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ENUMERATION OF ADULT
STEELHEAD IN THE UPPER
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Enumeration of Adult Steelhead in the Upper Sustut River 1993

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Summary

The Upper Sustut River steelhead stock was enumerated in the fall of 1993 for the second consecutive year. The enumeration methods included the use of the Johanson Creek and Upper Sustut migration fences and snorkel counts for 5 km below the fences to the Moosevale Creek junction. Seven total counts of steelhead at the Upper Sustut River were accomplished from September 3rd to 26th.Results showed a decrease in new arrivals toward the end of September and estimated the Upper Sustut stock to consist of 476 steelhead in the fall of 1993.

The first steelhead arrived in the Upper Sustut River in early August and continued to aggregate in the 1.5 km section of river below the Johanson confluence through most of September. Steelhead moved up the Sustut River through the Sustut fence at a low and inconsistent rate. Only 26 steelhead (11 males, 15 females) moved through the Sustut fence toward Sustut Lake. However, steelhead moved up Johanson Creek through the Johanson fence at a comparatively steady rate. A total of 182 steelhead (65 males, 117 females) moved through the Johanson fence toward Johanson Lake. When fences were removed on September 28th, there were still 276 steelhead below the fences. The final migration of these steelhead appeared to be delayed by extremely low discharge and possibly cool water temperatures that dropped below 4 °C.

I recommend that the Ministry of Environment continue to use the Upper Sustut River as a steelhead index stream and to work in coordination with the Department of Fisheries and Oceans to maintain practical and shared expenses to this project. The necessity for the operation of both fences is emphasized and it is suggested that future snorkel surveys include records of varying turbidity. It is also important that the Upper Sustut River is better monitored for an assessment of the impact of the Native fishery.

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Acknowledgements

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Special thanks also go to the Steffey family, who were friendly throughout the field season. Ron, Oak, Clayton, and Heather gave fantastic assistance with both installation and removal of the fish fences. Ron Tetreau and Mark Beere also provided great assistance in the final closing of the camp.

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1.0 Introduction

The Sustut River is a large drainage system at the upper end of the Skeena River. From Sustut Lake to the Skeena River, the Sustut River flows to the southwest for about 100 km; the watershed of the Sustut River covers approximately 20,000 km^2. The major tributaries of the Sustut are Birdflat Creek, Bear River, Saiya Creek, Asitka Creek, Red Creek, Two Lake Creek, Willow Creek, Moosevale Creek, and Johanson Creek (Figure 1). Presently, two Sustut River steelhead stocks are recognized: the lower Sustut (Bear River) and the Upper Sustut. Johanson Lake (elev. 1,444 m), and Sustut Lake (elev. 1,301 m) are the primary overwintering locations for the Upper Sustut steelhead stock. In fact, the Johanson and Sustut lakes' overwinterers also appear to remain reproductively isolated from each other; both populations spawn near the outlets of the lakes in which they overwinter (Bustard, 1993). However, the degree of genetic distinction between the Johanson Creek and Upper Sustut River populations is uncertain.

Recent studies of Sustut River steelhead have indicated early migrations to the higher elevations of Sustut and Johanson lakes (Spence *et al.* 1990). Bustard (1992) has found evidence of this early migration from the recovery of steelhead that were Floy Tagged by the commercial fishery. Tags that were recovered in the Upper Sustut River (above Bear River confluence) indicated that the Upper Sustut steelhead moved through the commercial fishing area during July and the first week of August in 1992 (Bustard 1992). Steelhead that move into the Skeena River in July are considered to be early-run summer stocks, and are among those most heavily impacted by the commercial and native fisheries. There is evidence that the lower Sustut steelhead stock arrives later in the season than the Upper Sustut stock and is at less risk from the commercial fishery (Spence *et al.* 1990).

The Ministry of Environment is particularly concerned with all summer-run stocks of steelhead influenced by commercial and native fisheries. The monitor of steelhead escapement at the upper Sustut River will assist in evaluating the impacts of the existing fisheries on early summer-run steelhead.

There were three basic objectives for this study:

1. To evaluate the timing of arrival, and abundance of steelhead at the Upper Sustut River in 1993.

2. To acquire an estimate of "substock" composition (Johanson and Sustut Lake overwinterers) for the Upper Sustut River stock.

3. To collect additional information regarding the impact of the native fishery on Upper Sustut River steelhead stock.

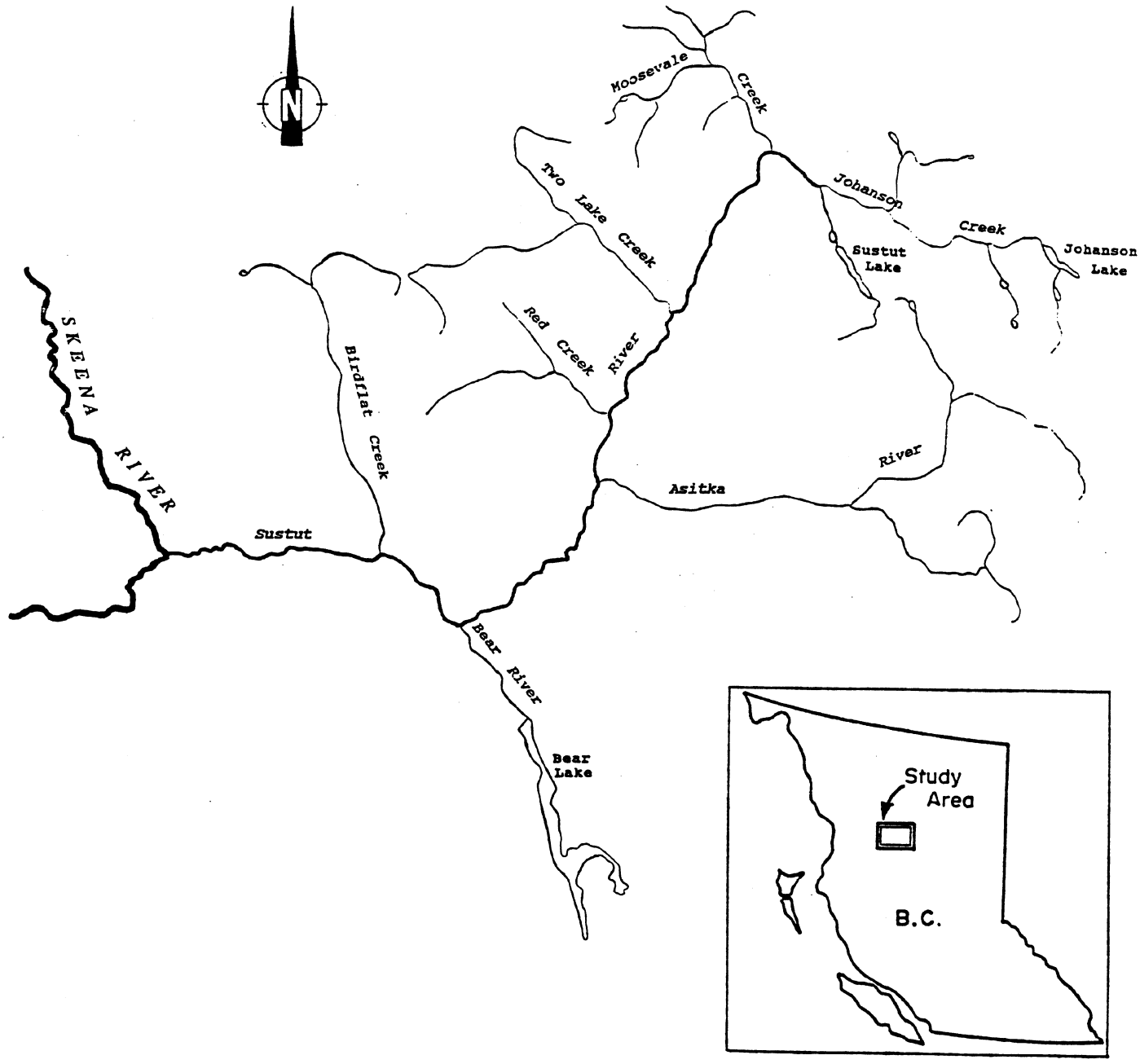


Figure 1. The Sustut River and its major tributaries.

2.0 Materials and Methods

2.1 Study Site

This study focused on the Upper Sustut River at an area extending approximately 7 km downstream from Johanson Creek confluence (Figure 2). This stretch of river is where steelhead are known to hold for variable lengths of time prior to their final migration upstream to the overwintering lakes. In 1993, counting fences were constructed across both the Johanson Creek and the Upper Sustut River. Previous studies have described the 7 km stretch of river below the Johanson confluence and have discovered that a majority of steelhead spend long periods of time holding in a series of pools located within *1.5* km of the confluence (Bustard 1992). Based on this evidence, this project used the entire 7 km stretch of river to estimate the timing and total number of steelhead migrating to Sustut and Johanson lakes for overwintering (Figure 2).

2.1.1 Sustut Fence

The Sustut Fence was installed 20 meters above the Johanson confluence on July 25th, 1993 (Figure 2). The fence was 20 meters in length and consisted of six 5'x 8' panels with 2" aluminum mesh screen, 10' of conduit fence, a 4'x 8'x 6' up-migration trap, and a 4'x4'x5' down-migration trap (Figure 3). Department of Fisheries and Oceans (DFO) modified the up-migration trap with a solid barrier in the center area of the up-stream face of this trap which slowed water flow down the center of the trap. This block of water flow increased the fish's ability to escape back down-stream, and should be revised before the trap is reused in 1994.

2.1.2 Johanson Fence

The Johanson Creek fence was installed approximately 200 m above its confluence to the Sustut River on July 25th (Figure 2). The fence was 20 meters in length and consisted of four 5'xlO' panels with 2" aluminum mesh screen, 10' of conduit fence, a 4' x 8' up-migration trap and a 4' x 4' down-migration trap (Figure 4). The two traps were installed directly beside one another on the west bank of the river; the down-migration trap was set nearest the shore in the slower moving water. The waterflow through the up-migration trap remained adequate enough to help prevent downstream escapement from fish that came into the trap; the blockage of down stream flow on the sides of the upstream face of the trap created resting locations in the trap but also maintained fast current through the center which decreased the abilities of fish to turn back down stream through the narrow end of the funnel entrance.

2.2 Timing and Logistics

This steelhead study was conducted in coordination with a project by the Department of Fisheries and Oceans (DFO) who initiated fence operation on July 25th and monitored migration of all species of salmonids including chinook *(Oncorhynchus tshawytscha),* sockeye *(0. nerka),* coho *(0. kisutch),* rainbow and steelhead *(0. mykiss),* dolly varden char

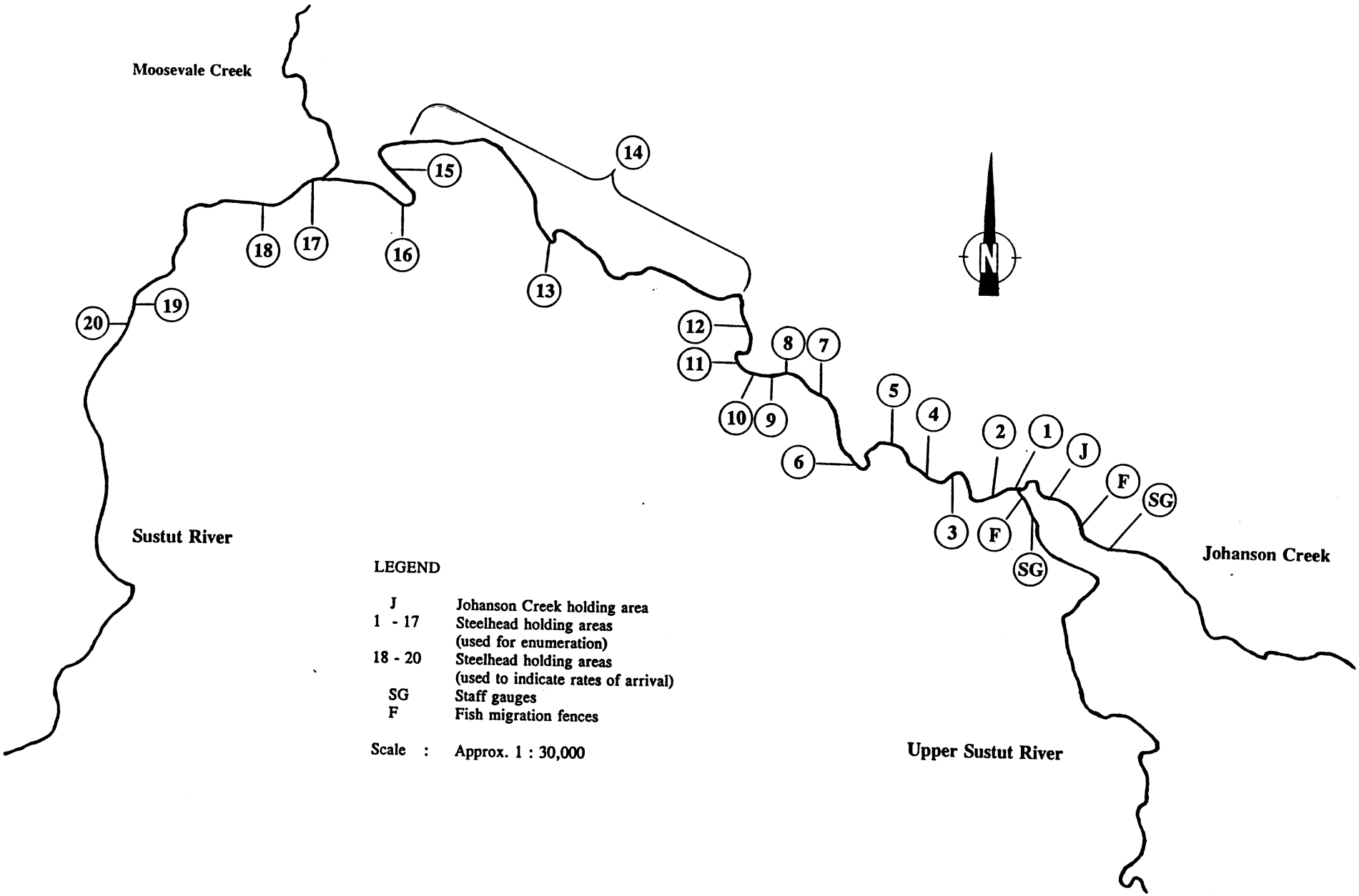


Figure 2. Detailed map of the study area used for the enumeration of the Upper Sustut steelhead stock during August and September, 1993.

(Salvelinus malma), and mountain whitefish *(Prosopium williamsoni).* The Ministry of Environment took over fence operation on September 2nd as the summer run steelhead began to arrive in significant numbers. Fences were operated until September 28th during which time water levels and turbidity were very low. Snorkel surveys below the fences were used to determine the rate of immigration to the study area and the need for continuing fence operation. Fences were removed prior to completion of migration by steelhead partially because it appeared that the fences were holding fish back at the junction pool while the native fishery for steelhead was just beginning at this location. Very low flows of water in both the Upper Sustut River and Johanson Creek, and long range weather forecasts that predicted little increase in precipitation for up to two weeks, also promoted the removal of fences before enumeration had accurately divided the two substocks (Sustut and Johanson lake overwinterers).

2.3 Fence Operation

Both, the Sustut and Johanson counting fences, were checked two times each day. Steelhead were measured for fork length (cm), weighed (kg), and five scales were taken from just above the lateral line between the dorsal and adipose fins for aging. Weight and scale samples were not taken after September 6th. A Cenco dissecting microscope was used to determine freshwater and ocean ages from readable scales. In addition, all steelhead that passed through the fences were Floy tagged on the left side of the dorsal fin; green tags were used at the Sustut fence and blue and yellow tags at the Johanson fence. Sockeye, chinook, and coho salmon were sexed and fork lengths (cm) were recorded. Rainbows, dolly varden char and rocky mountain whitefish were counted and quickly released to reduce injury and stress, which they appeared to be more vulnerable to. Fence maintenance also involved removal of debris and ice on alternate days during September.

2.4 Discharge and Temperature

Water height (+/- 0.5 cm) and water temperature (+/- 0.1 °C) were recorded at three different staff gauges : Upper Sustut River, Johanson Creek and below the confluence (Figure 2). From July 25th to September 9th**,** daily minimum water temperatures were recorded. From September 10th – 28th**,** water temperatures were taken at approximately 9:00 and 17:00 hours each day; morning and afternoon temperatures represent good estimates of minimum and maximum daily temperatures (Bustard 1992). Water heights were measured daily to document fluctuations in discharge.

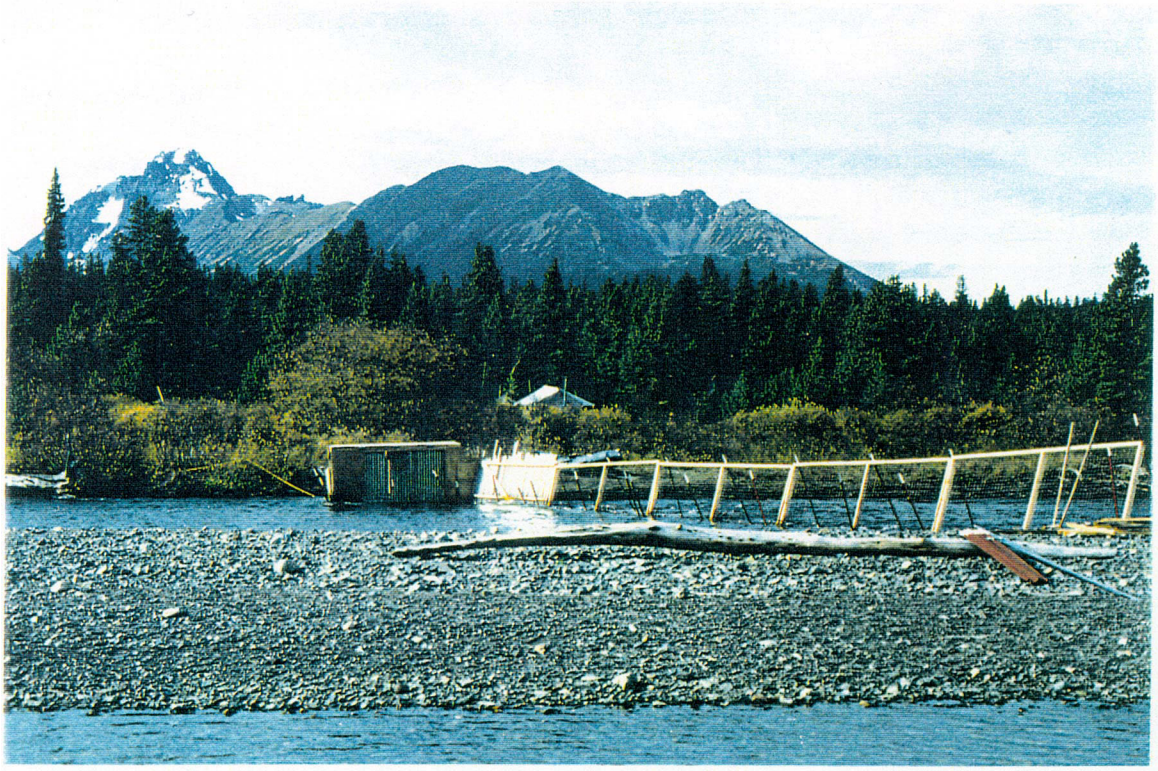
2.5 Enumeration below fences

2.5.1 Adult tagging below fences

Adult steelhead were caught by angling in the Sustut River between the Johanson and Moosevale confluences. In total, 24 steelhead were Floy tagged (yellow) on the left side of the dorsal fin from September 2nd – 8th. The initial intent of this process was to assist in corrections for snorkel survey counts (as in Bustard 1992), but visibility tests indicated the inaccuracy of yellow tags for this purpose *(see* Visibility Evaluation, *page* 11). Tagging efforts below the fences were therefore discontinued on September 8th.

Figure 3. Photograph of fish fence on the Upper Sustut River.

Figure 4. Photograph of the fish fence on Johanson Creek,



2.5.2 Snorkel Surveys

Seven snorkel surveys from the fences, downstream to the Moosevale Creek confluence (Figure 2), were conducted at four day intervals in order to enumerate steelhead below the two fences and to monitor rates of new arrivals to the upper area of the Sustut River. Three additional surveys were done in conjunction with the final three "fence to Moosevale counts" in order to cover the lowest locations above Bear River that steelhead are known to congregate; this included 3 holding pools in a 2 km stretch of river below the Moosevale confluence (Figure 2).

The initial snorkel survey was done with two snorkelers, and all others were done with one snorkeler accompanied by a person recording fish observations from a raft. Positioning of drifts during counts was critical in pools where high densities of fish were holding; observation was focused in only one direction which required the snorkeler to maintain position close enough to one shore to prevent fish from sneaking past without being counted. Due to good underwater visibility and low water levels in the river during all surveys, it was possible to have a complete view of all fish. In some cases, when fish doubled back and made counting difficult, pools were snorkelled two and sometimes three times to ensure accurate counts. The very low water levels which created very fast and shallow runs between holding pools deterred steelhead from moving from pool to pool. In less occupied and wider stretches of the river, snorkelling was done down the centre or deeper trench of the river searching for steelhead on both sides through the drift.

2.5.3 Visibility Evaluation

In order to monitor changes in underwater visibility, a black square (7.5 cm x 7.5 cm) versus a black circle (7.5 cm diameter) was used to test underwater shape recognition at variable distances. Shape identification (square versus circle) involved six random trials of circle and squares (always 3 circles/3 squares) at 5,7,9, and 11 meter distances; lengths of time (sec) to recognition were recorded giving mean times to identification at different distances. This test was also done in both light and shady conditions to account for the possible influence of light intensity on snorkel counts.

In addition, yellow, green, blue, and orange Floy tags were tested for comparative recognition of different colours of tags at variable distances. Tags were attached to the face of the black square *(7.5* cm) for identification of presence and colour at *4,5,6,7,9,* and 11 meter distances. These measures of tag recognition were done in good light (sun) conditions.

2.5.4 Aerial Survey

On September 15th, an aerial count of steelhead by helicopter was conducted from the Moosevale confluence to the fences. This allowed an interesting comparison to a snorkel count that had been completed on September 14th. The light conditions for these two surveys were very similar with clear skies on both days. The aerial count was done at a low enough elevation to allow easy identification between sockeye and steelhead. A difficulty with this technique was the multi-directional dispersal of steelhead that the helicopter created as it moved overhead. However, repeat passes over difficult pools allowed reasonable counts.

Table 1. Summary of all species of fish moving up-stream through the Sustut and Johanson fences from July 25th, 1993 – September 26th, 1993. *(for details see* Appendices 1 & 2).

	Sustut Fence			**Johanson Fence**		
Species	males	females	**TOTAL**	males	females	**TOTAL**
Steelhead	11	15	**26**	65	117	**182**
Sockeye	943	1214	**2169**	430	587	**1021**
Chinook	97	102	**199**	59	32	**91**
Coho	—	—	**5**	13	5	**18**
Rainbow trout	-	-	**6**	-	-	**1**
Dolly varden	-	-	**21**	-	-	**9**
Mountain whitefish	—	—	**12**	—	—	**4**

3.0 Results

3.1 Up-stream movement through fences

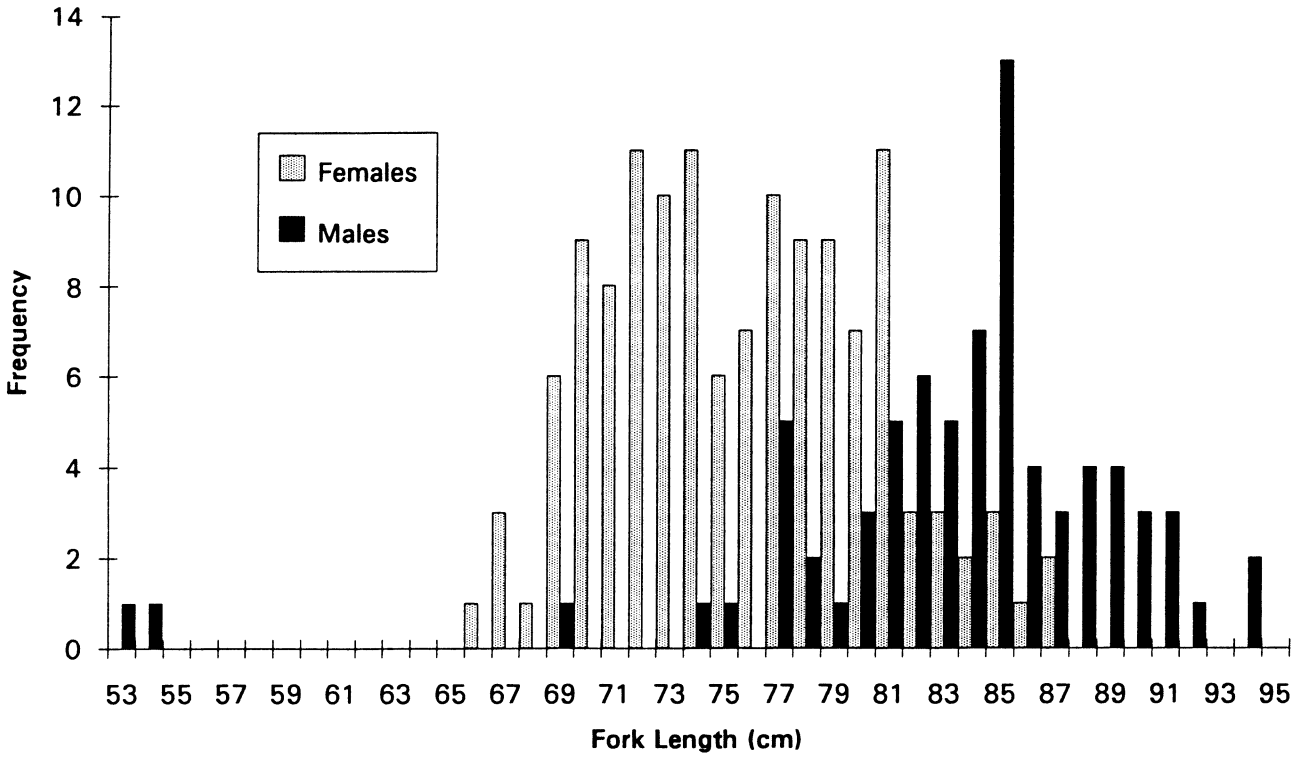
3.1.1 Steelhead

The first steelhead moved through the Sustut fence on August 9th**,** but the next steelhead was not recorded at the Sustut fence until August 24th. The movement of steelhead through the Sustut fence then continued sporadically until the fence was removed (Appendix 1). In total, only 26 steelhead (11 males, 15 females) were marked and released above this fence during the entire study (Table 1).

The first steelhead moved to the Johanson fence on August 9th and appeared to initiate a more consistent trend of up-stream migration to Johanson Lake than to Sustut Lake (Appendix 2). When the Johanson fence was removed, 182 steelhead (65 males, 117 females) had been tagged and released above the fence (Table 1).

From all steelhead that were tagged and released (Sustut and Johanson fence captures combined), the fork lengths of males ranged from 53 - 94 cm and fork lengths of females from 66 - 87 cm (Figure 5). The mean fork length of females was 75.9 cm and the mean fork length for males was 85.8 cm. Comparison of adult size in 1993 to previous surveys found a notable size increase from 1992 (Bustard 1992), but little difference from 1986 (Spence *et al.* 1990)(Table 2).

Figure 5. Distribution of fork lengths (cm) among all steelhead passing through the Upper Sustut and Johanson fish fences, 1993.



Freshwater ages ranged from 2 to 5 years but were difficult to evaluate. The majority of both males and females appeared to have lived either 3 or 4 years in freshwater. It is important to note that this evaluation of freshwater ages from scales may be missing one year. It has previously been suggested that the Upper Sustut stock primarily spends 4 to 5 years in freshwater, as opposed to the 3 or 4 years that has been more commonly described for this system (Spence *et al.* 1990). It is believed that the harsh environment and associated low growth rate in the first year excludes a detectable annulus (Wallis 1982).

Ocean ages from scales were easier to evaluate than freshwater ages due to the recognizably increased growth during the summers at sea. Scale samples were taken from the first 75 steelhead which passed through the fences. The steelhead arriving at the Upper Sustut River (1993) were found to have ocean ages of 2 + or 3 + years (Table 3).

3.1.2 Sockeye salmon

In coordination with DFO, this project included the continuation of monitoring sockeye migrations to Sustut and Johanson lakes. The first sockeye were recorded at the Johanson fence on July 9th, and at the Sustut fence on July 31st. Sockeye continued to move into the

Table 2. Summary of sample sizes (N), mean fork lengths (cm), and size ranges of male and female steelhead in the Upper Sustut River (data from 1992 and 1986 are taken from Bustard 1992, and Spence *et al.* 1990, respectively).

Year	N (%)	Mean Fork Length (cm)	Size Range (cm)
		MALES	
1993	**75 (35.7)**	**85.8**	**53 - 94**
1992	49 (19.8)	77.6	69 - 91
1986	66 (35.7)	84.1	76 - 98
		FEMALES	
1993	**135 (64.3)**	**75.9**	**66 - 87**
1992	198 (80.2)	72.1	65 - 82
1986	119 (64.3)	76.3	67 - 88

Table 3. Ocean ages and mean fork lengths of male and female steelhead from the Upper Sustut River in 1993.

	Males		**Females**	
Ocean Age	N(%)	Mean FL (cm)	N(%)	Mean FL (cm)
.2+	16 (67)	81.7	35 (78)	75.5
.3+	8 (33)	88.0	10 (22)	81.6

up-migration traps at both the Sustut and Johanson fences through August and September; the peaks of migration were during August at both fences (Appendices 1 & 2). In total, 2169 sockeye (943 males, 1214 females, 12 unknown) moved through the Sustut fence and 1021 sockeye (430 males, 587 females, 4 unknown) moved through the Johanson fence (Table 1); less than 100 sockeye were seen in the 5 km stretch of river below the fences during the final snorkel survey on September 26th.

3.1.3 Chinook salmon

Prior to transition of the responsibilities for this joint project to the MOE Fisheries Branch, DFO (Shirvell & Dubeau) also obtained data on numbers of chinook salmon that moved above the Sustut and Johanson fences. Unlike sockeye, chinook moved through the fence over an earlier and more concise time from late July to early August (Appendices 1 & 2). In total, 199 chinook (97 males, 102 females) moved past the Sustut fence, and 91(59 males, 32 females) were moved past the Johanson fence (Table 1). Fork lengths and weights of chinook salmon were recorded at both fences and are listed in Appendix 4.

3.1.4 Other fish species

Coho salmon, rainbow trout, dolly varden char, and rocky mountain whitefish were also found in up-stream traps at both fences. During the entire study, there were 18 coho (13 males, 5 females) recorded at the Johanson fence, and 5 coho (2 females, 3 unknown) recorded at the Sustut fence (Table 1). Only 4 rocky mountain whitefish, 9 dolly varden char, and 1 rainbow trout were recorded at the Johanson fence and 12 rocky mountain whitefish, 21 dolly varden char, and 6 rainbow trout were recorded at the Sustut fence (Table 1).

3.2 Down-stream movement through fences

Interestingly, there were very few fish caught in the downstream traps at either fence. Two weak and fungus infected steelhead were found in the Johanson and none were found in the Sustut downstream traps. It is possible that the downstream traps at both fences were positioned in locations with insufficient water flow to attract or retain fish.

3.3 Timing of steelhead movement through fences

The discharge of both Upper Sustut and Johanson rivers decreased steadily during September (Appendix 5) and suggested that stream flow may have reduced movement of steelhead to the overwintering lakes. A slight increase in water temperature from September 4th to 8th coincided with a notable increase of steelhead movement through the fences (Appendix 6) suggesting that temperature is influential on later migrations. It was apparent that water temperatures below 2 - 4 ^{o}C had a notable effect on steelhead activity. This was most evident during the handling of steelhead at different recorded temperatures. It was also recognized clearly that steelhead preferred to wait until the afternoon (perhaps highest temperature) to make attempts at surpassing the fences. There was very little activity below either the Sustut or Johanson fences in the morning hours and although some steelhead were recorded in the up-stream traps in the morning, the majority of them had entered the traps

overnight.

At the time when fences were removed, the majority of the Upper Sustut steelhead stock was still holding below the fences. Evidence from the 1992 survey (Bustard 1992) suggests that these fish were awaiting a major autumn freshet to stimulate movement to the lakes for overwintering.

3.4 Enumeration downstream from fences

3.4.1 Underwater Visibility

Tests were performed on September 19th to measure underwater visibility, and to evaluate accuracy of snorkel counts (Appendix 7). Visibility remained relatively unchanged for all seven surveys completed in this study. Test results revealed a definite advantage for drifts along the shady side of a river that directed the viewing into the better lighted areas; this allowed for a significantly longer range of vision. Comparison of different coloured Floy tags also revealed that yellow, green, and especially blue tags were difficult to identify at distances greater than 5 meters. In comparison, the black shapes were relatively easy to identify at distances greater than 10 m. Useful information for future work was the clear advantage of orange tags which were as easy to identify as the black shape markers. The results from these simple tests reveal that researchers must be cautious of population estimates that do not include a measure of tag visibility to allow for corrections related to tags not seen. It is important in snorkel surveys to only count fish that are within the range of tag visibility if mark/recapture estimates are going to be used. However, for the snorkel counts in this study, minimum distance of fish identification was from one side of the river to the other at all of the holding pools. This excellent visibility allowed accurate counts of steelhead without any corrections.

3.4.2 Snorkel Surveys

Data for the enumerations of steelhead by snorkel counts from the fences downstream to the Moosevale confluence are summarized in Table 4. Low water levels and low turbidity created excellent visibility and accurate counts for all seven surveys. The four day interval between surveys was chosen because it limited the disturbance to the fish but allowed for reasonable recognition of the rate that new arrivals entered the survey area. In addition, the three short snorkel surveys below the Moosevale Creek confluence were useful indicators of the comparative rates of steelhead arrival at the section of river where the snorkel counts were conducted (Table 5). The combined data from snorkel surveys and fence counts support that the enumeration on September 26th is a relatively good estimation of the number of adult steelhead of the Upper Sustut stock of 1993. The very small number of steelhead in the lower holding pools below the Moosevale confluence and the small increase (1.9 %) in population from September 22nd to 26th,indicated that the large majority of the stock had arrived at the Upper Sustut River.

Table 4. Summary of adult steelhead population estimates, as determined by snorkel and fence counts, in the Upper Sustut River, September 1993.

		Date (September)					
Pool#	3	7	11	14	18	22	26
Johanson	6	50	22	17	33	26	25
1	6	30	30	30	54	28	26
2	39	36	78	93	90	71	81
3	27	16	8	13	5	23	37
4	9	2	8	0	5	0	0
5	50	55	49	13	46	106	90
6	7	4	2	46	4	5	4
7	5	0	0	2	1	0	0
8	0	0	0	0	0	0	0
9	2	0	1	0	0	0	0
10	0	2	0	0	0	0	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	6	4	5	4	5	12	14
14	6	0	5	0	3	0	2
15	0	1	1	1	1	0	0
16	0	0	0	0	0	2	0
17	2	3	0	3	1	0	1
Snorkel Counts	165	205	209	224	228	273	276
Sustut Fence	15	19	25	25	25	26	26
Johanson Fence	50	81	144	155	165	168	174
Population	**230**	**305**	**378**	**404**	**418**	**467**	**476**
Percent increase	**-**	**32.6**	**23.9**	**6.9**	**3.5**	**11.7**	**1.9**

Table 5. Summary of results from snorkel surveys of the Sustut River for 2 km below the Moosevale junction (for locations of pool #, see Figure 2, *page* 3).

	Snorkel Surveys		
POOL #	September 17th	September 21st	September 25th
18	1	2	0
19	2	6	0
20	0	0	1
between pools	1	1	2
TOTALS	4	9	3

3.4.3 Aerial Survey

The aerial survey was completed in approximately 10 minutes and estimated 221 steelhead from Moosevale Creek up to the fences. Visibility was ideal with no pools too deep to see the bottom. This aerial survey on September 15th counted only 3 fewer fish than the snorkel count on September 14th. In fact, there was no difference in total enumerations because 3 fish had moved through the fences on the afternoon between the two counts. This was an excellent example of the efficiency and accuracy of aerial surveys when conditions such as depth and turbidity are optimal. In addition, there were also very few coho present in this stretch of stream. This added to the accuracy of this aerial count which was not reliant on species differentiation.

3.5 Enumeration of Upper Sustut steelhead

The summary of the stock enumeration through the month of September is displayed in Table 4. The combination of snorkel survey counts and numbers of fish through the Sustut and Johanson fences gave good estimates of the number of steelhead in the upper region of the Sustut River. Results revealed a steady increase in total numbers during early September, with progressively lower recruitment later in the month. The final snorkel survey below the Moosevale Creek confluence on September 25th counted only three steelhead approaching the survey area and implied that the 1993 run was essentially over. The final estimate for the Upper Sustut steelhead stock in 1993 was 476. This number of steelhead is well below the carrying capacity assessment for this drainage, which estimates that the Upper Sustut is able to sustain returns of more than 1000 steelhead (Tautz et al. 1992: Ward pers. comm.).

4.0 Discussion

The 1993 addition of the fence across Johanson Creek, in combination with the Upper Sustut fence, allowed accurate counts of all adult steelhead before their arrival at either Sustut or Johanson lakes for overwintering. The use of both fences provided useful evidence of the timing of the final upstream migration by steelhead from the major holding areas in the 1.5 km stretch below the Johanson confluence. A knowledge of holding times in this section of the river by both the Johanson and Sustut Lake overwinterers is important in predicting the vulnerability of these stocks to the Native fishery. In this year's record, the Johanson Lake overwinterers clearly showed earlier and more consistent migration to the lake. Since the Native fishery for steelhead did not start until the end of September 1993, this indicates that Sustut Lake overwinterers were more vulnerable to over fishing by natives. Due to the fact that fences can delay migration of fishes, it is necessary to balance the benefits of precise enumeration of Sustut Lake overwinterers with their increased vulnerability to Native fishing.

In addition to the exact counts of steelhead moving upstream through the fences to the lakes for overwintering, the snorkel surveys provided precise counts of fish that had arrived in the survey area. In agreement with the 1992 snorkel surveys (Bustard 1992), the 1993 surveys also found that steelhead congregated primarily in the holding pools within 1.5 km of the Johanson confluence. However, in 1993, fish also congregated in a holding pool in Johanson Creek, approximately 100 m below the Johanson fence (eg. 50 steelhead at this location on September 5th, 1993). Bustard (1992) reported seeing very few steelhead at this location in 1992. The new congregation of fish at this location may be an artifact of the fence. Another difference was that Bustard (1992) found 40 steelhead holding in the Sustut Canyon (two pools below the Moosevale confluence) on September 10th, 1992. In 1993, snorkel surveys of this lower region found significantly fewer fish holding at any of the pools below the Moosevale confluence. Counts at the canyon pool were two, six, and zero on September 17th, 21st and 25th, respectively. However, Bustard's only survey of this lower region of the Upper Sustut River was conducted earlier in September. Larger numbers of steelhead may have been holding at the Sustut Canyon pool earlier in 1993. This section of the river appears to be a useful indicator of new arrivals to the Upper Sustut River and should continue to be used to support the timing of future snorkel enumerations.

Due to early removal of the fences, it is difficult to assess the ratio of returns to Sustut and Johanson lakes. At the termination of the study, 182 steelhead had migrated through the Johanson fence and 26 through the Sustut fence, which left 268 steelhead downstream from the fences. Of these 268, 25 were in the Johanson Creek holding pool which implied that at least 207 fish would overwinter in Johanson Lake. How the remaining 243 steelhead below the confluence distributed is uncertain, but the total at Johanson Lake would lie between 207 and 450 steelhead. The number of steelhead reaching Sustut Lake would therefore lie between 26 and 243.

The final enumeration for 1993 does not take into account the impact of the Native fishery for steelhead that occurs at this location during late September and October. Takla Band members were observed fishing in the Upper Sustut River with both treble hooks and gill nets. A 25' gaff pole was also discovered hanging on a large tree beside the river. The first

participants in this fishery arrived on September 24th and 25th. Personal conversation with these families indicated there is an annual steelhead harvest of this stock during late September through to the middle of October. It is important to consider that the 476 steelhead likely represent two stocks from different tributaries and that the Sustut Lake overwinterers are especially vulnerable to the Native fishery due to an apparently prolonged delay below the Johanson confluence, where the fishery is focused. It is essential to further examine the discreteness of Johanson Creek and Upper Sustut stocks as this could greatly influence management decisions concerning these stocks.

The coordination of this work with the Department of Fisheries and Oceans is an excellent approach toward a complete annual fisheries management survey of the Upper Sustut River. The early migrations of steelhead to Johanson and Sustut lakes make this system an appropriate index for the variable impacts of the commercial and Native fisheries on early-run summer steelhead of the Skeena drainage system. Continued monitoring of the Upper Sustut stock will provide managers with the information needed to more adequately address interannual fluctuations in abundance and the impact of downstream fisheries.

5.0 Recommendations

5.1 It is recommended that the Upper Sustut River steelhead stock continue to be used as an index system for early run, summer steelhead stocks. It is important that both the Upper Sustut and the Johanson fences are maintained. This will require communication with the DFO to ensure the inclusion of the Johanson Creek fence. Operation of these two fences should be taken over from the DFO on September 1st then monitored for 4 - 6 weeks or as weather permits. The road from this location is usually in good condition until mid to late October (Ron Steffi: Moosevalley Outfitters, pers. comm.).

5.2 An accurate record of underwater visibility should be taken during all snorkel surveys. Measured changes of turbidity will give a valuable account for variation of enumeration.

5.3 It will be useful to determine whether the Sustut and Johanson lake overwinterers are in fact separate stocks. Blood samples should be taken from kelts near the outlets of both the Sustut and Johanson lakes for DNA sequencing. Genetic comparisons may provide the answer to the relationship between these two populations.

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Appendix 1. Daily catch of fish moving upstream in the Sustut River at the Upper Sustut Fish Fence from July 25th to September 28th, 1993 *(pages* 19 - 21).

	Chinook			Sockeye			Steelhead			Coho	RBT	DV	RMW
	Total	M	F	Total	M	F	Total	M	F				
July													
25													
26													
27													
28	10	6	4										
29	3	1	2										
30	3	1	2										
31	13	7	6	2	2	0							
Aug.													
1	18	9	9										
2	16	7	9	1	1	0							
3	26	10	16	1	1	0							
4	13	6	7	2	1	1							
5	16	6	10	5	3	2							
6	17	7	10	4	4	0							
7	3	1	2	13	10	3							1
8	16	10	6	40	26	14							
9	1	1	0	413	193	214	1	0	1				
10	4	3	1	106	53	53							
11	5	3	2	88	46	42							
12	8	5	3	9	5	4							
13	11	6	5	37	17	20							
14	6	1	5	8	5	3							
15	4	3	1	1	1	0							
16	4	2	2	22	17	5							
17	1	1	0	42	19	22							
18				13	5	8							
19				10	5	5							
20				1	0	1							
21													
22												3	1

Appendix 1. (cont.) Daily catch of fish moving upstream in the Sustut River at the Upper Sustut Fish Fence from July 25th to September 28th, 1993 *(pages* 19-21).

	Chinook			Sockeye			Steelhead			Coho	RBT	DV	RMW
	Total	M	F	Total	M	F	Total	M	F				
Aug													
23				95	60	33							1
24				331	152	178	3	0	3				
25				308	120	186	2	1	1			1	
26	1	1	0	4	3	1	4	1	3			1	
27							2	1	1				
28				10	9	1	1	0	1				
29				2	0	2						1	
30													
31				12	2	10							
Sept.													
1				88	28	60	2	2	0				
2													
3				6	3	3							
4				7	3	4							1
5				46	19	27	2	0	2			1	
6				10	6	4	2	1	1			1	
7				95	34	61	3	3	0			5	
8				27	11	16	3	2	1		1	1	
9				27	8	19				3	1		
10				3	2	1				1		1	1
11				60	15	45				1	1	1	1
12				44	12	32					1		
13				46	8	38							
14				48	6	42	1	0	1				
15				26	8	18						1	2
16				16	7	9							
17				16	3	13					1		
18				2	1	1					1		
19													
20				1	1	0							

Appendix 1. (cont.). Daily catch of fish moving upstream in the Sustut River at the Upper Sustut Fish Fence from July 25th to September 28th, 1993

	Chinook			Sockeye			Steelhead			Coho	RBT	DV	RMW
	Total	M	F	Total	M	F	Total	M	F				
Sept.													
21				2	1	1					1	1	4
22				6	3	3							
23				5	1	4						1	
24				2	1	1							
25												1	
26				6	2	4							
27													
38													
TOTAL	199	97	102	2169*	943	1214	26	11	15	5	7	14	9

()* 12 fish from this total escaped prior to record of sex

Appendix 2. Daily catch of fish moving upstream in the Johanson Creek at the Johanson Fish Fence from July 25th to September 28th, 1993 *(pages* 22-24).

	Chinook			Sockeye			Steelhead			Coho	RBT	DV	RMW
	Total	M	F	Total	M	F	Total	M	F				
July													
25	7	6	1										1
26	5	2	3										
27	6	5	1										
28	11	7	4										
29	4	3	1	1	1	0							
30	13	6	5	2	0	2							
31	11	4	7										
Aug.													
1	5	3	2	8	4	4						1	
2	4	4	0	1	1	0							
3	2	0	2	4	1	3							
4	6	5	1	2	1	1							
5	3	2	1	31	16	15							
6	2	1	1	27	17	10							
7	1	1	0	69	37	32							
8	4	4	0	37	17	19							
9	1	1	0	55	22	33	1	0	0				
10				56	26	30							
11	2	1	1	76	31	45						1	
12	1	1	0	13	6	7							
13	1	0	1	56	22	34	1	0	1				
14				43	20	23							
15				3	3	0	1	0	1				
16				9	7	2							
17				46	16	27							
18				17	9	8	1	0	1				
19				6	3	3							
20	2	1	1	28	11	17	5	2	3				
21				2	1	1	3	0	3				
22				23	11	12	2	0	2				

Appendix 2. (cont.) Daily catch of fish moving upstream in the Johanson Creek at the Johanson Fish Fence from July 25th to September 28th, 1993

	Chinook			Sockeye			Steelhead			Coho	RBT	DV	RMW
	Total	M	F	Total	M	F	Total	M	F				
Aug													
23				26	13	13	3	1	2				
24				66	26	40	9	4	5			1	
25				78	26	52	6	3	3				
26	1	1	0	4	2	2	5	4	1			1	1
27				8	5	3	1	0	1				
28				16	5	11	1	0	1				
29				11	7	4							
30				8	4	4	3	2	1				
31				11	7	4	3	0	3				
Sept.													
1							2	1	1	1			
2							3	2	1				
3				32	9	23	4	1	3				
4				20	7	13	2	0	2	1			
5				8	2	6	7	0	7	1			
6				13	3	10	10	3	7	1			
7				17	8	9	24	8	16	4	1		
8				17	3	14	31	12	19				
9				10	3	7	15	7	8				
10				1	1	0	1	0	1				
11				9	3	6	8	3	5	2			
12				4	2	2	5	1	4	1			
13				8	2	6	5	2	3				
14				14	2	12	3	0	3				
15				5	2	3							1
16				3	1	2	1	1	0			2	
17				3	0	3	5	3	2				
18							1	0	1				
19				1	0	1	1	1	0			1	
20													1

Appendix 2. (cont.) Daily catch of fish moving upstream in Johanson Creek at the Johanson Fish Fence from July 25th to September 28th, 1993

	Chinook			Sockeye			Steelhead			Coho	RBT	DV	RMW
	Total	M	F	Total	M	F	Total	M	F				
Sept.													
21				3	1	2	2	2	0			1	
22				3	1	2							
23				1	0	1				1			
24				1	0	1	5	1	4	3		1	
25							1	0	1				
26				3	0	3	2	1	1	3			
27													
28													
TOTAL	91	59	32	1021*	430	587	182	65	117	18	1	8	4

()* 4 fish from this total escaped prior to record of sex

Appendix 3. Fork Lengths and Weights of (a.) male and (b.) female steelhead from subset of fish moving through the Upper Sustut and Johanson fences in 1993 (Data from DFO records).

STEELHEAD

a.Males

Fork Length (cm)	Weight (kg)
83.0	6.21
53.0	1.70
68.5	3.57
83.5	5.88
84.5	6.04
85.0	6.45
81.0	5.75
82.0	6.29
77.0	5.22
84.5	7.22
79.5	4.94
54.0	1.72
93.5	7.87
82.0	6.45
84.0	6.05
89.0	6.43
85.0	5.98
87.5	7.03
89.5	7.02
82.5	6.36

Mean FL **=** 80.4 cm
Mean weight **=** 5.71 kg

b.Females

Fork Length (cm)	Weight (kg)
75.0	4.33
74.0	4.93
80.5	6.06
84.0	5.70
81.0	5.95
81.0	5.71
81.0	5.31
74.0	4.33
79.0	5.53
84.5	6.00
78.0	4.70
71.0	3.94
75.0	4.36
78.0	*5.56*
68.5	3.37
72.5	4.25
80.0	5.63
82.0	*5.55*
69.7	4.35
87.0	6.80
71.0	4.44
72.0	4.74
67.0	4.04
83.0	5.95
70.0	3.50
77.0	5.20
73.5	4.55
72.0	4.35
85.0	5.83
76.0	5.37
69.5	4.12
78.0	5.49
69.0	3.32
81.0	5.78
87.0	7.43
81.0	5.79

Mean FL **=** 76.9cm
Mean Weight = 5.01 kg

Appendix 4. Fork Lengths and Weights of (a.) male and (b.) female Chinook salmon from subset of fish moving through the Upper Sustut Fence in 1993 (Data from DFO records).

Chinook Salmon

a. Males

Fork Length (cm)	Weight (kg)
88.0	7.98
97.5	10.33
78.0	4.77
87.0	7.48
87.5	7.58
91.0	8.18
85.0	6.58
67.0	3.73
93.0	8.20
92.0	7.55
66.5	3.90
86.0	6.90
87.5	7.85
95.0	9.50
64.0	3.75
81.0	6.15
86.0	7.10
92.5	8.35
74.0	4.15
88.5	7.55

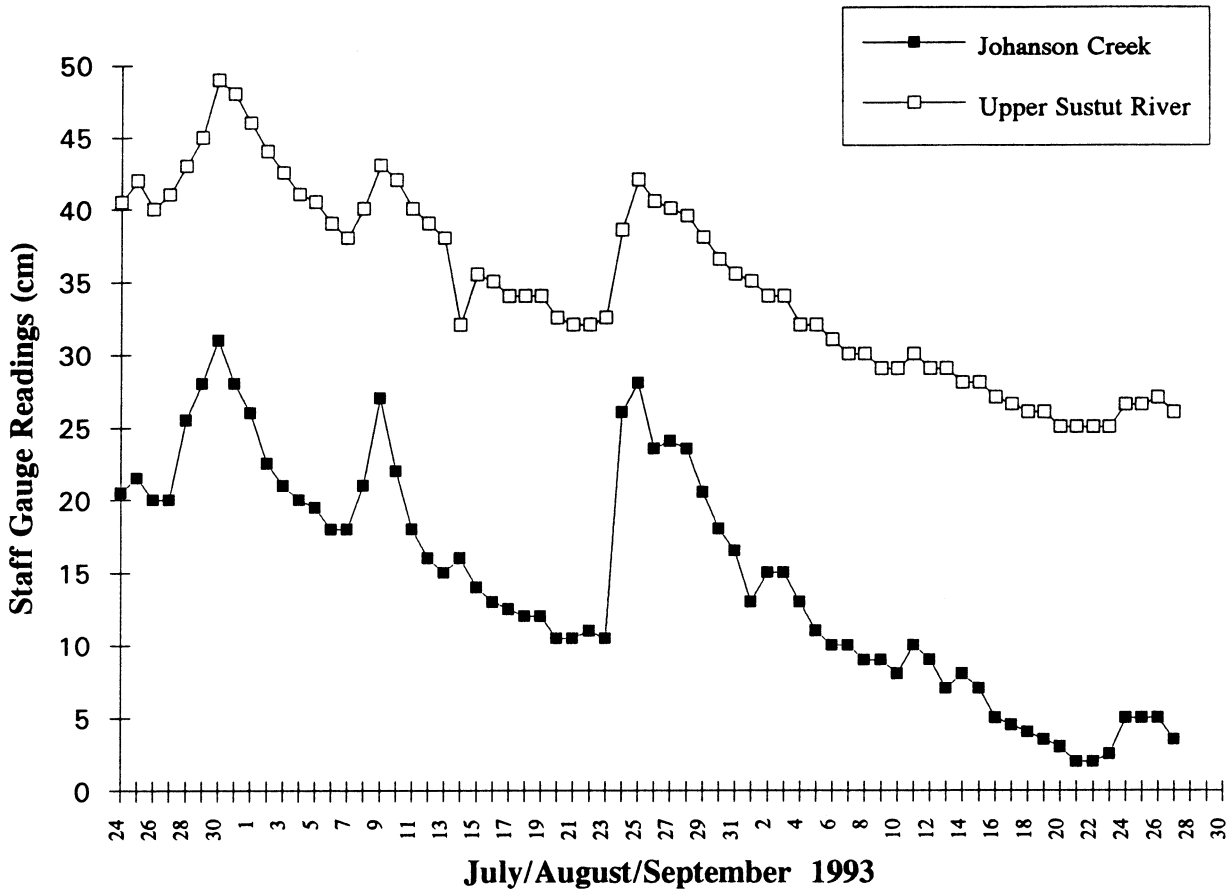
Mean FL = 84.4 cm
Mean Weight = 6.88 kg

b. Females

Fork Length (cm)	Weight (kg)
90.0	9.23
95.5	10.78
96.0	9.58
89.5	8.78
91.0	9.65
98.5	12.35
88.0	9.50
91.0	9.05
89.5	8.90
89.0	8.90
95.5	11.15
91.0	8.45
88.0	8.15
86.0	8.10
90.5	8.85
92.5	11.95
95.0	9.70

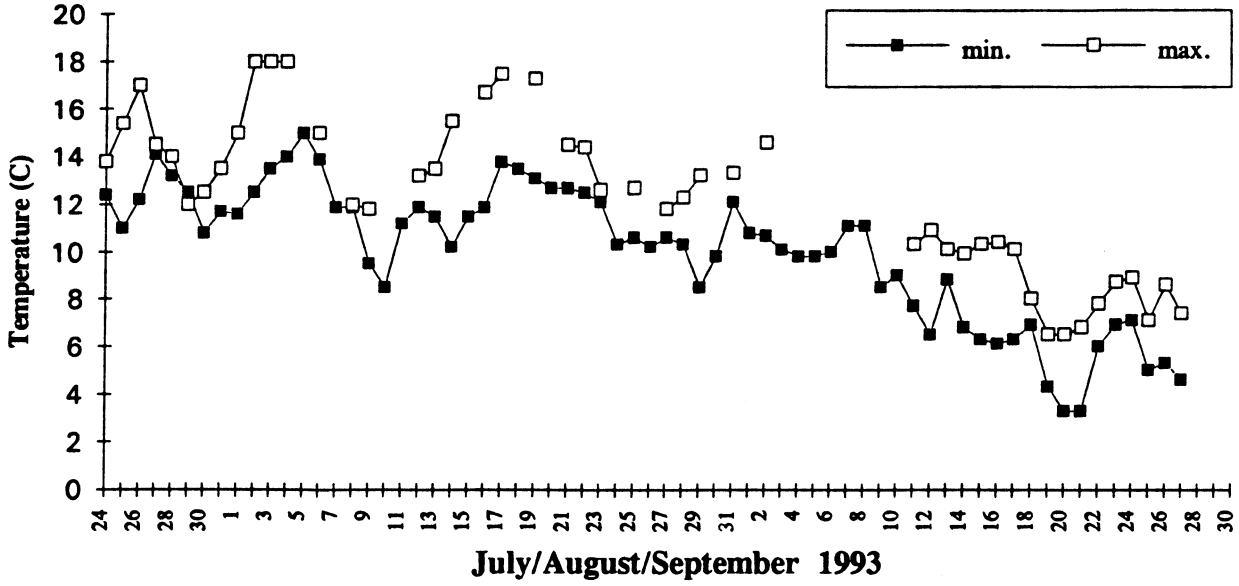
Mean FL = 91.6 cm
Mean Weight = 9.59 kg

Appendix 5. Discharge in Johanson Creek and the upper Sustut River above the Johanson confluence (July 24th - September 27th, 1993). Staff gauge readings were used as a measure of fluctuations in discharge: readings of water heights at the two systems are not comparable measures of total discharge (ie. Johanson Creek has higher total discharge than the upper Sustut River, despite lower staff gauge readings).

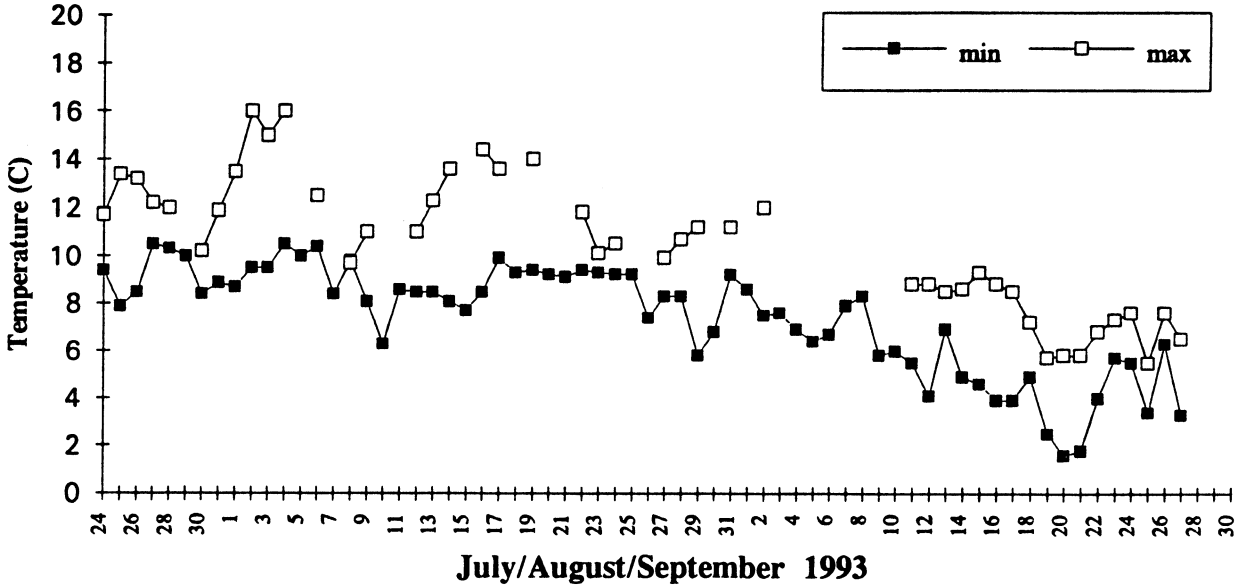


Appendix 6. Daily fluctuations of water temperatures for **a.** Upper Sustut River and **b.** Johanson Creek: temperatures were taken at staff gauges (*see* Figure 2, *page* 3). Minimum temperatures were represented by temperatures taken between 8:00 and 9:00, and maximum temperatures were recorded between 16:00 and 18:00.

a. Upper Sustut River



b. Johanson Creek



Appendix 7. Tests of underwater visibility at the Johanson/Sustut junction. (A) Time underwater to identify and differentiate between solid black circle (diameter 7.5 cm) and solid black square (7.5 cm x 7.5 cm) at increasing distances. (B) Time underwater to see Floy Tags on solid black square (7.5 cm x 7.5 cm) and identify their colour at increasing distances.

A. Test for range of underwater shape recognition.

	Mean time (sec) to recognize shape at Increasing Distance (m)					
Light cond.	4 m	5 m	6 m	7 m	9 m	11 m
Sun	-	3.3	-	5.9	7.0	7.0
Shade	-	3.4	-	20 ni*	nv**	-

ni* : Shape not identified or identified wrong
nv**: not visible

B. Test for visibility of Floy Tags and colour identification under good light conditions.

	Mean time (sec) to recognize Floy Tags at Increasing Distance (m)					
Tag Colour	4 m	5 m	6 m	7 m	9 m	11 m
Yellow	2.3	3.0	nv*	-	-	-
Orange	1.3	2.0	3.0	-	-	6.8
Green	3.7ni**	nv*	nv*	-	-	-
Blue	nv*	nv*	nv*	-	-	-
No Tag	10.0	>10	>10	-	-	-

nv* : Tag not visible
ni**: Colour not identified or identified wrong