality rate from handling at the fence (2.8 percent) was within the range of past mortality rates of steelhead enumeration in the upper Sustut River. In 1995, the mortality rate (4.3 percent; Parken and Morten 1996) was higher than in 1996, whereas the mortality rates in 1992 (2.0 percent; Bustard 1993), 1993 (0 percent; Saimoto 1994) and 1994 (0.5 percent; Saimoto 1995) were lower. The fluctuation of water temperatures between years may contribute to the variability in steelhead mortality rates.

The upper Sustut River population had a low percentage of repeat spawners, as evidenced by Floy tags. In 1996, at least 1.3 percent of steelhead passing through the fence were previously tagged in 1994 and were considered repeat spawners. In 1995, Parken and Morten (1996) found at least 1.2 percent of upper Sustut River steelhead were repeat spawners. Saimoto (1995) found six percent of the 1994 upper Sustut River population to consist of repeat spawners by examining scales. Fewer repeat spawners in 1995 and 1996 than 1994 may be a result of tag loss at gillnets or that scales more accurately indicate repeat and double repeat spawners. The low percentage of repeat spawners in the upper Sustut River is similar to the results found for other Skeena River steelhead populations in the Kitsumkalum River (2.6%; Lough and Whately 1984), Bulkley River (3.4%; O'Neill and Whately 1984), Suskwa River (3.8%; Chudyk 1978), Morice River (6.6%; Whately *et al*. 1978) and Babine River (6.9%; Narver 1969; Whately and Chudyk 1979). However, the percentage of repeat spawners was reported to be substantially higher in the Kispiox River (17.6%; Whately 1977) and the Zymoetz River (29%; Chudyk and Whately 1980).

Past enumeration projects of upper Sustut River steelhead indicated water temperature and river height could coincide with steelhead movement. In 1996, changes in steelhead migration through the fence did not coincide with fluctuations in water temperature as they did in 1994 (Saimoto 1995) and 1995 (Parken and Morten 1996). A slight increase in staff gauge height on September 7 followed by a strong freshet on September 26 through 29 both coincided with increased steelhead migration. Bustard (1993) also reported similar results for an increase in steelhead migration that coincided with an increase in river height in late September, 1992.

In 1996, 61 percent of steelhead were female and 38 percent were male (1.58 : 1). Similar to 1996, from 1992 to 1994 the sex ratio was strongly skewed towards females, which composed 63 to 80 percent of steelhead sampled (Bustard 1993; Saimoto 1994; and Saimoto 1995). The skewed sex ratios were strongly influenced by the disproportionate sampling throughout the run. From 1992 to 1994 and 1996 the under representation of males may be a result of only a few steelhead being identified for sex before September 1. In 1995, a more balanced ratio of females to males (1.23 : 1) resulted from every steelhead being identified for sex before September 1 (Parken and Morten 1996). Past research found males dominate in the beginning of the run and females dominate near the end of the run (R.S. Hooton, personal communication). Therefore, a difference in run timing could account for the increase in male steelhead sampled.

Based on estimated catch of sockeye, Native fishing activities in the upper Sustut River in 1996 (10 to 30 sockeye) appeared to have declined from the higher levels observed in 1992 (466 sockeye, Bustard 1993). The 1996 Native harvest was similar to the estimated harvest of 50 sockeye in the upper Sustut River in 1986 (Spence *et al*. 1990), but low compared to the estimated 466 sockeye taken in the 1992 Native fishery (Bustard 1993). In 1993, Native fishing commenced on September 24 and 25 and few sockeye were probably caught at this time since sockeye migrations had generally ended by then (Saimoto 1994). In 1994, Native fishing ended on August 31 when the Department of Fisheries and Oceans made an official closure (Saimoto 1995). Also, Saimoto (1995) expressed the amount of Native fishing activity had declined from 1992. Native fishing activities were not reported in 1995 (Parken and Morten 1996) and were assumed to be low, similar to 1994 and 1996.

5.2.0 Review of 1986, 1992 - 1996

A review of fall escapement estimation from 1986 to 1996 indicated that upper Sustut River steelhead escapement was fairly stable. The high abundance of steelhead in 1986 reflected high steelhead returns throughout the Skeena River as indicated by the second highest recorded cumulative steelhead index at Tyee test fishery on August 25 since 1956 (unpublished data; Fisheries and Oceans Canada). Similarly, the low steelhead abundance in 1992 and 1993 reflected low steelhead returns to the Skeena River as the cumulative steelhead index at Tyee test fishery were below the 5 and 10 year averages (unpublished data; Fisheries and Oceans Canada). Tautz *et al*. (1992) cautioned that some unproductive Skeena River steelhead populations, all of which had early run timing, could be exploited at rates in excess of their conservation requirements in some years. However, the fall steelhead escapement exceeded the minimum number of breeding adults required to meet the conservation requirements in all years (300; Waples *et al*. 1990; Labelle 1995).

Our results for timing of tagged upper and lower Sustut River steelhead passed the Tyee test fishery were consistent with other results that suggested two separate populations existed (Spence *et al*. 1990; Ward *et al*. 1993). Previous results indicated two populations may be present in the Sustut River, but prior research on run timing treated Sustut River steelhead as a single population because little information existed from the separate populations (Cox-Rogers 1986; Spence 1989; Ward *et al*. 1993). Waples (1995) suggested distinct population segments could be identified by differences in morphology (size, fecundity) and life history (age, migration timing) that reflect local adaptation, but genetic evidence was necessary to assess the degree of distinction between populations. Since morphology and life history information already indicate separate populations, the use of mini- and microsatellite single-locus markers may provide insight into the level of genetic differentiation between upper and lower Sustut River steelhead populations (Labelle *et al*. 1995).

Skeena River summer steelhead consist of a composite of separate populations with early, middle and late run timing (Lough 1981; Cox-Rogers 1986; Spence 1989; Beere 1991; Ward *et al*. 1993; Cox-Rogers 1994; Koski *et al*. 1995). Tagged upper and lower Sustut River steelhead had an estimated early (July 25) and late (August 15) timing passed Tyee when compared with the results for other Skeena River steelhead populations (Ward *et al*. 1993). Ward *et al*. (1993) estimated the mean run dates passed Tyee for steelhead populations in the Morice (August 4), Zymoetz (August 5), Babine (August 6), Bulkley (August 10), Kispiox (August 14) and Susqwa (August 24) rivers from tag recoveries. Cox-Rogers (1994) considered Morice, Babine and Kispiox river steelhead populations as examples of Skeena River steelhead with early, mid and late run timing, respectively. Upper Sustut River steelhead have been used as an index population for early run Skeena River steelhead since 1986 (Bustard 1993; Saimoto 1994; Saimoto 1995; Parken and Morten 1996).

The timing estimates of tagged upper and lower Sustut River steelhead migration passed Tyee were generally earlier than previous estimates. We estimated tagged upper Sustut River steelhead entered the commercial fishery on July 17, whereas Bustard (1993) estimated upper Sustut River steelhead migrated through the commercial fishery between July 10 and August 5. Similar to our results, Spence *et al*. (1990) estimated upper Sustut River steelhead entered the Skeena River during the latter part of July. For tagged lower Sustut River steelhead, timing through the commercial fishery (August 7) was estimated to be earlier than results of Spence *et al*. (late August to early September; 1990). For pooled Sustut River steelhead (upper and lower), timing passed Tyee (August 4) was estimated to be similar to the results of Cox-Rogers (August 3; 1986), but earlier than the results of Spence (August 9; 1989) and Ward *et al*. (August 13; 1993).

Past studies used run timing and travel time through the commercial fishery to calculate harvest rates and total harvest of steelhead in Area 4 (Ward *et al*. 1993; Cox-Rogers 1994). The mean date passed Tyee was used to estimate the time period for steelhead and salmon to migrate through the fishery and to back-calculate when different steelhead and salmon runs entered the commercial fishery. We estimated upper and lower Sustut River steelhead took eight days to reach Tyee from the time they entered the fishery, whereas Ward *et al*. (1993) and Cox-Rogers (1994) estimated steelhead took seven and four days to reach Tyee, respectively. We estimated tagged upper (early run timing) and lower (late run timing) Sustut River steelhead entered the fishery on July 17 and August 7. In comparison, Cox-Rogers (1994) estimated early, middle and late run Skeena River steelhead entered the Area 4 commercial fishery on July 27, August 5 and August 9, whereas sockeye entered on July 21.

Estimates of run timing and migration time through the commercial fishery were used to calculate harvest rates and total harvest of steelhead by Ward *et al*. (1993) and Cox-Rogers (1994). Our estimates of the timing of tagged upper Sustut River steelhead passed Tyee were earlier than previous estimates for upper Sustut River and pooled Sustut River steelhead (Cox-Rogers 1986; Spence *et al*. 1990; Ward *et al*. 1993). Also, we estimated steelhead spent more time in the commercial fishery (8 d) than previously estimated (7 d, Ward *et al*. 1993; 4 d, Cox-Rogers 1994). Thus, estimates of total harvest and harvest rates of upper Sustut River steelhead may be different than previously calculated.

The upper Sustut River steelhead population index values were positively correlated and significantly related to the cumulative steelhead index at Tyee test fishery on August 10. The correlation suggested that as cumulative steelhead index values at Tyee on August 10 increased, upper Sustut River steelhead population index values also increased. Thus, when large numbers of early run Skeena River steelhead were encountered migrating upstream at Tyee, large numbers were observed surviving upstream to overwintering grounds in the Sustut River. The significant relationship between the two indexes indicated the cumulative steelhead index at Tyee test fishery on August 10 was a useful predictor for the relative abundance of upper Sustut River steelhead population, although the relationship may not be causal. Variability in the relationship may have resulted from variation in catchability (q; Cox-Rogers and Jantz 1993) and the different methods used in indexing the upper Sustut River steelhead population.

In 1996, 14 percent of steelhead had gillnet marks and when all years were combined, 11 percent had gillnet marks. For all years, male and female steelhead with gillnet marks were significantly smaller than steelhead without gillnet marks, although the magnitude of differences was small. In comparison, Oguss and Andrews (1977) reported the size of steelhead caught in gill nets was the same as the size caught in seine nets and concluded gill nets were not size selective for steelhead. However, Oguss and Evans (1978) reported steelhead were generally tangled in gillnets rather than gilled. Our results were influenced by the voluntary release of steelhead by commercial fishers. Also, our results were based on steelhead that encountered gillnets and survived and were distinguishable by net marks adjacent to the gills or maximum girth. Steelhead that were tangled in gillnets may not have been distinguished.

6.0.0 Recommendations

1. Enumeration of the upper Sustut River steelhead population should continue to be used as an index population of early run Skeena River steelhead. Data collected over a number of years will provide insight to steelhead population trends in the Skeena Region as well as biological and physical factors impacting the upper Sustut River population.

2. Coloured and numbered Floy anchor tags should be applied to all steelhead passing the fence to help determine run timing through the commercial and Native fisheries. This would also help prevent double counting of steelhead that are released downstream of the fences or of steelhead that are able to swim downstream over the fences during periods of high river discharge.

3. All steelhead passing through the fence should be identified for sex and measured for fork length, provided they are Floy tagged.

4. Standardized sampling should follow the recommendations of Parken and Morten (1996) to facilitate inter-annual comparisons. Inter-annual variability in the proportion of steelhead passing through the fence or remaining downstream should be examined relative to water levels throughout the enumeration project. We suspect the proportion of steelhead remaining downstream of the fence is inversely related to river discharge throughout the enumeration program, particularly in September.

5. We recommend harvest rates and total harvest of early run Skeena River steelhead be based on upper Sustut River steelhead rather than Morice River steelhead because the upper Sustut River population has been used as the index population for early run Skeena River steelhead by the Ministry of Environment, Lands and Parks (Bustard 1993; Saimoto 1994; Saimoto 1995; Parken and Morten 1996).

6. The relationship between the upper Sustut River steelhead population index and the cumulative steelhead index at Tyee test fishery on August 10 should continue to be examined. Years with high sockeye abundance may interact with the variability in the cumulative steelhead index and investigations should include an examination of residuals as more data becomes available.

7. Trends in the abundance of early run Skeena River steelhead should continue to be based on population trends in upper Sustut River steelhead rather than early cumulative steelhead index values at Tyee test fishery. Variability in the catchability for sockeye has indicated the test fishery provides relatively inaccurate estimates of sockeye escapement (Cox-Rogers and Jantz 1993) and thus, until the catchability of steelhead is examined, estimates of steelhead escapement in the Skeena River from the Tyee test fishery should be considered cautiously.

8. We recommend all future studies of Skeena River steelhead make a differentiation between upper and lower Sustut River steelhead when possible.

9. We recommend investigations into the level of genetic differentiation between upper and lower Sustut River steelhead.

10. We recommend run timing estimates of Skeena River steelhead populations be updated at least once every five years.

11. Investigations of sockeye salmon head population estimation, travel time estimation and the percentage of recovered sockeye heads at the fence should be continued. Development of a ratio estimator for sockeye salmon heads recovered at the fence may permit better estimates of sockeye and steelhead harvest in the upper Sustut River.

12. Otoliths should be removed for aging analysis from all dead trout and char that are recovered at the fence.

7.0.0 Acknowledgments

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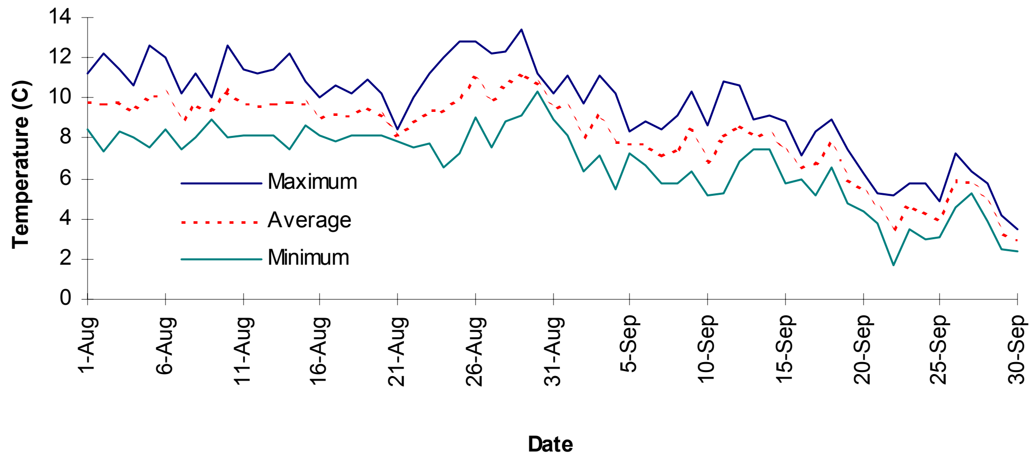
9.0.0 Appendices



Appendix Figure 1. Maximum, average and minimum water temperatures at the fence. Data from J.O. Thomas and Associates.

Appendix Table 1. Definition of statistical weeks.

Statistical Week	Corresponding Dates
6-3	June 17 to June 23
6-4	June 24 to June 30
7-1	July 01 to July 07
7-2	July 08 to July 14
7-3	July 15 to July 21
7-4	July 22 to July 28
7-5	July 29 to August 04
8-1	August 05 to August 11
8-2	August 12 to August 18
8-3	August 19 to August 25
8-4	August 26 to September 01
9-1	September 02 to September 08
9-2	September 09 to September 15

Appendix Table 2. Recaptured lower Sustut River steelhead.

Recapture Data				Tagging Data					
Date (yymmdd)	Location	Sex	Length (cm)	Tag #	Date (yymmdd)	Location	Sex	Length (cm)	Source
950815	Tyee Test Fishery/Skeena			O S00654	930910	Dewes/ Sustut	F	82.7	3
930629	Hudsons Bay Passage			O N07005	920927	Triplets/ Sustut	M	78.7	3
940804	4 m. canyon/Skeena			O S01066	921002	Sustut		76.2	3
880815	4-12				860910	Zone 2	F	79.5	2
880808	4-12				860917	Zone 1			2
880804	4-09				860914	Zone 4	F	79.0	2
880813	4-15				860925	Zone 4	F	80.0	2
880822	4-??				861007	Zone 3			2
930617	Inverness Passage, north of Smith Is.			O N07129	920914	Conception /Sustut	F	76.2	3
880809	4-??				860914	Zone 4			1
880804	45 km to Hazeport				860925	Zone 1	F	86.4	1
870908	Old Remo				850921	Zone 2	F	78.7	1
870702	4-12				860908	Lower Sustut			1
870618	4-15				860928	Zone 2	M	99.1	1
880626	Gull Rocks				870906	Zone 1	F	79.0	1
860705	Tyee				851001	Zone 3	M	85.1	1
850708	4-??				841013	Zone 1	F		1
901022	5 m U/S Suskeena			Y 02153	900801	Old Remo/ Skeena	M	85.0	2
921005	Sustut			OS04005	920820	Smith Is.			3
921013	Sustut			O C00755	920728	Birnie Is.		76.2	3
950111	Meathole /Sustut			O N07946	950919	Kitselas fish Wheel/ Skeena	M	81.0	3
880805	4-09				881018	9 m U/S			2
891011	Bear River Run				890814	Tyee GN			2
871022	Marvin Gardens /Lower Sustut				870911	Esker Is. /Skeena			2
901023	Sustut Mouth				900809	Delta Creek /Skeena			2

Source:

1. Unpublished hard copy data, Skeena Region Fisheries Branch, Ministry of Environment Lands and Parks, Smithers, B.C.
2. Old TAGS database. Skeena Region Fisheries Branch, Ministry of Environment Lands and Parks, Smithers, B.C.
3. Recent TAGS database. Skeena Region Fisheries Branch, Ministry of Environment Lands and Parks, Smithers, B.C.

Appendix Table 3. Recaptured upper Sustut River steelhead.

Recapture Data				Tagging Data					
Date (yymmdd)	Location	Sex	Length (cm)	Tag #	Date (yymmdd)	Location	Sex	Length (cm)	Source
960901	Moosevale Junction/ Sustut	M	84.4	O S06736	940916	Upper Sustut Fence	F	74.0	3
960911	Moosevale Junction/ Sustut	F	82.7	O S06165	940915	Upper Sustut Fence	F	75.0	3
960908	Moosevale Junction/ Sustut	F	79.1	O S06128	940912	Long Run/Sustut	F	74.0	3
950815	Upper Sustut Fence			O S06126	940912	Lower Sustut Fence	M	84.0	3
950906	Lower Sustut Fence			B 02976	930908	Johanson Fence/Sustut	F	68.0	3
950910	Lower Sustut Fence			B 02643	930906	Johanson Fence/Sustut	F	69.0	3
9509__	Lower Sustut Fence			B 02965	930907	Johanson Fence	F	78.5	3
9509__	Lower Sustut Fence			B 02983	930907	Johanson Fence	F	77.0	3
950908	Lower Sustut Fence			B 02984	930907	Johanson Fence	F	70.0	3
950921	Lower Sustut Fence			Y 06305	930902	D/S WhiteRock Pool/Sustut	M	77.0	3
940914	Lower Sustut Fence			O S02386	921023	D/S Sustut Lake	F	74.0	3
940915	Upper Sustut Fence		81.0	G 01656	920919	Sustut	F	73.0	3
940914	Upper Sustut Fence			Y 02818	920910	Sustut	F	70.0	3
940914	Lower Sustut Fence			U 01582	920910	Moosevale Creek/Sustut	F	74.0	3
960627	Skeena mouth (Area 4-15)			O C05700	950825	Lower Sustut fence	F	80.5	3
940621	Tyee Test Fishery/ Skeena			B 02409	930909	Johanson fence/Sustut	F		3
930615	4 m. canyon/ Skeena			W 07136	920819	WhiteRock pool/Sustut	F	74.0	3
960706	West side Stephens Is.			O S06166	940915	Upper Sustut fence	F	65.0	3
950910	Lower Sustut Fence			O C00126	9308__	West Side Stephens Is.			3
960722	Tyee Test Fishery/ Skeena			Y 00178	940829	Lower Sustut Fence			3

Recapture Data				Tagging Data					
Date (yymmdd)	Location	Sex	Length (cm)	Tag #	Date (yymmdd)	Location	Sex	Length (cm)	Source
940806	1 m U/S Kispiox/ Skeena			Y 00178	920924	Moosevale Cr, Junct./Sustut			3
870628	Tyee				860930	Zone 7	F	75.0	1
870629	Tyee				861003	Zone 7	F	83.8	1
950906	Upper Fence	F	77.0		930907	Johanson Fence	F	70.0	3
950922	Upper Fence	F	70.0		930902	Sustut River	M	77.0	3
960901	Lower Fence	F	83.0		940827	Lower Fence	F	76.0	3
960914	Lower Fence	F	82.1		940827	Lower Fence	M	79.0	3
940914	Upper Sustut Fence			G 01653	920919	Black Bear Pool/Sustut	F	72.0	3
920919	Grizzly Run/Sustut			G 01653	920919	Black Bear Pool/Sustut	F	72.0	3
930907	Johanson Fence/Sustut			B 02409	930909	Johanson fence/Sustut	F		3
920920	Sustut Fence			W 07136	920819	WhiteRock pool/Sustut	F	74.0	3
950908	Lower Sustut Fence	M	79.0	Y 01518	9508__	Near Smith & Kennedy Is.			3
950923	Lower Sustut Fence			O C01173	950726	West Side Stephens Is.			3
940918	Lower Sustut Fence	F	73.0	O C04320	940725	South end of Chatham Sound			3
920829	Moosevale Junction			O C00570	920802	Tugwell Island			3
920922	Johanson Junct./Sustut			O C00574	920802	Tugwell Island			3
920919	Moosevale Junct./Sustut			O C02398	920804	Near Smith & Kennedy IS			3
920920	Upper Sustut Fence			O C01287	920716	Smith Is.			3
920825	Moosevale Junct./ Sustut			O 05171	920718	Tyee GN/Skeena			3
920825	D/S Moosevale Cr./ Sustut			O 05130	920723	Tyee GN/Skeena			3
950915	Upper Sustut Fence			O C03021	950625	Tyee Test Fishery/ Skeena			3
950926	Lower Sustut Fence			O C03008	950728	Tyee GN/Skeena			3
950906	Upper Fence	M	77.0		95????	Tidal Seine			3
960909	Lower Fence	M	84.5		96????	Ocean			3
960914	Lower Fence	F	69.8		96????	Ocean			3
920920	Upper Sustut			G 01656	920919	Sustut	F	73.0	3

Recapture Data				Tagging Data					
Date (yymmdd)	Location	Sex	Length (cm)	Tag #	Date (yymmdd)	Location	Sex	Length (cm)	Source
	Fence								
940918	Lower Sustut Fence	F	73.0	O C04320	940725	South end of Chatham Sound			3
920829	Moosevale Junction			O C00570	920802	Tugwell Island			3
950913	Upper Fence	F	73.0		950726	Stephens Is.			3
920919	White Rock Pool/ Sustut			O S02335	920919	Old Remo/ Skeena			3
950904	Lower Sustut Fence			0 N07177	950723	Kitselas Fish Wheel/ Skeena			3
920920	Sustut Fence			W 07136	920819	WhiteRock Pool/Sustut			3
920924	Sustut Fence			U 01583	920924	Moosevale Cr, Junct./ Sustut			3
950823	Bear River Confluence/ Sustut			0 N07177	950723	Kitselas Fish Wheel/ Skeena			3

Source:

1. Unpublished hard copy data, Skeena Region Fisheries Branch, Ministry of Environment Lands and Parks, Smithers, B.C.
2. Old TAGS database. Skeena Region Fisheries Branch, Ministry of Environment Lands and Parks, Smithers, B.C.
3. Recent TAGS database. Skeena Region Fisheries Branch, Ministry of Environment Lands and Parks, Smithers, B.C.

Appendix Table 4. Daily and cumulative totals for fish passing through the fence 1996.

	Steelhead		Sockeye		Coho		Bull trout
Date	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	
Aug. 4-13		0		102	0		0
14-Aug.	0	0	59	161	0	0	0
15-Aug.	0	0	139	300	0	0	0
16-Aug.	0	0	161	461	0	0	0
17-Aug.	3	3	256	717	0	0	0
18-Aug.	1	4	178	895	0	0	0
19-Aug.	4	8	136	1031	0	0	0
20-Aug.	2	10	233	1264	0	0	0
21-Aug.	8	18	276	1540	0	0	0
22-Aug.	4	22	250	1790	1	1	0
23-Aug.	5	27	86	1876	0	1	0
24-Aug.	4	31	75	1951	0	1	0
25-Aug.	8	39	72	2023	0	1	0
26-Aug.	14	53	98	2121	0	1	0
27-Aug.	16	69	218	2339	0	1	0
28-Aug.	15	84	179	2518	1	2	0
29-Aug.	7	91	153	2671	0	2	0
30-Aug.	14	105	104	2775	0	2	0
31-Aug.	20	125	130	2905	1	3	0
01-Sep.	21	146	121	3026	0	3	0
02-Sep.	3	149	41	3067	0	3	0
03-Sep.	8	157	48	3115	0	3	0
04-Sep.	32	189	34	3149	1	4	1
05-Sep.	13	202	22	3171	1	5	1 (dead)
06-Sep.	17	219	22	3193	0	5	2
07-Sep.	30	249	29	3222	0	5	0
08-Sep.	20	269	49	3271	4	9	0
09-Sep.	22	291	41	3312	1	10	0
10-Sep.	6	297	24	3336	1	11	00
11-Sep.	5	302	9	3345	0	11	0
12-Sep.	3	305	26	3371	0	11	0
13-Sep.	6	311	14	3385	3	14	0
14-Sep.	18	329	28	3413	1	15	1
15-Sep.	21	350	18	3431	2	17	1
16-Sep.	10	360	6	3437	2	19	0
17-Sep.	14	374	1	3438	0	19	0
18-Sep.	29	403	23	3461	2	21	0
19-Sep.	4	407	2	3463	3	24	0
20-Sep.	2	409	0	3463	2	26	0
21-Sep.	1	410	1	3464	2	28	0
22-Sep.	0	410	1	3465	0	28	1 (downstream)
23-Sep.	0	410	1	3466	0	28	0
24-Sep.	0	410	1	3467	0	28	0
25-Sep.	1	411	0	3467	1	29	0
26-Sep.	3	414	1	3468	0	29	1
27-Sep.	28	442	1	3469	1	30	1
28-Sep.	20	462	0	3469	0	30	0
29-Sep.	2	464	0	3469	1	31	0
30-Sep.	2	466	1	3470	2	33	1
01-Oct.	0	466	0	3470	0	33	0

Appendix Table 5. Summary of steelhead tagging data at the fence in 1996.

Date (yr/mo/dy)	Time	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
960823	830	f	70.5	orange	n6430	
960823	1230	m	79.0	orange	n6431	
960824	1630	f	77.5	orange	n6432	
960824	1630	m	79.5	orange	n6433	
960825	1930	f	78.5	orange	n6434	small puncture under dorsal fin exactly like a tagging gun hole, was fresh, still bleeding
960826	1330	f	74.0	orange	n6435	
960826	1830	m	87.5	orange	n6436	
960826	1830	m	78.0	orange	n6437	
960827	1430	f	74.0	orange	n6438	
960827	1430	m	74.5	orange	n6439	
960828	1530	f	80.0	orange	n6440	
960829	1630	f	75.0	orange	n6441	
960828	1430	m	80.0	orange	n6442	
960828	1600	f	74.0	orange	n6443	
960828	1800	m	81.0	orange	n6444	
960828	1800	f	72.5	orange	n6445	
960829	1100	f	66.5	orange	n6446	patch of skin scraped off head
960829	1100	m	82.0	orange	n6447	scrape on tail
960831	1500	f	78.5	orange	n6452	
960831	1500	f	76.5	orange	n6453	
960831	1500	m	87.0	orange	n6454	
960830	1730	f	72.0	orange	N06448	
960830	1730	f	70.5	orange	N06449	
960830	1730	f	73.5	orange	N06450	
960830	1730	m	74.2			seal wounds
960830	1730					got away, gill net marks behind head
960830	1730	m	80.9	orange	N06451	DNA, Scales #1, 6.2 kg
960831	1030	m	81.8			
960831	1345	f	76.5			
960831	1345	f	76.5			
960831	1415	f	72.3			
960831	1415	f	74.5			
960831	1830	f	73.5			
960831	1830	m	87.0			
960831	1830	f	72.0			
960831	1830	m	75.7			
960831	1830	m	75.0			
960831	1830	m	84.4	orange	N06455	DNA, Scales #2, 6.8 kg
960831	1830	m	75.2			
960901	1145	m	86.3			

Date (yr/mo/dy)	Time	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
960901	1345	f	71.0			
960901	1345	m	83.0	Yellow	DFO 00160	Recaptured
960901	1345	m	87.3			torn operculum
960901	1345	f	72.7			
960901	1345	m	84.4	Pink	MOE S06735	Recaptured, gill net marks
960901	1345	m	79.4			
960901	1600	m	82.0	orange	N05401	
960901	1600	m	84.2	orange	N05402	DNA, Scales #3
960901	1600	?	?			got away through the fence
960901	1800	m	77.6	orange	N05403	
960901	1800	f	72.0			DNA, Scales #4, gill net marks
960901	1800	f	77.7			
960901	1800	m	77.9	orange	N05404	
960901	1800	f	72.8	orange	N05405	went downstream
960901	2000	m	85.0			
960901	2000	m	77.4			
960901	2000	f	71.8			gill net marks
960901	2000	f	70.0			
960901	2000	m	91.5			
960901	2000	f	72.5			
960902	1445	m	82.8			DNA, Scales #5
960902	1700	m	81.5	orange	N05406	DNA, Scales #6, gill net marks, 5/0 hook in mouth
960902	1900	m	91.8	orange	N05407	
960903	1600	f	76.0			DNA, Scales #7
960903	1830	f	82.4	orange	N05408	
960903	1830	f	72.4	orange	N05410	tag N05409 broke
960903	1830	f	79.6			
960903	1830	f	73.5			
960903	1830	f	78.9			DNA, Scales #8, gill net marks, damaged caudal fin
960903	1830	f	70.0			
960903	1830	f	71.3			
960904	845	m	85.3			DNA, Scales #9
960904	845	f	57.9	orange	N05411	gill net marks
960904	845	f	83.9	orange	N05412	
960904	845	m	91.5			
960904	1600					slipped through the fence and had a blue tag
960904	1730	f	81.4			
960904	1730	f	71.8	orange	N05413	DNA, Scales #10
960904	1730	f	73.5	orange	N05414	

Date (yr/mo/dy)	Time	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
960904	1730	m	86.0	orange	N05415	
960904	1730	m	86.5			
960904	1730	m	82.8			DNA, Scales #11
960904	1730	f	76.9	orange	N05416	
960904	1730	f	73.0	orange	N05417	
960904	1730	f	71.9			
960904	1730	m	86.3			
960904	1730	m	88.5			DNA, Scales #12
960904	1730	f	76.0	orange	N05418	seal scars
960904	1730	m	82.5	orange	N05419	
960904	1730	f	70.8			
960904	1730	m	81.0			
960904	1730	f	73.5			DNA, Scales #13, seal scars
960904	1730	m	80.4	orange	N05420	
960904	1730	f	76.5	orange	N05421	
960904	1730	m	79.8			
960904	1730	f	69.4			
960904	1730	m	79.4			DNA, Scales #14
960904	2030	f	69.9	orange	N05422	
960904	2030	f	74.0	orange	N05423	
960904	2030	f	72.2			
960904	2030	m	81.2			
960904	2030	m	73.4			DNA, Scales #15
960904	2030	m	84.4	orange	N05424	
960905	830	m	80.2			DNA, Scales #16
960905	830	f	71.1			gill net marks, seal scar
960905	1330	m	80.8	orange	N05425	
960905	1330	f	73.9	orange	N05426	
960905	1630	m	73.4			
960905	1630	f	71.2			DNA, Scales #17
960905	1630	f	71.5	orange	N05427	seal scars
960905	1830	f	78.6	orange	N05428	
960905	1830	m	88.1			
960905	1830	f	73.2			
960905	1830	f	80.5			DNA, Scales #18, seal scars
960905	1830	m	87.6	orange	N05429	seal scars
960905	1830	m	79.7	orange	N05430	gill net marks, damaged caudal fin
960906	900	f	77.9			DNA, Scales #19, seal marks
960906	900	f	74.3	orange	N05431	
960906	900	f	76.0	orange	N05432	
960906	1400	m	82.1			
960906	1400	f	71.6			

Date (yr/mo/dy)	Time	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
960906	1400	f	69.8			DNA, Scales #20, gill net marks, seal marks
960906	1530	f	74.0	orange	N05433	
960906	1930	f	70.8	orange	N05434	
960906	1930	f	69.3			
960906	1930	f	80.8			
960906	1930	m	80.9			DNA, Scales #21
960906	1930	f	76.6			Fungus head, seal marks
960906	1930	f	75.1	orange	N05435	
960906	1930	m	85.2	orange	N05436	
960906	1930	m	90.8			
960906	1930	f	73.9			DNA, Scales #22
960906	1930	f	70.0	orange	N05437	gill net marks
960907	900	f	70.2			DNA, Scales #23
960907	1500	m	86.8	orange	N05438	tag broke off
960907	1500	f	67.6	orange	N05439	
960907	1500	m	80.8	orange	N05440	
960907	1500	m	80.5			
960907	1500	f	74.2			DNA, Scales #24, seal marks
960907	1500	f	70.3	orange	N05441	
960907	1500	m	80.1			
960907	1500	f	72.6	orange	N05442	
960907	1500	m	92.0			
960907	1500	f	72.0			DNA, Scales #25, seal marks
960907	1500	f	75.9	orange	N05443	
960907	1500	f	75.1			gill net marks
960907	1900	m	71.8	orange	N05444	
960907	1900	m	93.7			
960907	1900	f	69.1			DNA, Scales #26, gill net marks
960907	1900	f	74.1	orange	N05446	N05445 broke off
960907	1900	m	84.8	orange	N05447	
960907	1900	m	83.4			
960907	1900	f	71.2			gill net marks
960907	1900	m	84.3			DNA, Scales #27, seal marks
960907	1900	m	83.6	orange	N05448	
960907	1900	f	79.2	orange	N05449	
960907	1900	f	74.0			
960907	1900	f	71.7			
960907	1900	m	79.4			DNA, Scales #28
960907	1900	f	72.9	orange	N05450	
960907	1900	f	72.2	orange	N05451	
960907	1900	f	74.9			
960907	1900	f	71.6			gill net marks
960908	1500	f	69.8			DNA, Scales #29

Date (yr/mo/dy)	Time	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
960908	1500	f	76.2	orange	N05452	
960908	1500	m	81.4	orange	N05453	
960908	1500	m	79.6			
960908	1730	f		orange	N05405	old tag that went downstream
960908	1730	f	74.7			gill net marks, torn operculum, fungus head
960908	1730	m	82.7			DNA, Scales #30
960908	1730	f	70.4	orange	N05454	
960908	1730	f	75.9	orange	N05455	
960908	1730	f	79.1	orange(old)	S06128	Recaptured
960908	1730	m	85.5			fungus head
960908	1730	f	70.6			DNA, Scales #31, gill net marks open wound on ventral side
960908	1730	f	70.2	orange	N05456	
960908	1730	m	81.0	orange	N05457	
960908	1730	f	67.6			
960908	1730	f	75.2			
960908	1900	m	86.0			DNA, Scales #32
960908	1900	f	73.8	orange	N05458	
960908	1900	f	74.8	orange	N05459	
960908	1900	f	75.1			
960908	1900	f		yellow	DFO 160	DNA, Scales #33, dead on fence
960909	900	m	86.4			DNA, Scales #34
960909	900	f	70.3		N05460	tag broke off, seal marks
960909	900	m	84.1	orange	N05461	
960909	1530	m	88.9			
960909	1530	m	84.5	Yellow	715	PRFVOA, PO Box 695 Pr. Rupert, Recaptured
960909	1530	m	90.9			DNA, Scales #35
960909	1530	f	73.3	orange	N05462	
960909	1530	m	82.2	orange	N05463	tag broke off
960909	1530	m	87.8	orange	N05464	
960909	1530	m	82.3			fungus on operculum
960909	1530	f	84.0			DNA, Scales #36, gill net marks
960909	1530	m	89.6	orange	N054+5	
960909	1530	m	78.1	orange	N05466	
960909	1530	m	75.4	orange	N05467	
960909	1900	f	73.0			
960909	1900	f	84.2			DNA, Scales #37, appears to have been sampled for DNA before
960909	1900	m	80.6	orange	N05468	missing adipose fin
960909	1900	f	72.1	orange	N05469	
960909	1900	f	69.5			

Date (yr/mo/dy)	Time	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
960909	1900	f				got away
960909	1900	m	73.9			DNA, Scales #38
960909	1900	f	72.4	orange	N05470	gill net marks
960910	1530	f	76.2			DNA, Scales #39
960910	1530	m	73.5			N05471
960910	1730	m	89.6			N05472
960910	1730	f	73.9			
960910	1730	f	73.2			
960910	1730	f	74.7			DNA, Scales #40
960911	900	f	72.4			DNA, Scales #41
960911	1915	f	73.4	orange	N0547	
960911	1915	m	75.3			
960911	1915	f	82.7	orange	N05474	
960911	2000	m	89.6	orange (old)	S06165	MOE tag recaptured
960912	945	f	74.0			DNA, Scales #42, gill net marks
960912	1830	m	84.6	orange	N05478	
960912	1830	f	67.2	orange	N05476	gill net marks
960913	900	f	76.7	orange	N05477	DNA, Scales #43
960913	900	f	69.2	orange	N05478	gill net marks, seal scars
960913	1500	m	78.4	orange	N05479	
960913	1830	m	87.0	orange	N05480	gill net marks
960913	1830	f	74.1	orange	N05481	seal scars
960913	1830	m	84.1	orange	N05482	DNA, Scales #44
960914	900	f	76.7	orange	N05483	gill net marks
960914	900	m	87.0	orange	N05480	DNA, Scales #45, dead on fence
960914	1430	m	87.9	orange	N05484	
960914	1430	f	76.8	orange	N05485	
960914	1430	f	69.8	yellow	2504	PRFVOA, PO Box 695 Pr. Rupert, Recaptured, gill net marks
960914	1430	m	81.6	orange	N05486	DNA, Scales #46
960914	1630	m	77.3	orange	N05487	
960914	1630	f	69.9	orange	N05488	gill net marks
960914	1630	f	75.2	orange	N05489	gill net marks
960914	1630	m	95.7	orange	N05490	
960914	1630	f	82.1	yellow	158	recaptured
960914	1630	m	85.7			DNA, Scales #47
960914	1630	f	82.8	orange	N05491	gill net marks
960914	1630	f	80.9	orange	N05492	
960914	1630	f	82.6	orange	N05493	
960914	1630	f	68.5	orange	N05494	gill net marks
960914	1845	f	69.6	orange	N05495	
960914	1845	f	71.2	orange	N05496	

Date (yr/mo/dy)	Time	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
960914	1845	f	70.5	orange	N05497	
960915	900	f	69.3	orange	N05498	
960915	900	f	73.7	orange	N05499	DNA, Scales #48
960915	900	f	82.4	orange	N05500	fungus spot on head
960915	900	m	83.9	orange	N05501	
960915	900	m	82.3	orange	N05502	
960915	900	f	72.4	orange	N05503	gill net marks
960915	900	f	59.6	orange	N05504	
960915	900	m	80.2	orange	N05505	
960915	900	f	70.7	orange	N05506	
960915	900	f	69.4	orange	N05507	gill net marks
960915	900	f	70.2	orange	N05508	gill net marks
960915	900	f	69.1	orange	N05509	seal marks
960915	900	f	71.9	orange	N05510	
960915	1700	f	73.1	orange	N05511	
960915	1800	f	74.6	orange	N05512	
960915	2000	f	74.8	orange	N05513	gill net marks
960915	2000	f	76.0	orange	N05514	
960915	2000	m	79.2	orange	N05515	
960915	2000	m	80.8	orange	N05516	
960916	900	m	89.7			DNA, Scales #49, seal wounds on head
960916	900	f	71.0	orange	N05517	gill net marks
960916	900	f	70.3	orange	N05518	seal marks
960916	900	f	74.6	orange	N05519	
960916	900	m	88.1	orange	N05520	
960916	900	m	72.8	orange	N05521	fungus on rostrum
960916	1500	f	74.2	orange	N05522	gill net marks
960916	1700	f	78.8			seal marks
960916	2000	f	68.0	orange	N05526	gill net marks
960916	2000	f	72.5	orange	N05527	
960917	845	m	75.6	orange	N05528	DNA, Scales #50
960917	845	f	70.2	orange	N05529	
960917	845	f	72.9	orange	N05530	
960917	845	m	91.8	orange	N05531	
960917	845	m	80.0	orange	N05532	cut operculum
960917	845	f	74.9	orange	N05533	
960917	845	f	70.6	orange	N05534	seal marks
960917	845	f	73.3	orange	N05535	tag was lost on net by fence
960917	1751	f	85.0	orange	N05536	
960917	1751	m	82.5	orange	N05537	
960917	1751	f	74.5	orange	N05538	old scar on side
960917	1751	m	78.0	orange	N05539	gill net mark on side, operculum scar

Date (yr/mo/dy)	Time	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
960917	1751	m	88.0	orange	N05541	hook and dorsal fin scar
960917	1751	m	77.5	orange	N05542	scar right side,
960918	1000	f	72.5	orange	N05543	
960918	1000	f	76.0	orange	N05544	gill net marks
960918	1000	m	87.0	orange	N05545	
960918	1000	f	73.0	orange	N05546	
960918	1000	f	71.0	orange	N05547	scar on side,
960918	1000	f	75.5	orange	N05548	gill net marks, scar on side
960918	1000	f	78.5	orange	N05550	
960918	1000	f	82.5	orange	N05551	scar on side (daggertooth?)
960918	1000	f	69.0	orange	N05552	bad gill net scar, fungus, released downstream
960918	1000	f	69.0	orange	N05553	gill net mark, predator scar
960918	1500	f	81.0	orange	N05554	gill net marks
960918	1500	f	74.5	orange	N05555	predator scar, scale loss
960918	1500	f	75.0	orange	N05556	operculum scar
960918	1500	f	73.0	orange	N05557	gill net marks
960918	1900	f	82.5	orange	N05558	gill net marks
960918	1900	m	83.0	orange	N05559	
960918	1900	f	69.0	orange	N05560	gill net marks
960918	1900	f	74.0	orange	N05561	
960918	1900	m	84.5	orange	N05563	
960918	1900	f	79.0	orange	N05564	
960918	1900	f	75.5	orange	N05565	
960918	1900	m	83.5	orange	N05568	
960918	1900	f	72.5	orange	N05569	
960918	1900	f	77.0	orange	N05570	seal scar
960918	1900	m	76.0	orange	N05571	
960918	1900	f	68.5	orange	N05572	
960918	1900	f	71.5	orange	N05573	hook scar, scar on side
960918	1900	f	72.5			old scar
960918	1900	f	70.0			
960919	940	f	76.0	orange	N05574	
960919	1700	f	74.9			
960919	1700	f	69.5	orange	N05576	seal scar, left side
960919	1700	f	78.7	orange	N05577	
960920	900	f	76.5	orange	N05578	marked operculum, cut caudal fin
960920	1800	f	76.0	orange	N05579	
960921	900	f	67.2	orange	N05580	
960922	0STHD					
960923	0STHD					
960924	0STHD					
960925	1900	f	66.9	orange	N05581	

Date (yr/mo/dy)	Time	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
960926	1730	f	78.9	orange	N05582	
960926	1730	f	67.8	orange	N05583	
960926	1730	f	74.1	orange	N05584	
960927	900	f	72.8	orange	N05585	dorsal fin scar
960927	900	f	77.6	orange	N05586	
960927	900	m	79.0	orange	N05588	
960927	900	f	75.9	orange	N05589	seal scar
960927	900	f	74.8	orange	N05590	
960927	900	m	82.0	orange	N05591	
960927	900	f	70.2	orange	N05592	gill net scar
960927	900	m	74.7	orange	N05593	
960927	900	m	85.0	orange	N05594	gill net scar
960927	900	m	84.4	orange	N05596	predator scar, right side
960927	900	f	78.4	orange	N05598	
960927	900	m	81.6	orange	N05600	
960927	900	m	86.0			caudal fin scar
960927	900	f	71.0	orange	N05602	operculum scar
960927	900	m	78.1	orange	N05603	
960927	900	f	70.9	orange	N05604	predator scar
960927	900	m	91.8	orange	N05605	
960927	900	m	76.9	orange	N05606	
960927	900	m	90.4	orange	N05607	
960927	900	f	79.2	orange	N05608	gill net scar, predator scar
960927	900	m	84.7	orange	N05609	gill net scar
960927	900	m	91.3	orange	N05610	tag broke off
960927	900	f	78.5	orange	N05611	predator scar, right side
960927	900	f	76.9	orange	N05612	seal scar
960927	900	f	74.7	orange	N05613	seal scar, tag broke off
960927	900	m	81.4	orange	N05614	
960927	900	f	68.5	orange	N05615	dorsal fin scar
960927	900	f	69.8	orange	N05616	
960928	900	m	86.3	orange	N05617	
960928	900	m	62.9			gill net marks
960928	900	f	78.5	orange	N05619	
960928	900	f	75.6	orange	N05620	
960928	900	m	76.1	orange	N05621	
960928	900	m	84.7	orange	N05622	
960928	1900	f	84.5	orange	N05623	
960928	1900	f	71.8	orange	N05624	
960928	1900	m	78.5			
960928	1900	m	91.5	orange	N05626	
960928	1900	m	87.0	orange	N05627	
960928	1900	m	92.0	orange	N05628	

Date (yr/mo/dy)	Time	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
960928	1900	m	87.2	orange	N05629	
960928	1900	m	82.3	orange	N05630	
960928	1900	f	81.4	orange	N05631	
960928	1900	f	70.6	orange	N05632	
960928	1900	f	77.0	orange	N05633	
960928	1900	f	74.7	orange	N05634	dorsal fin scar, predator scar left side
960928	1900	m	83.1	orange	N05635	
960928	1900	f	71.6	orange	N05636	old gill net scar
960929	830	f	80.7	orange	N05637	scar left side (daggertooth?)
960929	830	f	79.2	orange	N05638	
960930	900	f	71.9	orange	N05639	predator scar, left side
960930	900	f	76.1	orange	N05640	open wound on head

Appendix Table 6. Steelhead mortalities at the fence.

Date (yymmdd)	Tag	Sex	Length (cm)	Comments
960903	MOE C06427			dead on fence at 845
960907	no tag			dead on fence at 900, sent downstream
960908	no tag	m	79.4	dead on fence, fish from previous day
960908	Yellow DFO 160			dead on fence, DNA, Scales #33
960914	N05480			dead on fence
960917	no tag	f	87.4	dead on fence
960917	N05525			dead on fence
960917	N05482			dead on fence
960918	N05402			dead on fence
960918	no tag	f	76.0	dead on fence, gill net scar
960921	N05436			dead on fence
960925	N05472			dead on fence
960927	no tag	m	92.1	dead on fence, some fungus spots

Appendix Table 7. Sustut River upper and lower staff gauge, precipitation, water temperature and weather data.

	Staff Gage		Precipitation	Water Temperature		
Date	Upper	Lower	(mm)	Max	Min	Weather
Sept. 1	0.392	0.180	0	9	7	partly cloudy
2	0.355	0.147	0	9	6	sun and clouds
3	0.340	0.118	0	8.5	7	sunny and clear
4	0.318	0.089	0	9.5	4	sunny
5	0.300	0.061	0	9.5	5	cloudy with sun
6	0.309	0.071	8	8	6	rainy
7	0.309	0.075	7	8	6	cloudy
8	0.298	0.057	0	7	4.5	sunny
9	0.289	0.040	trace	8.5	5	partly sunny
10	0.275	0.024	0	9	4	overcast
11	0.262	0.012	0	6	4	sunny and clear
12	0.254	0.004	0	10.5	4	cloudy, bit of sun
13	0.250	0.004	trace	9	3	cloudy with showers
14	0.254	0.014	2	10	3	cloudy with showers
15	0.262	0.020	4	8.5	1	partly cloudy with showers
16	0.272	0.022	2	8	1	rainy
17	0.284	0.056	4	6.5	1	fog and sun
18	0.275	0.050	5.5	6.5	0.5	cloudy to showers
19	0.300	0.070	0.5	8.5	0	clear and cold
20	0.292	0.054	1	6	-0.5	partly cloudy
21	0.282	0.044	trace(snow)	5	0	cloudy with snow showers
22	0.274	0.030	0	4	-3	cloudy with snow showers
23	0.258	0.016	0	4	0	overcast
24	0.252	0.006	0	5	-1	partly cloudy
25	0.252	0.004	2 +2.5mm snow	5	-1	snowing
26	0.260	0.020	4	4	0	raining
27	0.404	0.192	20	5	1	rain, mixed with snow at times
28	0.480	0.274	6	5	0	foggy and sunny
29	0.422	0.204	0	4	-3	sunny and clear, clouds later on
30	0.378	0.154	0	4	-3	partly cloudy with snow showers

Appendix Table 8. Summary of upper Sustut River steelhead DNA sample information.

DNA Sample Number	Scale Sample Number	Date (yr/mo/dy)	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
1	1	960831	m	81.8			6.2 kg
2	2	960831	m	84.4	orange	N06455	6.8 kg
3	3	960901	m	84.2	orange	N05402	
4	4	960901	f	77.7			gill net marks
5	5	960902	m	82.8			
6	6	960902	m	81.5	orange	N05406	gill net marks, fish hook in mouth
7	7	960903	f	76.0			
8	8	960903	f	78.9			gill net marks, damaged caudal fin
9	9	960904	m	85.3			
10	10	960904	f	71.8			
11	11	960904	m	82.8			
12	12	960904	m	88.5			
13	13	960904	f	73.5			
14	14	960904	m	79.4			
15	15	960904	m	73.4			
16	16	960905	m	80.2			
17	17	960905	f	71.2			seal marks
18	18	960905	f	80.5			seal marks
19	19	960906	f	77.7			seal marks
20	20	960906	f	69.8			seal marks
21	21	960906	m	80.9			
22	22	960906	f	73.9			
23	23	960907	f	70.2			
24	24	960907	f	74.2			seal marks
25	25	960907	f	72.0			seal marks
26	26	960907	f	69.1			gill net marks
27	27	960907	m	84.3			seal marks
28	28	960907	m	79.4			
29	29	960908	f	69.8			
30	30	960908	m	82.7			
31	31	960908	f	70.6			gill net marks, open wound- ventral side
32	32	960908	m	86.0			
33	33	960908	f	83.0	yellow	DFO 160	dead on fence, migrated on 960901
34	34	960909	m	86.4			
35	35	960909	m	90.9			
36	36	960909	f	84.0			
37	37	960909	f	84.2			healed adipose, DNA sampled before?
38	38	960909	m	73.9			
39	39	960910	f	76.2			
40	40	960910	f	74.7			
41	41	960911	f	74.2			
42	42	960912	f	74.0			gill net marks
43	43	960913	f	76.7	orange	N05477	
44	44	960913	m	84.1			

DNA Sample Number	Scale Sample Number	Date (yr/mo/dy)	Sex	Fork Length (cm)	Tag Colour	Tag Number	Comments
45	45	960914	m	87.0	orange	N05480	dead on fence, migrated on 960913
46	46	960914	m	81.6	orange	N05486	
47	47	960914	m	85.7			
48	48	960915	f	73.7	orange	N05499	
49	49	960916	m	89.7			seal wounds on head
50	50	960917	m	75.6	orange	N05528	

Appendix Table 9. Summary of upper Sustut River bull trout DNA sample information.

DNA Sample Number	Scale Sample Number	Fin Ray Sample Number	Date (yy/mm/dd)	Sex	Fork Length (cm)	Branch-iostegal Ray Count	Comments
1		1	960904	unknown	45.1	26	
2	2	2	960905	f	69.3	25	dead on fence, a downstream migrating fish, gravid female
3		3		unknown	58.0	unknown	
4	4	4	960906	unknown	51.0	26	
5	5	5		unknown	44.2	27	
6	6	6	960914	unknown	38.9	25	
7	7	7	960915	unknown	51.3	25	no adipose fin and well healed, sampled distal end of pelvic fin
8	8	8	960922	unknown	51.9	27	downstream fish
9		9	960923	unknown	51.2	26	
10	10	10	960926	unknown	49.3	26	dead in trap, wedged between dowels, spawned out and no distinguishable gonads
11	11	11	960927	unknown	60.9	27	spawned out
12	12	12	960930	unknown	47.7	25	

Appendix Table 10. Summary of coho salmon data.

Date	Sex	Length	DNA Sample Number	Comments
960831	m	68.0		
960904	m	44.5		seal scars
960905	m	65.8	1	
960907	m	48.5	2	
960907	m	70.4	3	
960907	f	66.5	4	
960907	f	66.3	5	fungus on head
960908	m	61.5	6	
960909	m	70.0	7	
960912	m	66.1	8	
960912	f	62.0	9	
960912	m	63.6	10	
960913	f	67.9	11	
960914	m	48.4	12	
960914	m	70.3	13	
960915	f	62.8	14	
960915	m	43.4	15	
960917	m	47.0	16	
960917	m	68.0	17	
960918	f	67.0		
960919	m	78.4		
960919	m	63.5		
960920	f	62.6		
960920	m	61.3		
960924	m	41.7		
960926	f	64.5	18	
960928	m	71.0	19	gill net marks
960930	m	57.7	20	
960930	f	65.5		