Funding for this project was provided by the Skagit Environmental Endowment Commission

Snorkel Survey of Trout and Char in the Canadian Skagit River, 2011

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Executive Summary

R.J. Anaka, K.J. Scott and R. Masson. 2012. Snorkel Survey of Trout and Char in the Canadian Skagit River, 2011. Prepared for the Skagit Environmental Endowment Commission, by Scott Resource Services Inc.

Scott Resource Services Inc. was retained by the Skagit Environmental Endowment Commission to conduct rainbow trout (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*) stock assessments by snorkel survey in the Canadian Skagit River from the Sumallo River confluence south to Chittenden Bridge for the period of 2009 to 2011.

The survey area was divided into 14 contiguous sections. Rainbow trout and Bull trout were counted and categorized by size class (10 to 20 cm, 20 to 30 cm, 30 to 40 cm, and >40 cm). An abundance index (number of fish per floater per kilometer) was used to determine relative fish abundance in each section per Burrows and Neuman (1995). Total number of catchable (>20 cm) rainbow trout and bull trout in the study sections was estimated using an expansion factor developed by Burrows and Neuman (1995). Trends in abundance indices and catchable fish estimations were described using data collected in this study and from studies using similar methodologies in 1982 to 1994 and 1998.

A total of 1215 rainbow trout were counted in 2011. The majority were in the 30 to 40 cm size class (70.0%) and 20 to 30 cm size class (25.1 %). Abundance indices for rainbow trout were highest in Sections 3 and 2, and lowest in Sections 10 and 8. Counts of 10 to 20 cm rainbow trout in 2011 were markedly lower than any other years of survey, and >40 cm rainbow trout were consistently low during all snorkel surveys.

The sharp decline in sub-catchable (<20 cm) rainbow trout numbers could signal the beginning of a decline in the adult rainbow trout population. Fish of this size would likely be age 1+. Therefore, a corresponding decrease in the age 2+ trout in the over 20 cm size that contribute to the sport fishery may become evident as soon as 2012. The cause for the decline of 10 to 20 cm trout is unknown but predation by bull trout could be a contributing factor.

There were no definite trends in rainbow trout abundances between 1982 and 2011. Estimates of catchable rainbow trout in the Canadian Skagit River have been relatively constant since 1982 with the exception of an increase in 1994.

A total of 1938 bull trout were counted in 2011. The majority were in the >40 cm size class (91.1%). Bull trout counts increased by 5 fold from 1998 to 2009, and more than doubled between 2009 and 2011. Abundance indices for bull trout were highest in Sections 9 and 3, and lowest in Sections 14 and 11.

Although there is no snorkel survey data between 1998 and 2009, the observed increase in bull trout abundance between 2009 and 2010, and further increase in 2011 suggests that bull trout population growth is a recent phenomenon. Redside shiners (*Richardsonius balteatus*) were first observed in Ross Lake Reservoir in 2004. The introduced population may have provided a new and abundant food source for bull trout and contributed to improved survival and fecundity of adult fish. In addition, a no retention regulation has been in place in the Canadian Skagit River for over two decades and there has been a ban on retention of all bull trout in the American side

of Ross Lake Reservoir since 1998. The observed increase in bull trout abundance in the present study could also show that conservation efforts, such as restrictive angling regulations, are having a positive effect.

The relatively recent introduction of redside shiners in Ross Lake Reservoir, the dramatic increase in bull trout abundance and the low count of 10 to 20 cm rainbow trout in the 2011 survey likely indicate the beginning of a shift in the ecology of the Canadian Skagit River and Ross Lake Reservoir above Ross Dam. There has been concern that redside shiners could invade the Canadian Skagit River and compete with juvenile trout and bull trout for limited resources; however, on-going research has yet to identify negative effects on salmonid stocks (Welch 2011). Further study would be required to monitor the ecological changes that are occurring and to determine whether changes to sport fishing management are required.

Conclusions and recommendations are presented at the end of the report.

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ACKNOWLEDGEMENTS

Scott Resource Services Inc. (SRS) thanks the Skagit Environmental Endowment Commission (SEEC) for funding this study. SRS would also like to thank Duane Jesson and Iain Lunn of the Ministry of Forests, Lands and Natural Resource Operations and Pete Caverhill (SEEC) for their support, guidance and technical assistance during the study. Thanks to Poul Bech for assisting the SRS team during the field component of the project. Duane Jesson reviewed a draft of the report and provided useful comments.

1.0 INTRODUCTION

Scott Resource Services Inc. (SRS) was contracted by the Skagit Environmental Endowment Commission (SEEC) to undertake a fish stock assessment of the Canadian Skagit River. The purpose of this project was to collect and report on current rainbow trout/bull trout biological and population information in the Canadian Skagit River, with comparisons made to past results. This report documents the results of the 2011 snorkel survey of rainbow trout and bull trout in the Canadian Skagit River, and includes an analysis of the 2009 to 2011 snorkel survey data.

The 2011 stock assessment involved enumerating rainbow trout (*Oncorhynchus mykiss*) and bull trout species (*Salvelinus sp.*) by snorkeling the Skagit River from the Sumallo River confluence downstream to Chittenden Bridge. The objective of the snorkel survey was to determine the number, size and spatial distribution of rainbow trout and bull trout. Annual counts have previously been undertaken between 1982 and 1994, and in 1998. The 2011 survey was the final of a three year stock assessment program for the Skagit River. The first two surveys were completed in 2009 and 2010 (Anaka et al. 2010b) (Anaka et al. 2011). The three consecutive surveys allow for recent trend data on fish supply to be developed, the first such trend data since 1994. This report includes an analysis of the data from 2009, 2010 and 2011, including comparisons with historical snorkel survey results.

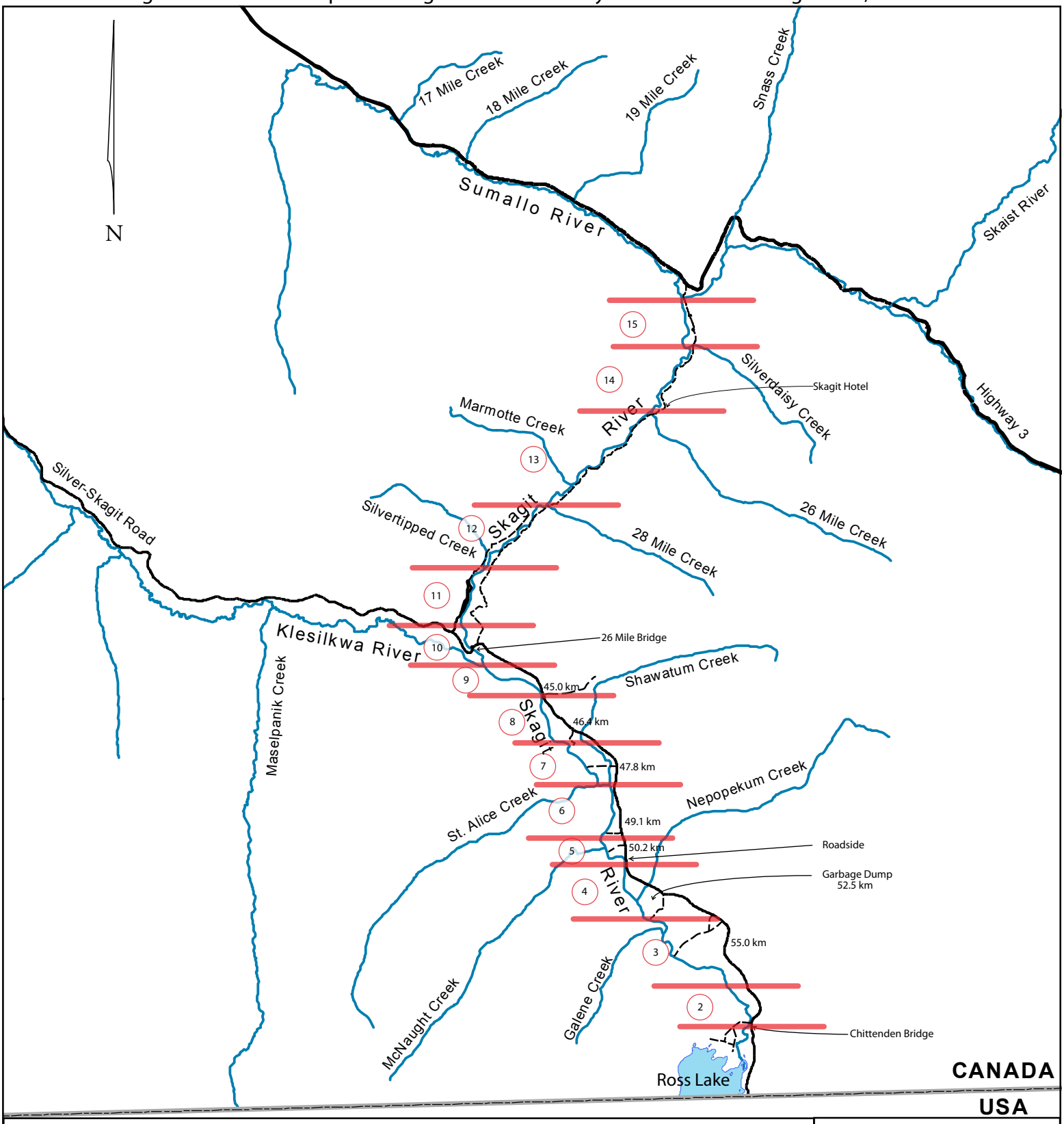
In total, 14 sections (36.9 km) of the Canadian Skagit River were surveyed, from the confluence of the Sumallo River to Chittenden Bridge (Figure 1) on the lower river near Ross Reservoir. The 2011 snorkel survey was conducted by SRS staff from September 6 through 10. The weather during the float was mainly sunny, with some high overcast. Due to the warm weather, snow melt flow from tributaries was high, resulting in river visibility varying from moderate to good (from 4 m to 8 m) during the survey, decreasing downstream. Water temperature was taken daily during the survey and ranged from 8 °C to 10 °C during the day. Air temperature ranged from 16 °C in the mornings to 22 °C in the afternoon.

1.1 Objectives

The objectives of the 2011 stock assessment of the Canadian Skagit River were to:

1. Count total rainbow trout and bull trout.
2. Categorize rainbow trout and bull trout observed by size class (<20 cm; 20 to 30 cm; 30 to 40 cm; >40 cm).
3. Compare distribution of rainbow trout and bull trout by species and location.
4. Calculate abundance indices for rainbow trout and bull trout within the assessed section of the river.
5. Provide observations and comments affecting rainbow trout/bull trout abundance and distribution.
6. Analyze and compare results to previous snorkel surveys on the BC Upper Skagit.

Figure 1. Sections sampled during the snorkel survey of the Canadian Skagit River, 2011.



Legend

Section number	Description	Section number	Description
15	Sumallo River to Silverdaisy Creek	8	45 km to 46.4 km
14	Silverdaisy Creek to Skagit Hotel	7	46.4 km to Shawatum Creek
13	Skagit Hotel to 28 Mile Creek	6	Shawatum Creek to fuel dump
12	28 Mile Creek to Silvertipped Creek	5	Fuel dump to roadside
11	Silvertipped Creek to 26 Mile Bridge	4	Roadside to garbage dump
10	26 Mile Bridge to Klesilkwa River	3	Garbage dump to 56 km
9	Klesilkwa River to 45 km	2	56km to Chittenden Bridge

Highway 3
Gravel Road
Trail
Lake
Creek

0 2.5 5 10 km

Overview of the study area. Note that many of the smaller creeks have been omitted to simplify the map.

Map features modified from TRIM and other BC Government base data. Projected in NAD 83, UTM 10.

SCOTT RESOURCE SERVICES

2.0 METHODS

2.1 Field data collections

Field data were collected consistent with standard procedures previously employed to survey this portion of the Skagit River (Burrows and Neuman, 1995). The survey team consisted of a senior consultant, contract biologist and field technician. The survey team was organized into floaters and a shore/boat tender to ensure floater safety. The river was divided into the same sections as previous years. Each section was sampled by floating through it once and counting all rainbow trout and bull trout observed by fork length size class. Floaters were equipped with a wet suit, snorkel, mask and personal underwater slate to record their observations. The tender was equipped with data sheets for summarizing the information as the float was conducted. The shore tender carried emergency gear and was responsible for ensuring floater safety and that the team progressed as a unit.

Prior to starting the survey, floaters were visually orientated to fish size classes by using representative lengths of wood dowel. Each morning, prior to floating a given section, the wood dowels were used to re-calibrate the floaters' ability to judge size class length. Safety procedures and emergency response plans were also reviewed prior to commencing the survey. To minimize duplication of counts, each floater was assigned a lane in the river and only recorded fish observed in that lane. The number of floaters in the water varied between 2 and 3 depending on the width of the wetted channel being surveyed (Photographs 1, 2, 3 and 4). In Sections 15 through 9, the narrower portion of the river, the survey team was comprised of 2 floaters and one tender. For Sections 8 through 2 the survey team was comprised of 3 floaters and 2 tenders (Table 1).

The team stopped frequently and collectively reviewed their counts. If a large number of fish were observed within a given length of river, it was re-floated to confirm fish numbers. Once a consensus was reached, the tender recorded the count on the data sheet (Appendix 1) and the survey team proceeded to float the next section of river.

2.2 Field data analysis

Data analysis followed Burrows and Neuman (1995), and included the calculation of abundance indices, which refers to the number of fish by species observed per kilometre per floater. Abundance indices were calculated using the following formula:

$$Abundance\ Index = \frac{Fish\ count\ by\ species\ per\ section}{(Section\ length\ in\ km)(Floater\ equivalent)}$$

The section lengths used for the snorkel survey were determined by Burrows and Neuman (1995). Although it has been determined that some of Burrows and Neumans' (1995) section lengths are erroneous, we have continued their use in this study for the purpose of comparison with previous studies.

For the purposes of this survey, the floater equivalent used for this analysis was 2, based on an average of 2 floaters.

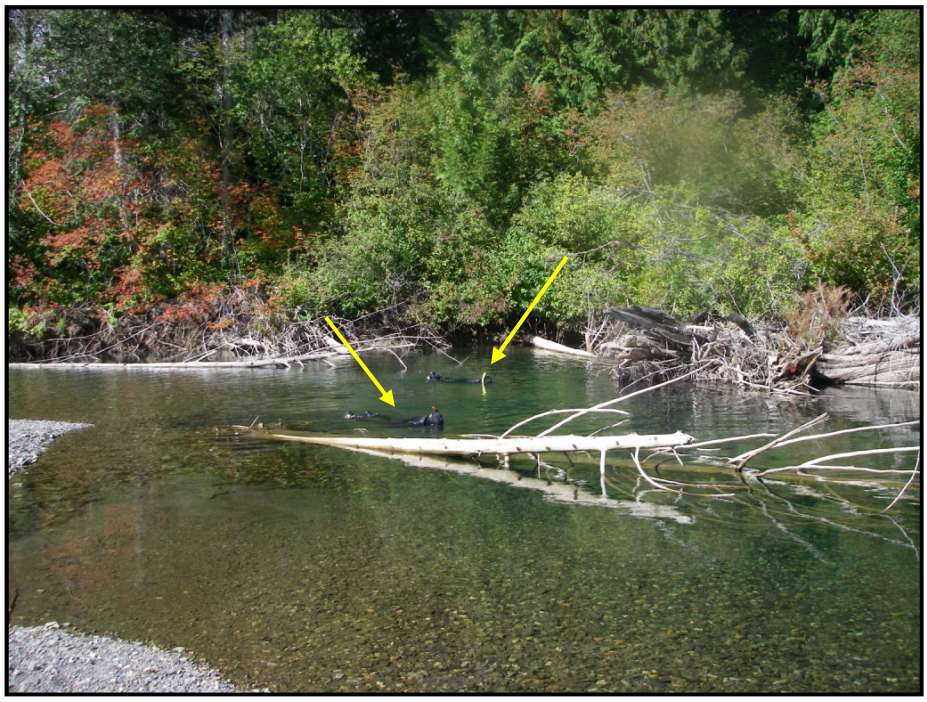
While not completed in the 2009, and 2010 reports, 2009 to 2011 population trends were examined to determine the number of catchable rainbow trout (i.e. > 20 cm in length) per kilometre using expansion factors (low and high) previously determined by Burrows and Neuman (1995).

Table 1. Descriptions and associated lengths of the sections floated during rainbow trout and bull trout survey in the Canadian Skagit River, 2011.

Section Number	Section Description	Length (m)	Number of Floaters
15	Sumallo River to Silverdaisy Creek	1,900 m	2
14	Silverdaisy Creek to Skagit Hotel	2,570 m	2
13	Skagit Hotel to 28 Mile Creek	6,010 m	2
12	28 Mile Creek to Silvertipped Creek	3,480 m	2
11	Silvertipped Creek to 26 Mile Bridge	3,310 m	2
10	26 Mile Bridge to Klesilkwa River	740 m	2
9	Klesilkwa River to 45 km	2,490 m	2
8	45 km to 46.4 km	1,980 m	3
7	46.4 km to Shawatum Creek	2,510 m	3
6	Shawatum Creek to Fuel Dump	960 m	3
5	Fuel Dump to Roadside	2,490 m	3
4	Roadside to Garbage Dump	2,860 m	3
3	Garbage Dump to 56 km	2,920 m	3
2	56 km to Chittenden Bridge	2,630 m	3
Total Length Enumerated		**36,850 m**	

Photograph 1. In riffles that tailed out into long deep pools one floater would walk to the bottom of the tail out to count from the bottom while the other floater would float through. This would mitigate double counting startled fish that may swim downstream and then turn back upstream. The floaters are identified by the yellow arrows.

Photograph 2. In areas of boulders and large cobbles which create a step pool flow pattern, fish observation can be difficult. Floaters would observe fish by strategically sliding around the channel substrate and peering from the fast moving water to the slower clearer water.



Photograph 3. In areas with coarse woody debris cover, one floater would float adjacent to the debris/pool and look in at the debris/pool while the other floater moved in and about the woody debris.

Photograph 4. Two floaters were floating the edge of a deep cut bank run. In this instance one floater floated directly through the run while the second paralleled the run edge. Both floaters counted the same area and compared observations.

3.0 RESULTS

3.1 Fish count

The snorkel survey of the Canadian Skagit River from September 6 to September 10, 2011 included 14 sections of the river, spanning approximately 36.9 km (Table 1). During the survey, totals of 1215 rainbow trout (Table 2) and 1938 bull trout (Table 3) were counted.

No other fish species were observed.

3.1.1 Rainbow trout

The majority (95.1 %) of the rainbow trout were found in the two intermediate size classes. This included 851 (70 %) in the 30 to 40 cm size class and 305 (25.1 %) in the 20 to 30 cm size class. The remaining rainbow trout were divided between the smallest and largest size classes. This included 24 (2.0 %) in the 10 to 20 cm size class and 35 (2.9 %) in the > 40 cm size class (Table 2).

During the survey large numbers of rainbow trout or bull trout fry were observed in pools and shallow side channel, gravel bar habitat.

Table 2. Summary of rainbow trout counted by section during the snorkel survey of the Canadian Skagit River, 2011.

Section Number	Rainbow Trout				
	10 to 20 cm	20 to 30 cm	30 to 40 cm	> 40 cm	Total
15	0	4	33	0	**37**
14	3	8	25	1	**37**
13	0	23	95	3	**121**
12	2	29	68	4	**103**
11	0	20	94	5	**119**
10	0	5	19	1	**25**
9	0	15	53	1	**69**
8	0	7	18	3	**28**
7	0	27	45	2	**74**
6	0	4	26	2	**32**
5	1	24	57	0	**82**
4	0	23	74	7	**104**
3	17	74	135	3	**229**
2	1	42	109	3	**155**
Total	**24**	**305**	**851**	**35**	**1215**
Percent of Total	**2.0%**	**25.1%**	**70.0%**	**2.9%**	

3.1.2 Bull trout

All of the bull trout counted (100 %) were found to be > 30 cm in length. The majority (1765 or 91.1 %) were in the > 40 cm size class while the remaining 173 (8.9 %) were in the 30 to 40 cm size class (Table 3).

During the snorkel survey incidental observation indicated that some of the bull trout appeared to be in spawning colours, mostly in the > 40 cm size class. A larger percentage of bull trout in the lower sections exhibited colouration typical of spawning fish compared to the upper sections.

Table 3. Summary of char counted by section during the snorkel survey of Canadian Skagit River, September, 2011.

Section Number	Bull trout				
	10 to 20 cm	20 to 30 cm	30 to 40 cm	> 40 cm	Total
15	0	0	0	116	**116**
14	0	0	1	23	**24**
13	0	0	2	107	**109**
12	0	0	0	105	**105**
11	0	0	3	56	**59**
10	0	0	0	23	**23**
9	0	0	9	284	**293**
8	0	0	14	76	**90**
7	0	0	22	114	**136**
6	0	0	7	48	**55**
5	0	0	13	103	**116**
4	0	0	30	181	**211**
3	0	0	41	358	**399**
2	0	0	31	171	**202**
Total	**0**	**0**	**173**	**1765**	**1938**
Percent of Total	**0.0%**	**0.0%**	**8.9%**	**91.1%**	

3.2 Fish distribution

Distribution of rainbow trout and bull trout showed less variability in the upper Skagit compared to the Lower Skagit. With the exception of Section 15, rainbow trout and bull trout counts were nearly equal in the Upper Skagit (Figure 2). Whereas, there were nearly twice as many bull trout compared to rainbow trout (1502 vs. 773) in Sections 9 to 2. Rainbow trout numbers differed section by section, with the highest numbers counted in Sections 13 to 11, 3 and 2. There was more variability in bull trout counts than in rainbow trout. The highest bull trout numbers were found in Sections 9, 4, 3 and 2.

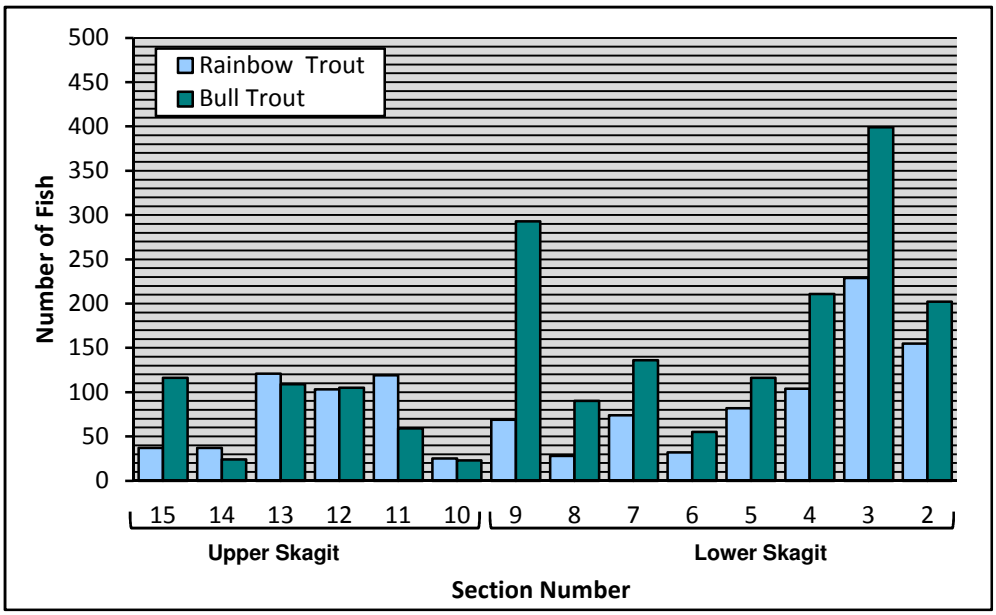


Figure 2. Distribution of rainbow trout and bull trout by section within the Canadian Skagit River, September, 2011.

3.3 Abundance indices

Consistent with the 1998 report (Harper and Scott, 1998a) and similar to Burrows and Neuman's (1995) report, abundance indices (number of fish per kilometre per floater) were calculated for rainbow trout within the assessed sections of the Canadian Skagit River during the 2011 survey (Table 4 and Figure 5). In previous studies abundance indices were not calculated for bull trout, as bull trout were not the primary focus of the studies and historically were not observed in large numbers. The increase in the number of bull trout counted in 2009 and 2010 stock assessments enabled the calculation of abundance indices for bull trout (Anaka et al. 2010b, Anaka et al. 2011). Abundance indices for bull trout calculated for this report and can be found in Section 3.3.2.

3.3.1 Rainbow trout abundance indices

The highest abundance of > 40 cm rainbow trout was found in the middle (Sections 12 through 10) to lower sections (Sections 8 through 2, excluding Section 5) of the Canadian Skagit River. The highest abundance of 30 to 40 cm rainbow trout was found in Sections 3 and 2. The abundance of 20 to 30 cm rainbow trout was relatively even throughout, with the highest abundance in Sections 3 and 2. The highest abundance indices of 10 to 20 cm rainbow trout was located in Section 3 (Table 4; Figure 3).

Table 4. Summary of abundance indices for rainbow trout counted in the Canadian Skagit River, September, 2011.

Section Number	Length of Section (km)	10 - 20 cm		20 - 30 cm		30 - 40 cm		> 40 cm		Total Counted	
		No. of RB	Abundance Index	No. of RB	Abundance Index	No. of RB	Abundance Index	No. of RB	Abundance Index	No. of RB	Abundance Index
15	1.90	0	0.00	4	1.05	33	8.68	0	0.00	37	9.74
14	2.57	3	0.58	8	1.56	25	4.86	1	0.19	37	7.20
13	6.01	0	0.00	23	1.91	95	7.90	3	0.25	121	10.07
12	3.48	2	0.29	29	4.17	68	9.77	4	0.57	103	14.80
11	3.31	0	0.00	20	3.02	94	14.20	5	0.76	119	17.98
10	0.74	0	0.00	5	3.38	19	12.84	1	0.68	25	16.89
9	2.49	0	0.00	15	3.01	53	10.64	1	0.20	69	13.86
8	1.98	0	0.00	7	1.77	18	4.55	3	0.76	28	7.07
7	2.51	0	0.00	27	5.38	45	8.96	2	0.40	74	14.74
6	0.96	0	0.00	4	2.08	26	13.54	2	1.04	32	16.67
5	2.49	1	0.20	24	4.82	57	11.45	0	0.00	82	16.47
4	2.86	0	0.00	23	4.02	74	12.94	7	1.22	104	18.18
3	2.92	17	2.91	74	12.67	135	23.12	3	0.51	229	39.21
2	2.63	1	0.19	42	7.98	109	20.72	3	0.57	155	29.47
Total	**36.85**	**24**	**0.33**	**305**	**4.14**	**851**	**11.55**	**35**	**0.47**	**1215**	**16.49**

*Abundance index (No.of rainbow trout per km per floater) = Count for section/(section length (km) x floater equivalent). Floater equivalent = 2.0 (Burrows and Neuman, 1995).

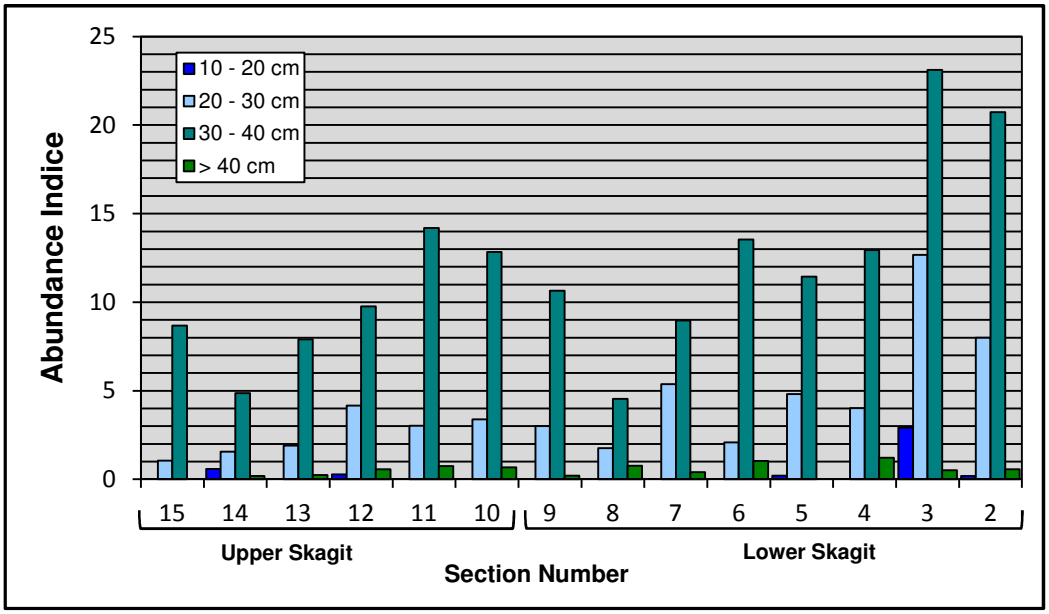


Figure 3. Abundance indices by section for rainbow trout counted in the Canadian Skagit River, September, 2011. Refer to Table 4 for actual numbers of fish used to generate abundance indices.

3.3.2 Bull trout abundance indices

The highest abundance of > 40 cm bull trout was found in three separate sections (Sections 15, 9 and 3) of the Canadian Skagit River. Bull trout abundance steady increased as one moved downstream, except for Section 15, which had the third largest abundance indices. Further abundance details are illustrated in Table 5 and Figure 4.

Table 5. Summary of abundance indices for char counted in the Canadian Skagit River, September, 2011.

Section Number	Length of Section (km)	10 - 20 cm		20 - 30 cm		30 - 40 cm		> 40 cm		Total Counted	
		No. of Bull trout	Abundance Index	No. of Bull trout	Abundance Index	No. of Bull trout	Abundance Index	No. of Bull trout	Abundance Index	No. of Bull trout	Abundance Index
15	1.90	0	0.00	0	0.00	0	0.00	116	30.53	116	30.53
14	2.57	0	0.00	0	0.00	1	0.19	23	4.47	24	4.67
13	6.01	0	0.00	0	0.00	2	0.17	107	8.90	109	9.07
12	3.48	0	0.00	0	0.00	0	0.00	105	15.09	105	15.09
11	3.31	0	0.00	0	0.00	3	0.45	56	8.46	59	8.91
10	0.74	0	0.00	0	0.00	0	0.00	23	15.54	23	15.54
9	2.49	0	0.00	0	0.00	9	1.81	284	57.03	293	58.84
8	1.98	0	0.00	0	0.00	14	3.54	76	19.19	90	22.73
7	2.51	0	0.00	0	0.00	22	4.38	114	22.71	136	27.09
6	0.96	0	0.00	0	0.00	7	3.65	48	25.00	55	28.65
5	2.49	0	0.00	0	0.00	13	2.61	103	20.68	116	23.29
4	2.86	0	0.00	0	0.00	30	5.24	181	31.64	211	36.89
3	2.92	0	0.00	0	0.00	41	7.02	358	61.30	399	68.32
2	2.63	0	0.00	0	0.00	31	5.89	171	32.51	202	38.40
Total	**36.85**	**0**	**0.00**	**0**	**0.00**	**173**	**2.35**	**1765**	**23.95**	**1938**	**26.30**

*Abundance index (No.of rainbow trout per km per floater) = Count for section/(section length (km) x floater equivalent). Floater equivalent = 2.0 (Burrows and Neuman, 1995).

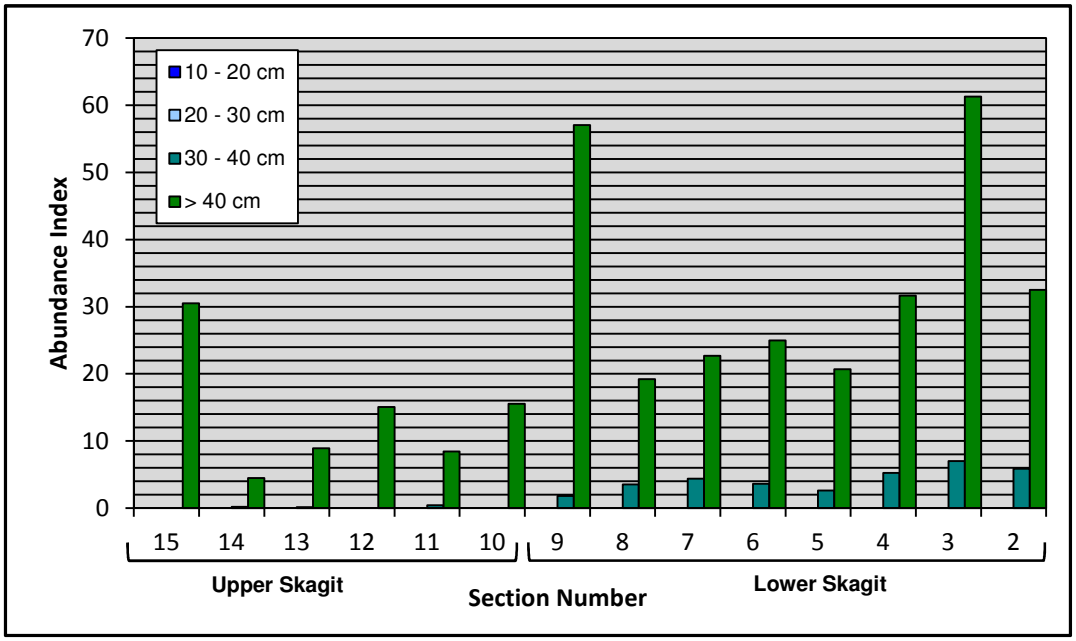


Figure 4. Abundance indices by section for bull trout counted in the Canadian Skagit River, September, 2011. Refer to Table 5 for actual numbers of fish used to generate abundance indices.

3.3.3 Comparison of 2011 rainbow trout and bull trout abundance indices

Figure 5 illustrates the abundance indices of both rainbow trout and bull trout for comparative purposes. Bull trout were found in higher abundance that rainbow trout in all but four sections (Sections 14, 13, 11 and 10)

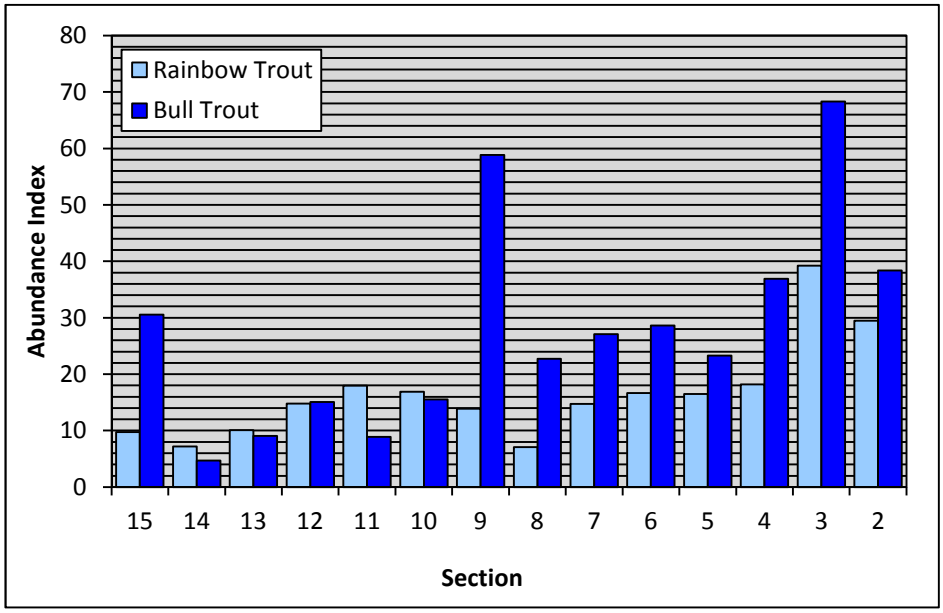


Figure 5. Abundance indices by section for rainbow trout and bull trout counted in the Canadian Skagit River, September, 2011.

3.4 Catchable versus non-catchable fish

To illustrate the availability of catchable fish, the recorded 2011 rainbow trout population was grouped as non-catchable (< 20 cm in length) or catchable (> 20 cm in length), consistent with Burrows and Neuman (1995).

Previous studies have not included an analysis of non-catchable bull trout due to low numbers of bull trout counted. However, the 2009, 2010 and 2011 surveys observed a substantial increase in the number of bull trout allowing for a comparison of catchable and non-catchable fish.

3.4.1 Rainbow trout

Non-catchable rainbow trout (24) were only observed in five sections (Section 14, 12, 5, 3, and 2), with the majority of non-catchable rainbow trout found in Section 3 (17; Table 2). The highest abundances of catchable rainbow trout were found in Sections 11, 3 and 2, and the lowest abundances of catchable rainbow trout were found in Sections 14 and 8 (Figure 6).

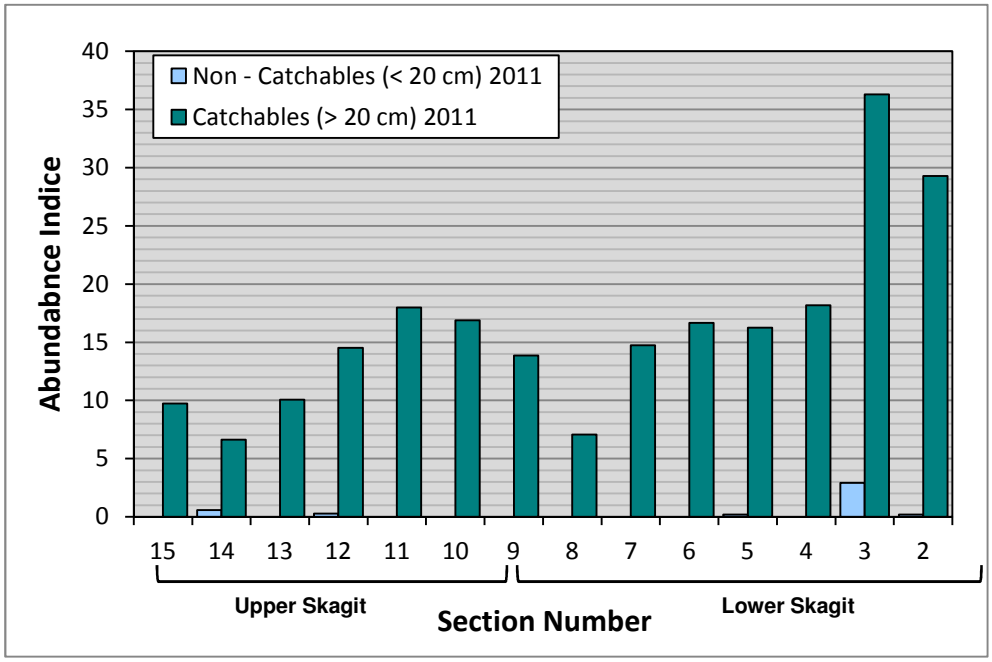


Figure 6. Abundance indices by section for catchable versus non-catchable rainbow trout counted in the Canadian Skagit River, September, 2011.

3.4.2 Bull trout

Of the bull trout observed during the 2011 snorkel survey 100 % were > 20 cm in length and considered catchable. No non-catchable bull trout were observed.

4.0 YEAR TO YEAR TREND DATA

4.1 Fish counts and distributions

4.1.1 Rainbow trout

There has been a decrease in the number of rainbow trout from 1998 to 2011. Highest numbers were recorded in 1998 (2149), followed by 2010 (1849), 2009 (1442) and 2011 (1215; Table 6). Despite variability in year to year population counts, most rainbow trout were counted in the lower 8 sections (9 to 2) of the river in 1998, 2009, 2010, and 2011 (Figure 7). Highest numbers were counted in Sections 3 and 2, and lowest numbers in Section 15, 10, and 6.

While the total number of rainbow trout varied by year, there was a noticeable pattern in the decrease in fish counts for all size classes, except for the 30 to 40 cm size class (Table 7, Figure 8). The number of > 40 cm fish decreased from 1998 to 2009, and remained similar during the 2009 to 2011 period of this study. The number of 10 to 20 cm fish also decreased from 1998 to 2009 and witnessed a pronounced decline from 2010 to 2011.

Table 6. Total rainbow trout counted by section during the 1998, 2009, 2010 and 2011 snorkel surveys of the Canadian Skagit River.

Skagit River Float Count 1998, 2009 - 2011				
Section Number	Rainbow Trout			
	1998	2009	2010	2011
15	21	61	76	37
14	148	101	116	37
13	177	246	218	121
12	104	114	129	103
11	104	126	167	119
10	28	17	25	25
9	54	65	83	69
8	180	89	127	28
7	96	102	93	74
6	36	58	45	32
5	144	33	135	82
4	293	47	163	104
3	413	232	283	229
2	351	151	189	155
Total	**2149**	**1442**	**1849**	**1215**

Table 7. Total rainbow trout by size class for the 1998, 2009, 2010 and 2011 snorkel surveys of the Canadian Skagit River.

Year	Size Class			
	10 - 20 cm	20 - 30 cm	30 - 40 cm	> 40 cm
1998	296 (13.8%)	759 (35.3%)	918 (42.7%)	176 (8.2%)
2009	153 (10.6%)	542 (37.6%)	713 (49.4%)	34 (2.4%)
2010	166 (9.0%)	640 (34.6%)	998 (54.0%)	45 (2.4%)
2011	24 (2.0%)	305 (25.1%)	851 (70.0%)	35 (2.9%)

*Percentages are percent of total for that year.

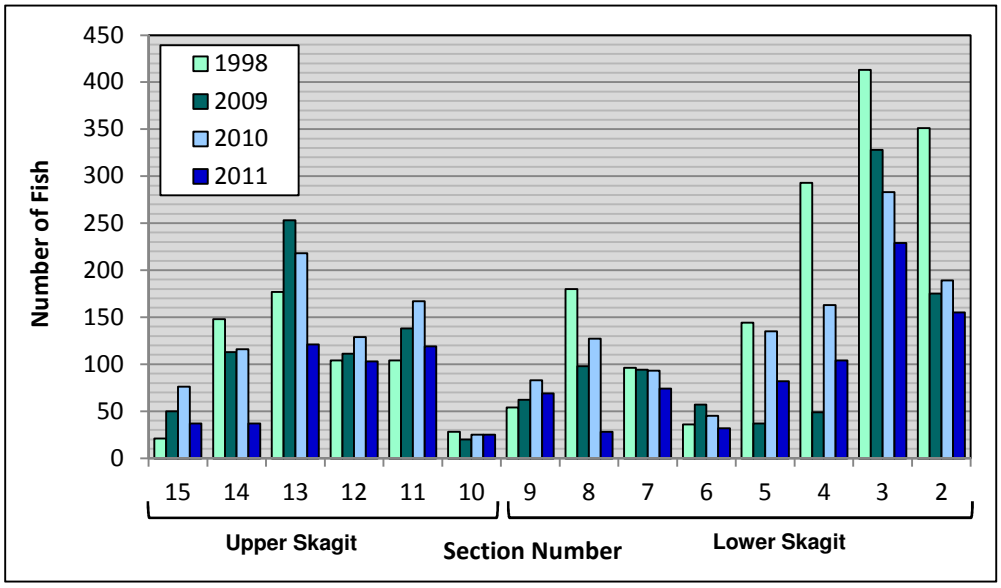


Figure 7. Distribution of 1998, 2009, 2010 and 2011 rainbow trout by section within the Canadian Skagit River.

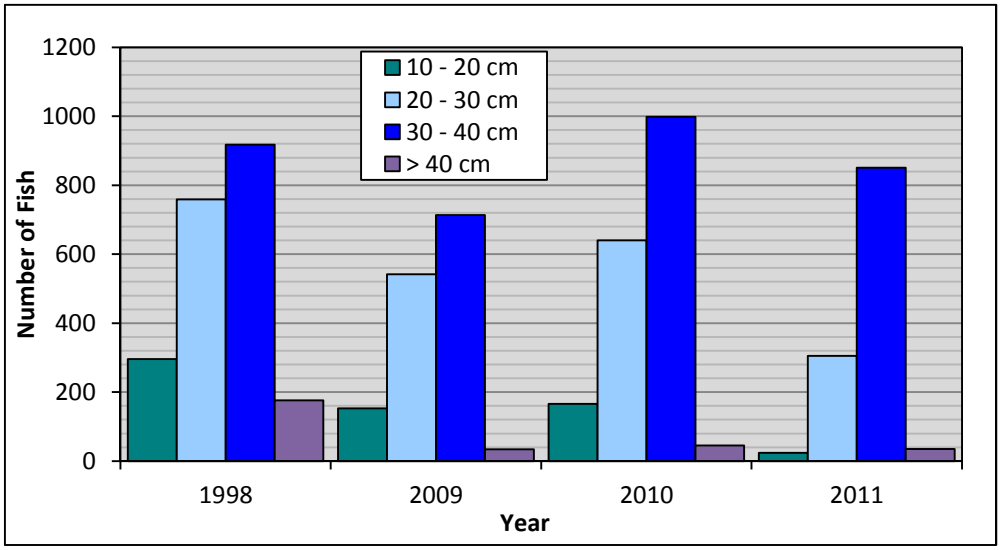


Figure 8. Number of rainbow trout by size class from 1998, 2009 to 2011.

4.1.2 Bull trout

Bull trout counts have increased dramatically from 186 in 1998 to 1938 in 2011 (Table 8; Figure 9). A table and figure displaying bull trout by size class have not been provided for this section as 97.3 % were > 30 cm in 1998, 99 % were > 30 cm in 2009, 99.6 were > 30 cm in 2010 and 100 % were > 30 cm in 2011. Distribution of bull trout in the surveyed portion of the river was concentrated mainly in in the lower sections (9 to 2), with the highest numbers occurring in Section 3 (Table 8; Figure 9).

Table 8. Total bull trout counted by section during the 1998, 2009, 2010 and 2011 snorkel surveys of the Canadian Skagit River.

Skagit River Float Count 2009 - 2011				
Section Number	Bull trout			
	1998	2009	2010	2011
15	0	7	62	116
14	21	8	4	24
13	33	108	57	109
12	38	72	61	105
11	3	6	53	59
10	1	0	2	23
9	2	82	133	293
8	20	87	229	90
7	2	13	56	136
6	0	31	22	55
5	5	60	182	116
4	17	44	191	211
3	37	237	586	399
2	7	202	173	202
Total	**186**	**957**	**1811**	**1938**

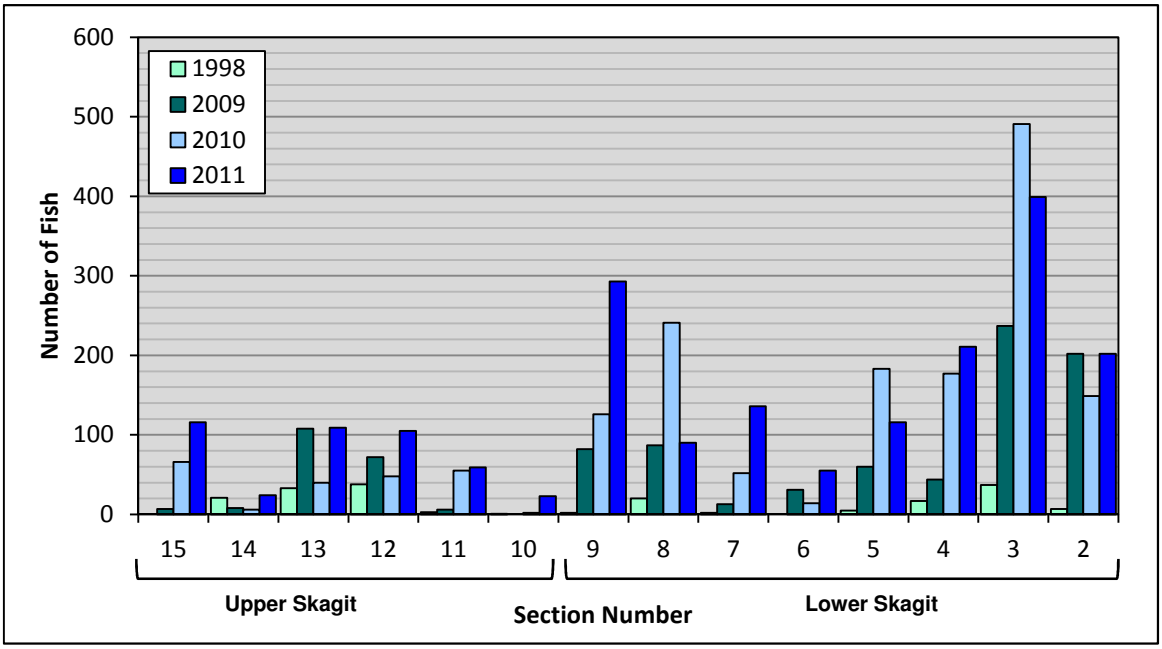


Figure 9. Distribution of bull trout by section in 1998, 2009, 2010 and 2011 within the Canadian Skagit River.

4.2 Abundance indices

4.2.1 Rainbow trout

Rainbow trout abundance indices (density) have a similar trend to total counts between 1998 and 2011 with the highest abundance index recorded in 1998 (29.16), followed by 2010 (25.09), 2009 (19.57) and 2011 (16.49; Table 9). Abundance indices were relatively uniform on a section by section basis, with the exception of Sections 8, 4, 3 and 2 in 1998: these sections in 1998 had a much higher density of rainbow trout than in 2009, 2010 and 2011. Section 8 had a much lower density in 2011 compared to previous years, as did Sections 5 and 4 in 2009 (Figure 10).

Total rainbow trout density was relatively stable from 1982 to 1985 (Figure 11). Rainbow trout density approximately doubled from 1985 to 1986. This was followed by a steady decrease to pre 1986 densities in 1991. For the period of 1992 to 2011 rainbow trout density was variable. However, densities for this period did not decrease to pre 1992 levels. The highest density of rainbow trout occurred in 1994 and 1992. The lowest density for this period occurred in 2011. Densities in 1993 and 2009 were similar and approximately even with the highest pre 1992 densities. The 1998 density was the third highest of 1992 to 2011, and was greater than densities from 2009 to 2011. The highest density of the 2009 to 2011 sample period occurred in 2010.

Survey data collected between 1982 and 2011 reveals that overall year to year rainbow trout density trends are similar in the 20 to 30 cm, and 30 to 40 cm size classes, with the exception of 1986 and 1987, when 30 to 40 cm rainbow trout were more abundant than the other size classes (Table 10, Figure 12). The smallest and largest rainbow trout size classes had relatively low population densities throughout the survey program. The lowest density of 10 to 20 cm rainbow trout was in 2011 (0.33). The 2011 density of sub-catchable trout was 1/3 of the next lowest density which occurred in 1983 (1.00).

Table 9. Rainbow trout abundance indices by section for 1998, and 2009 to 2011.

Section Number	Length of Section (km)	1998		2009		2010		2011	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	21	5.53	61	16.05	76	20.00	37	9.74
14	2.57	148	28.79	101	19.65	116	22.57	37	7.20
13	6.01	177	14.73	246	20.47	218	18.14	121	10.07
12	3.48	104	14.94	114	16.38	129	18.53	103	14.80
11	3.31	104	15.71	126	19.03	167	25.23	119	17.98
10	0.74	28	18.92	17	11.49	25	16.89	25	16.89
9	2.49	54	10.84	65	13.05	83	16.67	69	13.86
8	1.98	180	45.45	89	22.47	127	32.07	28	7.07
7	2.51	96	19.12	102	20.32	93	18.53	74	14.74
6	0.96	36	18.75	58	30.21	45	23.44	32	16.67
5	2.49	144	28.92	33	6.63	135	27.11	82	16.47
4	2.86	293	51.22	47	8.22	163	28.50	104	18.18
3	2.92	413	70.72	232	39.73	283	48.46	229	39.21
2	2.63	351	66.73	151	28.71	189	35.93	155	29.47
Total	**36.85**	**2149**	**29.16**	**1442**	**19.57**	**1849**	**25.09**	**1215**	**16.49**

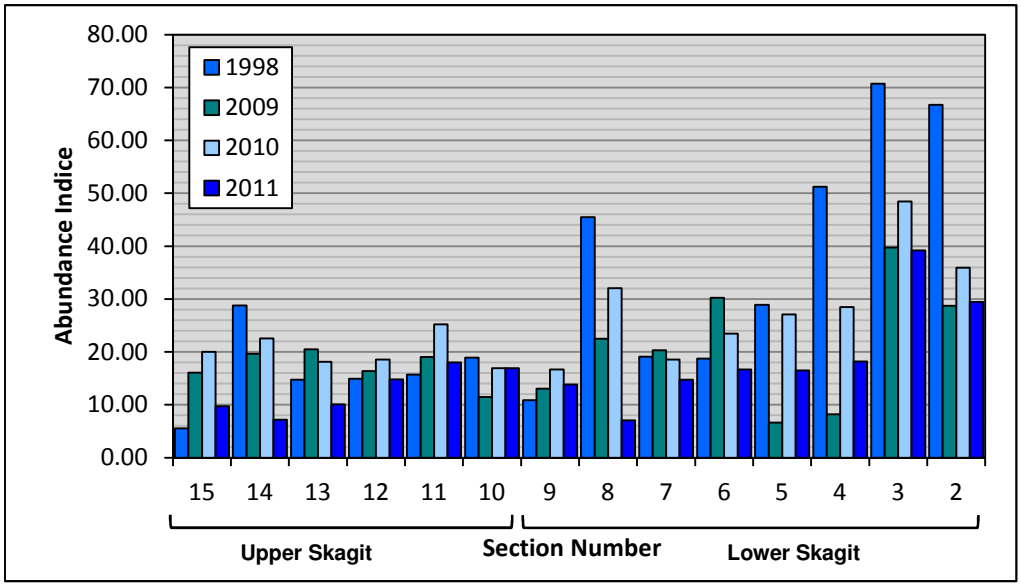


Figure 10. Rainbow trout abundance indices by section for 1998, and 2009 to 2011.

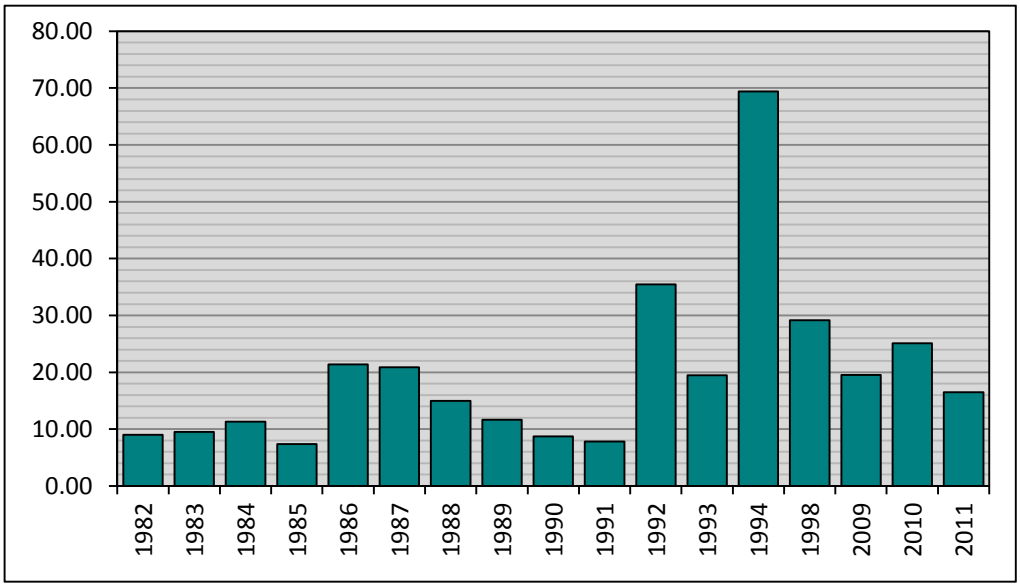


Figure 11. Comparison of total rainbow trout abundance indices from 1982 to 2011. Note: Abundance indices for 1982 to 1994 data are based on estimated "mean" values derived from graphs presented in Burrows and Neuman (1995). Also note there is a 4 year gap between 1994 and 1998, as well as a 10 year gap between 1998 and 2009.

Table 10. Comparison of abundance indices by size class of rainbow trout in the Canadian Skagit River from 1982 to 2011*.

Year	10 - 20 cm	20 - 30 cm	30 - 40 cm	> 40 cm
1982	4.00	3.00	2.00	0.00
1983	1.00	3.00	5.50	0.00
1984	2.00	2.50	4.50	2.30
1985	2.00	2.00	3.00	0.35
1986	2.00	5.00	13.00	1.40
1987	2.50	4.90	12.00	1.50
1988	2.00	3.00	9.00	0.95
1989	1.50	4.00	5.50	0.65
1990	2.00	2.50	4.00	0.20
1991	2.00	2.50	3.00	0.30
1992	10.00	12.00	13.00	0.45
1993	2.50	6.50	10.00	0.45
1994	12.00	29.50	27.00	0.90
1998	4.02	10.30	12.46	2.39
2009	2.08	7.35	9.67	0.46
2010	2.25	8.68	13.54	0.61
2011	0.33	4.14	11.55	0.47
Average	**3.19**	**6.52**	**9.34**	**0.79**

***= Abundance indices for 1982 to 1994 data are based on estimated "mean" values derived from graphs presented in Burrows and Neuman (1995). Also note there is a 4 year gap between 1994 and 1998, as well as a 10 year gap between 1998 and 2009.**

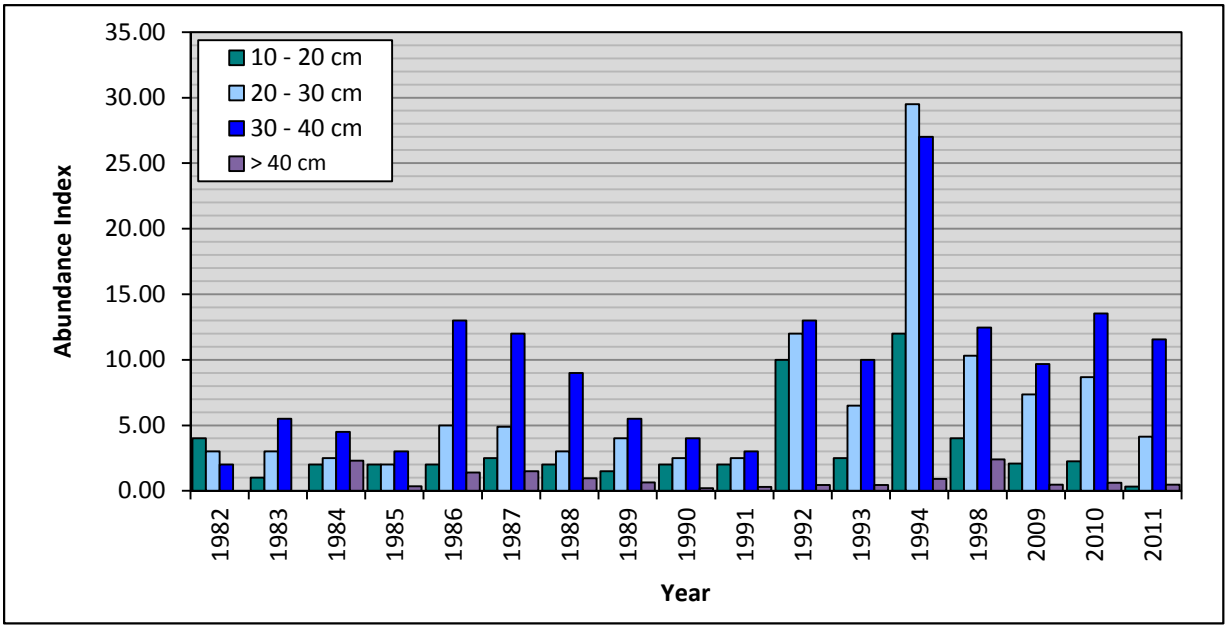


Figure 12. Comparison of abundance indices of rainbow trout by year and size class, Canadian Skagit River, 1982 to 2011. Note: Abundance indices for 1982 to 1994 data are based on estimated "mean" values derived from graphs presented in Burrows and Neuman (1995). Also note there is a 4 year gap between 1994 and 1998, as well as a 10 year gap between 1998 and 2009.

4.2.2 Bull trout

Bull trout density increased substantially from 1998 (2.52) to 2009 (12.99; Table 11). The abundance index of bull trout increased yearly during the 2009 to 2011 study period. Between 2009 and 2010 the bull trout abundance index nearly doubled from 12.99 in 2009 to 22.39 in 2010. Density increased from 2010 (22.39) to 2011 (26.30), but not at the same rate as between 2009 and 2010. Bull trout density increased tenfold from 2.52 in 1998 to 26.30 in 2011 (Table 11).

The highest abundance indices were relatively consistent from year to year in each section during the stock assessment program (Table 11; Figure 13). Abundance indices per section in 1998 were consistently low (<7). Abundance indices were highest in Sections 9, 8, 3, and 2 in 2009, in Sections 8 and 3 in 2010, and in Sections 9 and 3 in 2011.

Most of the counted bull trout were in the > 40 cm size class (Table 12 and Figure 14). The abundance index of > 40 cm bull trout increased during each sample year, with the highest density in 2011. The density of 30 to 40 cm bull trout was highest in 2009, declined in 2010, then increased in 2011. The lowest density of 30 to 40 cm bull trout was observed in 1998.

Table 11. Bull trout abundance indices by section for 1998, and 2009 to 2011.

Section Number	Length of Section (km)	1998		2009		2010		2011	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	0	0.00	7	1.84	66	17.37	116	30.53
14	2.57	21	4.09	8	1.56	6	1.17	24	4.67
13	6.01	33	2.75	108	8.99	40	3.33	109	9.07
12	3.48	38	5.46	72	10.34	48	6.90	105	15.09
11	3.31	3	0.45	6	0.91	55	8.31	59	8.91
10	0.74	1	0.68	0	0.00	2	1.35	23	15.54
9	2.49	2	0.40	82	16.47	126	25.30	293	58.84
8	1.98	20	5.05	87	21.97	241	60.86	90	22.73
7	2.51	2	0.40	13	2.59	52	10.36	136	27.09
6	0.96	0	0.00	31	16.15	14	7.29	55	28.65
5	2.49	5	1.00	60	12.05	183	36.75	116	23.29
4	2.86	17	2.97	44	7.69	177	30.94	211	36.89
3	2.92	37	6.34	237	40.58	491	84.08	399	68.32
2	2.63	7	1.33	202	38.40	149	28.33	202	38.40
Total	**36.85**	**186**	**2.52**	**957**	**12.99**	**1650**	**22.39**	**1938**	**26.30**

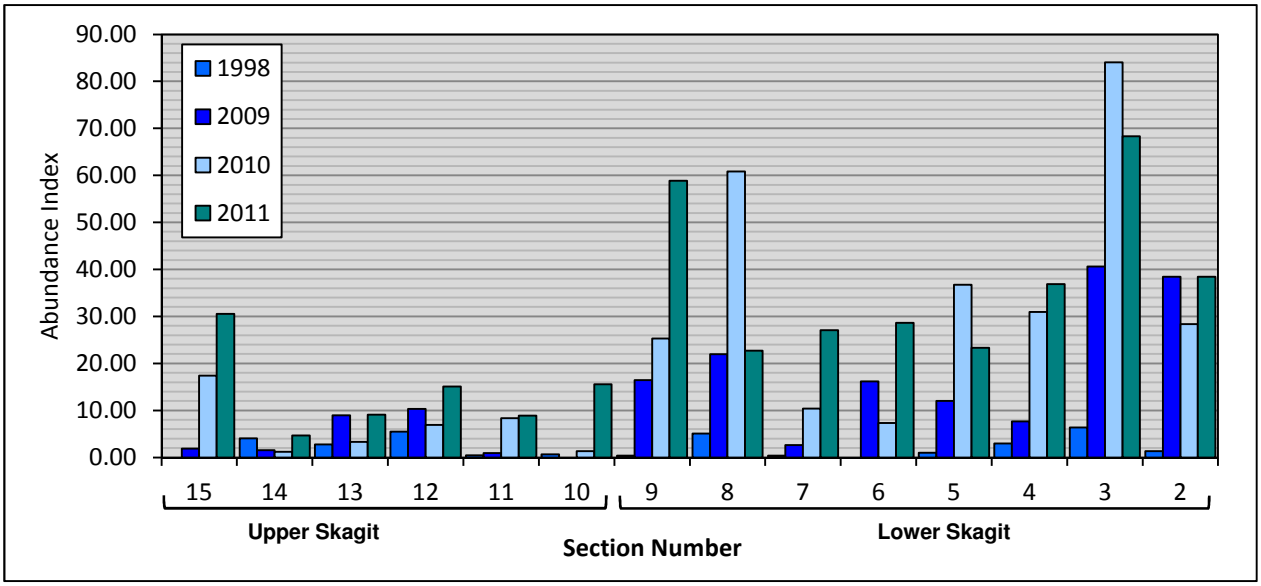


Figure 13. Bull trout abundance indices by section for 1998, and 2009 to 2011.

Table 12. Comparison of size class of Canadian Skagit River char from 1998 to 2011*.

Year	10 - 20 cm	20 - 30 cm	30 - 40 cm	> 40 cm
1998	0.00	0.07	0.45	2.01
2009	0.03	0.11	3.01	9.84
2010	0.07	0.01	0.83	21.48
2011	0.00	0.00	2.35	23.95
Average	**0.03**	**0.05**	**1.66**	**14.32**
***= Note there is a 10 year gap between 1998 and 2009.**				

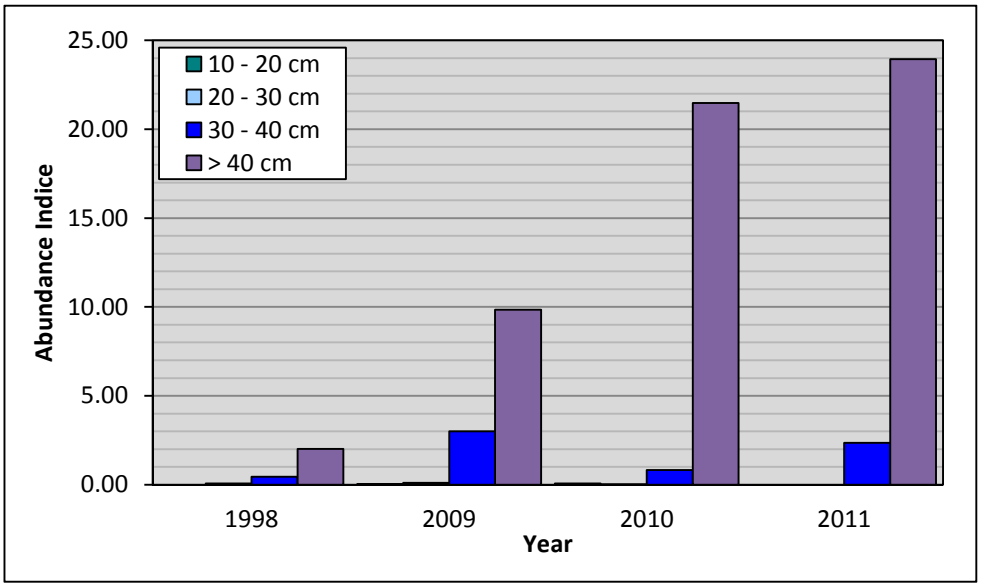


Figure 14. Comparison of abundance indices of bull trout by year and size class, Canadian Skagit River, 1982 to 2011. Note: There is a 10 year gap between 1998 and 2009, although not shown on the graph.

4.3 Catchable versus non-catchables

4.3.1 Rainbow trout

Expansion factors used by Burrows and Neuman (1995) were based on mark recapture studies of rainbow trout conducted in an attempt to provide more reliable estimates of catchable versus non-catchable fish. The results of the studies allowed Burrows and Neuman (1995) to calculate both low (2.09) and high (4.59) expansion factors. These expansion factors were used to provide a population range of catchable rainbow trout per kilometre within the surveyed area for all the years of study (Table 13; Figure 15).

The greatest number of catchable rainbow trout per kilometre occurred in 1994, followed by 1986, 1992, and 1998. Of the 2009 to 2011 sample period the greatest number of catchable trout per kilometre was in 2010, followed by 2009 and 2011. The period of 1992 to 2011 generally had more catchable rainbow trout than from 1982 to 1991.

Year	No. of Sections	Length Surveyed (km)	No. of Fish < 20 cm	No. of Fish > 20 cm	Catchables/km[1] (e = 2.09)	Catchables/km (e = 4.59)
1982	6	21.6	240	203	20	43
1983	3	9.3	18	187	42	92
1984	9	33.2	198	595	37	82
1985	11	33.3	189	433	27	60
1986	4	13.6	74	767	118	258
1987	8	27.2	187	1168	90	197
1988	8	27.2	138	915	70	154
1989	14	36.9	113	926	53	115
1990	16	42.4	303	720	35	78
1991	12	33.0	153	349	22	49
1992	13	34.0	836	1909	117	258
1993	11	36.9	184	1247	71	155
1994	14	36.9	1027	4696	266	585
1998	14	36.9	296	1853	105	230
2009	14	36.9	153	1289	73	160
2010	14	36.9	166	1683	95	209
2011	14	36.9	24	1191	67	148

[1]Catchables per km = (No. of Fish > 20cm / km of stream assessed) x (expansion factor)

Table 13. Summary of catchable rainbow trout per kilometer within the Canadian Skagit River using both low (2.09) and high (4.59) expansion factors as per Burrows and Neuman (1995).

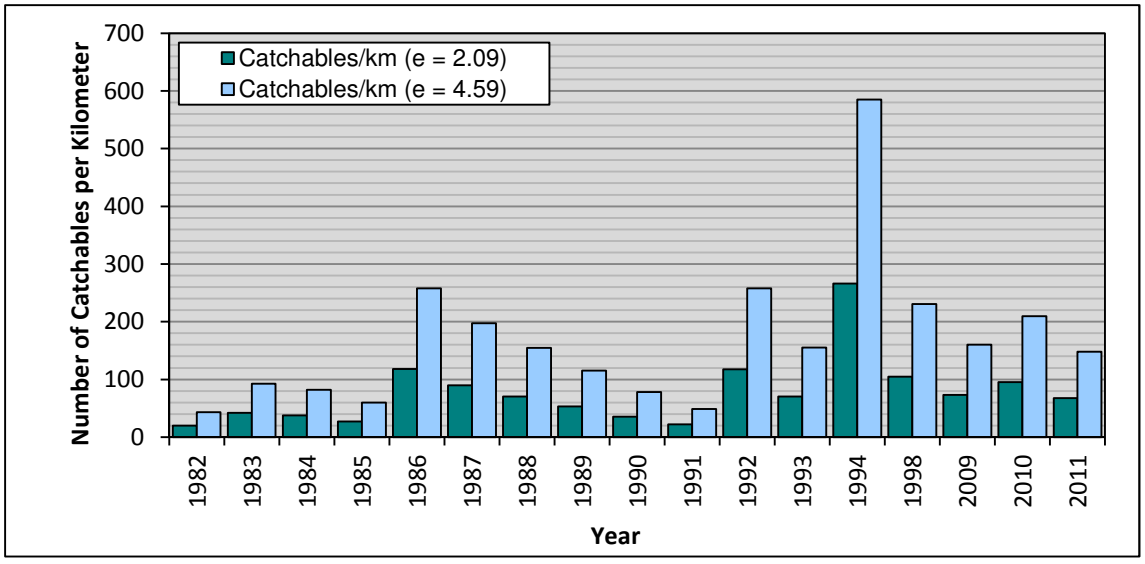


Figure 15. Catchable rainbow trout per kilometer by year, within the Canadian Skagit River using both low (2.09) and high (4.59) expansion factors as per Burrows and Neuman (1995). Note: While not indicated on the graph there is a four year data gap between a 1994 and 1998 and a 10 year data gap between 1998 and 2009.

4.3.2 Bull trout

The expansion factors created by Burrows and Neuman (1995) for rainbow trout have been applied to bull trout counted during the 1998 and 2009 to 2011 Canadian Skagit River snorkel surveys. The number of catchable bull trout increased from 1998 to 2009, and continued to increase in 2010 and 2011 (Table 14; Figure 16).

Table 14. Summary of catchable bull trout per kilometer within the Canadian Skagit River using both low (2.09) and high (4.59) expansion factors as per Burrows and Neuman (1995).

Year	No. of Sections	Length Surveyed (km)	No. of Fish < 20 cm	No. of Fish > 20 cm	Catchables/km[1] (e = 2.09)	Catchables/km (e = 4.59)
1998	14	36.9	0	186	11	23
2009	14	36.9	2	955	54	119
2010	14	36.9	5	1806	102	225
2011	14	36.9	0	1938	110	241

1Catchables per km = (No. of Fish > 20cm / km of stream assessed) x (expansion factor)

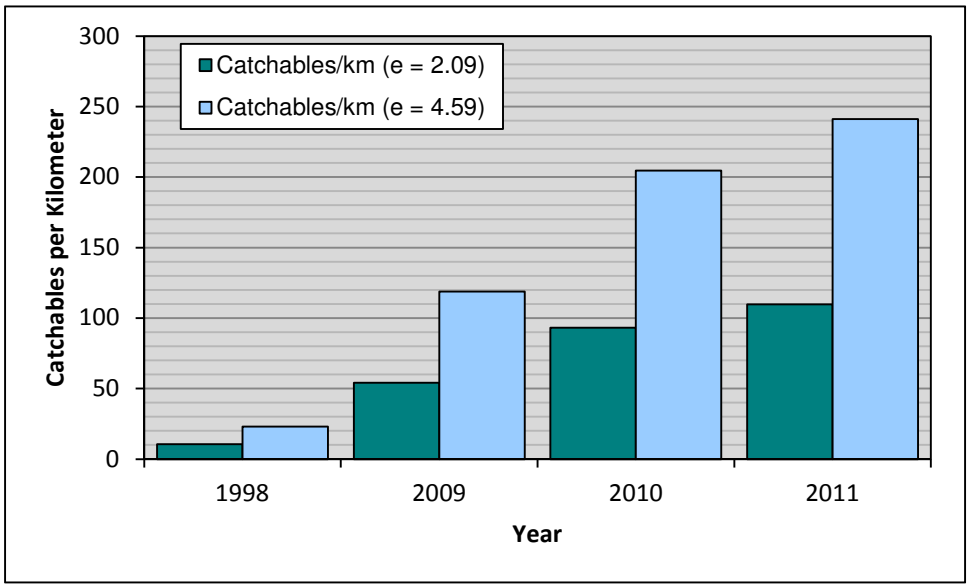


Figure 16. Catchable bull trout per kilometer by year, within the Canadian Skagit River using both low (2.09) and high (4.59) expansion factors as per Burrows and Neuman (1995).

5.0 DISCUSSION

Results of this three year study confirm there has been a dramatic shift in the fish species composition in the Canadian Skagit River during the summer sport fishery. The snorkel surveys from 1982 through 1994 and in 1998 showed rainbow trout were the predominant species available to anglers, with comparatively low numbers of bull trout also present. The current study showed bull trout numbers have increased by more than 10 fold, and may be still increasing.

The change in fish species composition may influence fisheries management decisions into the future. The Skagit is managed as a premier rainbow trout fishery with fly fishing the preferred angling method. The shift to a bull trout dominated system may require management action in the face of possible rainbow trout conservation concerns. Angler attitudes and satisfaction may also change with a shift to a bull trout dominated system.

5.1 Bull trout

The bull trout numbers presented in this report would represent the minimum number of bull trout utilizing the Skagit River because of the timing of the survey and the observed distribution of bull trout in the survey. The focus of the surveys, both historically and at the initiation of this study in 2009, was primarily on rainbow trout stock assessment and the surveys were conducted in late August and early September to be consistent with historical survey timing and conditions for maximum comparability of the results. While some bull trout typically immigrate into the Skagit River with the spring spawning immigration of rainbow in late March and April, the majority of the bull trout spawning run enters the river in the August through September period (Murray and Gaboury 2002). The timing of our survey would coincide with the middle of the bull trout immigration period. The very high counts of bull trout in the lower river just upstream of Ross Reservoir and the lack of evidence of spawning behaviour suggest that bull trout were still immigrating into the river from the reservoir at the time of the survey and a portion of the spawning run still in the reservoir was not counted. While the timing of the survey doesn't capture the maximum number of bull trout that could potentially utilize the Skagit and Sumallo Rivers', replication of this survey over time will provide a good indication of the bull trout population trend.

Although there is no data between 1998 and 2009, the observed increase in abundance of bull trout between 2009 and 2010, and further increase in 2011 suggests that bull trout population growth is a relatively recent phenomenon. Reasons for the increase of bull trout in the Canadian Skagit River have not yet been conclusively established. However, the introduction of redside shiners (*Richardsonius balteatus*) into Ross Reservoir (first detected in 2004) may have provided a new and abundant food source for bull trout, improving survival and fecundity of adult fish. There has been concern that redside shiners could invade the Canadian Skagit River and compete with juvenile trout and bull trout for limited resources; however, on-going research has yet to identify negative effects on salmonid stocks (Welch 2011). In addition, a no retention regulation has been in place on the Canadian Skagit River for over two decades and there has been a ban on retention of all bull trout in the American side of Ross Reservoir since 1998, and the BC portion of Ross Reservoir since 1994. The observed increase in bull trout abundance in the present study could also show that conservation efforts are having a positive effect.

The ecological consequences of the growing bull trout population on the upper Skagit River ecosystem have not yet been studied. Potential effects could include increased predation on rainbow trout, competition with juvenile rainbow trout for food and habitat, and changes to the relationship between Dolly Varden and bull trout.

Size class data for bull trout only exists for 1998, 2009, 2010, and 2011. In those years, > 40 cm fish were most common, and fish in the 10 to 20 cm and 20 to 30 cm were rare or absent in the surveyed sections of the upper Skagit River. The most likely explanation is that juvenile bull

trout (<30 cm) in the Skagit River system are known to rear in tributaries and therefore were not counted as part of the survey (McPhail and Taylor 1995).

5.2 Rainbow trout

While the numbers of rainbow trout counted in the three surveys varied and appeared lower than historical numbers, particularly in 2011, the relationship of our counts to the Skagit River portion of the Ross Reservoir rainbow trout population is inconclusive. It is possible that some rainbow trout are staying in the reservoir to feed on redside shiners. Alternatively, some rainbow trout could potentially be displaced by bull trout in the river and emigrating back to Ross Reservoir earlier than they might have if bull trout were not present in the river in such great numbers. Previous studies have shown that the Skagit River rainbow trout stock is highly migratory (Harper and Scott 1998a). Rainbow trout typically initiate immigration into the Skagit River in late March and April to spawn. Shortly after spawning, a large proportion (up to 85% in 1986) of the run returns to the reservoir (Scott and Neuman 1988). The remaining portion of the run stays in the river and contributes to the sport fishery. Over the summer, the rainbows that remained in the river gradually emigrate back to the reservoir. By later October, very few trout remain in the Skagit River. Various environmental factors such as water level, temperature and availability of food items also influence the rate of return to the reservoir.

Changes in rainbow trout habitat utilization were also evident during the study compared to the 1998 and previous surveys. Historically, rainbow trout occupied pools at the tail outs of riffles and rather lazily fed on benthic invertebrates. As observed in the past three years, rainbow trout now tend to occupy shallower riffle habitat, pool tail outs and stream margin micro habitats, possibly in an attempt to avoid bull trout predation. An example of this behaviour would be the upstream pool accessed from the Nepopekum Day Use Area where historically, location specific counts of rainbow trout were the highest of any site on the river. In 2011, only one trout was counted in this pool amid a substantial number of bull trout. Bull trout predation on rainbow trout was also evident from the large number of rainbows observed with bite scars or nipped caudal fins.

Of particular concern, the number of 10 to 20 cm rainbow trout observed in 2011 was substantially lower than any previous year of study, including 2009 and 2010. Given that the snorkel survey was conducted in exactly the same manner by the same crew as in 2009 and 2010, it could be assumed that any size selective bias would be consistent throughout the three years. Therefore, the sharp decline in juvenile rainbow trout numbers could signal the beginning of serious decline in the adult rainbow trout population. Fish of this size would likely be age 1+. Therefore, a corresponding decrease in the age 2+ trout in the over 20 cm size that contribute to the sport fishery may evident as soon as 2012 (Anaka et al. 2010a). The cause for the decline of 10 to 20 cm trout is unknown but predation by bull trout, as previously mentioned, could be a contributing factor.

Although they were not counted, large numbers of fry were observed in side channels and pools during the 2011 survey. The species of fry was not determined. However, of significant concern would be the potential invasion of redside shiners into the Skagit River and competition with juvenile trout and bull trout.

5.3 Impact to the sport fishery

Based on the expansion factors from Burrows and Neuman (1995), the number of catchable sized (>20 cm) rainbow trout in the upper Skagit River has remained relatively stable between 1982 and 2011, with the exception of a peak in 1994. The peak abundance of rainbow trout in 1994 was corroborated by an angler survey, which also showed the highest catch for rainbow trout in five angler surveys conducted between 1986 and 2002 (Scott et.al. 1995). The reason for this anomaly is unknown. However, as explained above, due to a substantial decline in juvenile rainbow trout, a serious decline in catchable sized rainbow trout could be expected as early as 2012 and the decline would likely be more pronounced by 2013.

Anglers were well aware of the increased abundance of bull trout in the Skagit River and the complexion of the sport fishery has changed with many anglers now targeting bull trout. Results of an angler survey conducted by MNRO during the summer of 2011 showed angler satisfaction has declined since 2002. The proportion of the anglers that rated their fishing experience as excellent in 2002 (54.6%) declined to 21.0% in 2011, while the "fair" category increased to 34% in 2011 from 7.6% in 2002. The shift to a bull trout dominated system may require management action in the face of possible rainbow trout conservation concerns and reduced angler satisfaction.

5.4 Conclusions

1. There has been a dramatic increase in the abundance of bull trout in the Canadian Skagit River compared to previous surveys conducted from 1982 to 1994 and in 1998.

2. The number of rainbow trout available to anglers during the summer sport fishery has declined from 1998. It is unclear if the decline in trout numbers is due to a decline in the Ross Lake Reservoir/Skagit River trout population or due to a change in behavior (i.e. increased rate of emigration back to the reservoir post spawning).

3. The decline in the number of under 20 cm rainbow trout observed during the 2011 survey may suggest a serious decline in the number of adult rainbow trout that will be available in the Skagit River sport fishery over the next two years.

4. Redside shiners will pose a competitive threat to juvenile trout and bull trout if they begin to invade the Canadian Skagit River.

5.5 Recommendations

1. In light of the increased bull trout abundance and potential decline of the Skagit River rainbow trout as indicated by the paucity of under 20 cm fish observed, additional stock assessment surveys should be conducted to monitor Skagit River/Ross Lake Reservoir fish stocks. Ideally, the surveys would be conducted for an additional 4 years to span the entire life cycle of a Skagit River/Ross Reservoir bull trout (approximately 7 years). However, at a minimum, 2 more years of survey would be required to assess the potential decline of rainbow trout stock as predicted by the low numbers of subcatchable (<20cm) trout in 2011.

2. Collection of bull trout biological data (size at age class distribution, tissue samples and stomach contents) is recommended to assess the bull characteristics and stability of the bull trout population. The focus of the stomach samples would be to assess the extent of bull trout predation on rainbow trout.

3. Juvenile fish sampling should be conducted in the lower Skagit River downstream of Chittenden's Bridge to determine if redside shiners are beginning to invade the Canadian Skagit River, since redside shiners are a known river dwelling species (Welch, 2011).

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Appendix 1: Sample Field Data Sheet, 2011 Snorkel Survey

Skagit River Float Count 2011 / Section

10-20	20-30	30-40	40+

Start: 1130 hrs | Date: 11/09/08 | Crew: RA/PB/JS/EL/BE | Section 7: 46.4 km to Shawatum

Start Air: 20.0°C Start water = 9.0°C End time = 1322
End Air = 17.0°C End water = 10°C

	10-20	20-30	30-40	40+
RB	—	8+6+13 (=27)	1+2+12+4+26 (=45)	2
BT	—	—	18+4	103+11

Start: 1330 hrs | Date: 11/09/08 | Crew: RA/PB/JS/DS/EL | Section 6: Shawatum to Fuel Dump

Start Air: 17.0°C Start water = 10.0°C End time: 1352
End Air = 21°C End water = 10.0°C

	10-20	20-30	30-40	40+
RB	—	4	26	2
BT	—	—	7	48

Start: 1355 | Date: 11/09/08 | Crew: RA/PB/DS/JS/EL | Section 5: Fuel Dump → Roadside

Start Air: 21.0°C
Start water 10.0°C
Anglers 3
End Air: 21.0°C
End water: 10.0°C
End time 1445

	10-20	20-30	30-40	40+
RB	1	3+2+1+2 (=26)	4+53 (=57)	—
BT	—	—	13	103

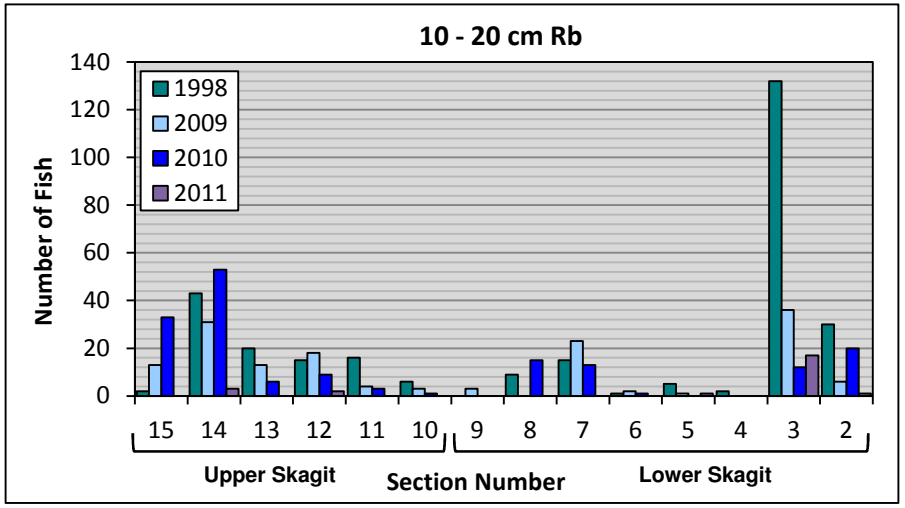
Appendix 2: 1998 and 2009 – 2011 Snorkel Survey Additional Data

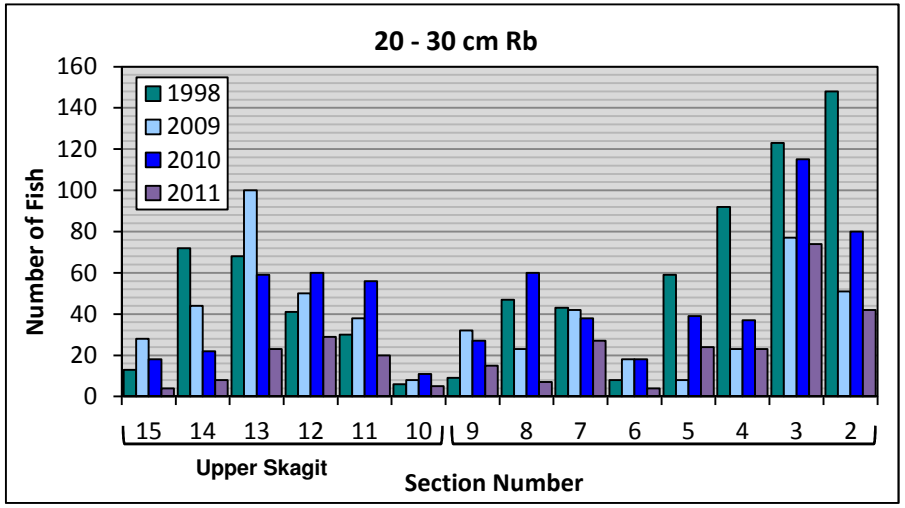
- Rainbow trout count numbers, 1998 and 2009 to 2011.
- Figures of rainbow trout count numbers by size class, 1998 and 2009 to 2011.
- Rainbow trout abundance indices, 1998 and 2009 to 2011.
- Figures of rainbow trout abundance indices, 1998 and 2009 to 2011.
- Char count numbers, 1998 and 2009 to 2011.
- Figures of char count numbers by size class, 1998 and 2009 to 2011.
- Char abundance indices, 1998 and 2009 to 2011.
- Figures of char abundance indices by size class, 1998 and 2009 to 2011.
- Non – catchable versus catchable rainbow trout 1998 and 2009 to 2011.
- Figures of non – catchable versus catchable rainbow trout 1998 and 2009 to 2011.

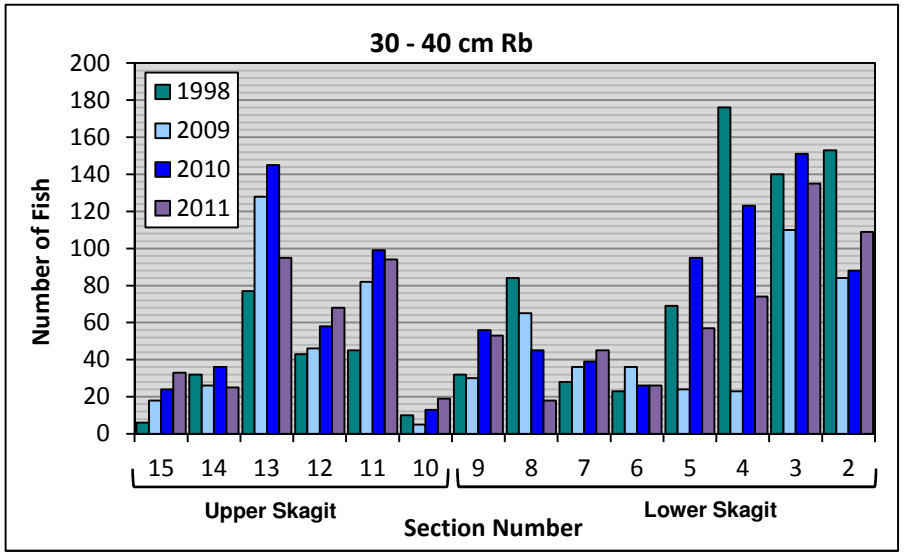
Rainbow trout count numbers, 1998 and 2009 to 2011

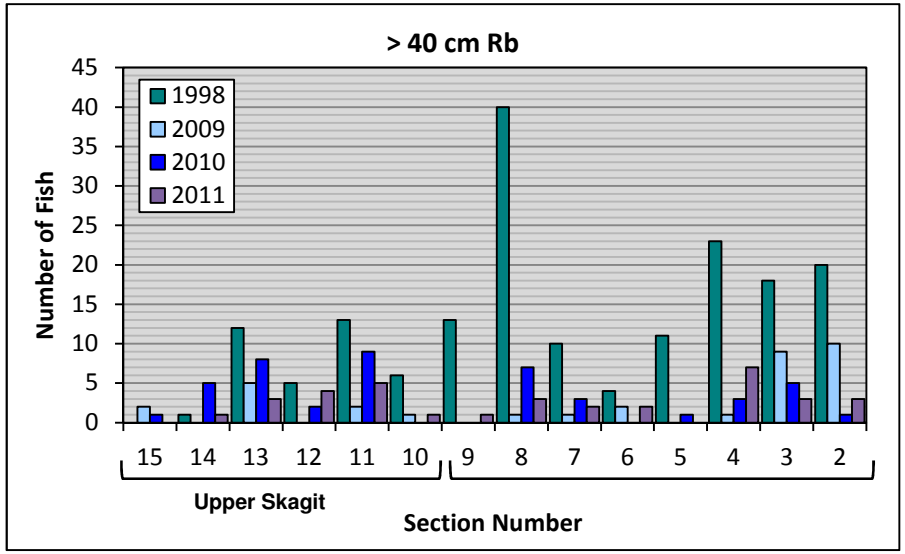
Skagit River Float Count 2009 - 2011																				
Section Number	Rainbow Trout																			
	10 to 20 cm				20 to 30 cm				30 to 40 cm				> 40 cm				Total			
	1998	2009	2010	2011	1998	2009	2010	2011	1998	2009	2010	2011	1998	2009	2010	2011	1998	2009	2010	2011
15	2	13	33	0	13	28	18	4	6	18	24	33	0	2	1	0	**21**	**50**	**76**	**37**
14	43	31	53	3	72	44	22	8	32	26	36	25	1	0	5	1	**148**	**113**	**116**	**37**
13	20	13	6	0	68	100	59	23	77	128	145	95	12	5	8	3	**177**	**253**	**218**	**121**
12	15	18	9	2	41	50	60	29	43	46	58	68	5	0	2	4	**104**	**111**	**129**	**103**
11	16	4	3	0	30	38	56	20	45	82	99	94	13	2	9	5	**104**	**138**	**167**	**119**
10	6	3	1	0	6	8	11	5	10	5	13	19	6	1	0	1	**28**	**20**	**25**	**25**
9	0	3	0	0	9	32	27	15	32	30	56	53	13	0	0	1	**54**	**62**	**83**	**69**
8	9	0	15	0	47	23	60	7	84	65	45	18	40	1	7	3	**180**	**98**	**127**	**28**
7	15	23	13	0	43	42	38	27	28	36	39	45	10	1	3	2	**96**	**94**	**93**	**74**
6	1	2	1	0	8	18	18	4	23	36	26	26	4	2	0	2	**36**	**57**	**45**	**32**
5	5	1	0	1	59	8	39	24	69	24	95	57	11	0	1	0	**144**	**37**	**135**	**82**
4	2	0	0	0	92	23	37	23	176	23	123	74	23	1	3	7	**293**	**49**	**163**	**104**
3	132	36	12	17	123	77	115	74	140	110	151	135	18	9	5	3	**413**	**328**	**283**	**229**
2	30	6	20	1	148	51	80	42	153	84	88	109	20	10	1	3	**351**	**175**	**189**	**155**
Total	**296**	**153**	**166**	**24**	**759**	**542**	**640**	**305**	**918**	**713**	**998**	**851**	**176**	**34**	**45**	**35**	**2149**	**1585**	**1849**	**1215**
Percent of Total	**13.8**	**9.7**	**9.0**	**2.0**	**35.3**	**34.2**	**34.6**	**25.1**	**42.7**	**45.0**	**54.0**	**70.0**	**8.2**	**2.1**	**2.4**	**2.9**				

Figures of rainbow trout count numbers by size class, 1998 and 2009 to 2011









Rainbow Trout Abundance Indices, 1998 and 2009 to 2011

1998 Rainbow Trout Abundance Indices											
Section Number	Length of Section (km)	10 - 20 cm 1998		20 - 30 cm 1998		30 - 40 cm 1998		> 40 cm 1998		1998 Total	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	2	0.53	13	3.42	6	1.58	0	0.00	21	5.53
14	2.57	43	8.37	72	14.01	32	6.23	1	0.19	148	28.79
13	6.01	20	1.66	68	5.66	77	6.41	12	1.00	177	14.73
12	3.48	15	2.16	41	5.89	43	6.18	5	0.72	104	14.94
11	3.31	16	2.42	30	4.53	45	6.80	13	1.96	104	15.71
10	0.74	6	4.05	6	4.05	10	6.76	6	4.05	28	18.92
9	2.49	0	0.00	9	1.81	32	6.43	13	2.61	54	10.84
8	1.98	9	2.27	47	11.87	84	21.21	40	10.10	180	45.45
7	2.51	15	2.99	43	8.57	28	5.58	10	1.99	96	19.12
6	0.96	1	0.52	8	4.17	23	11.98	4	2.08	36	18.75
5	2.49	5	1.00	59	11.85	69	13.86	11	2.21	144	28.92
4	2.86	2	0.35	92	16.08	176	30.77	23	4.02	293	51.22
3	2.92	132	22.60	123	21.06	140	23.97	18	3.08	413	70.72
2	2.63	30	5.70	148	28.14	153	29.09	20	3.80	351	66.73
Total	**36.85**	**296**	**4.02**	**759**	**10.30**	**918**	**12.46**	**176**	**2.39**	**2149**	**29.16**

*Abundance index (No.of rainbow trout per km per floater) = Count for section/(section length (km) x floater equivalent). Floater equivalent = 2.0 (Burrows and Neuman, 1995).

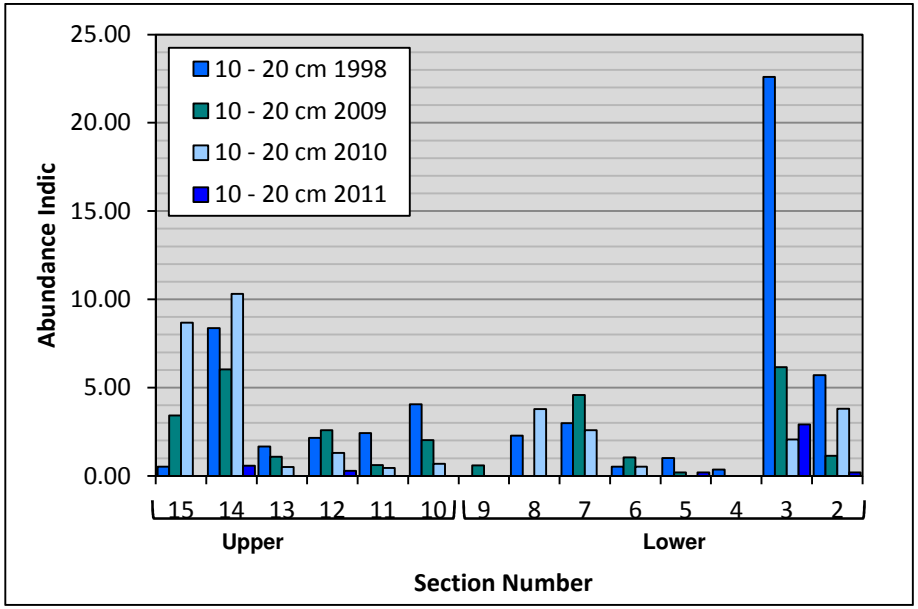
2009 Rainbow Trout Abundance Indices											
Section Number	Length of Section (km)	10 - 20 cm 2009		20 - 30 cm 2009		30 - 40 cm 2009		> 40 cm 2009		2009 Total	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	13	3.42	28	7.37	18	4.74	2	0.53	61	16.05
14	2.57	31	6.03	44	8.56	26	5.06	0	0.00	101	19.65
13	6.01	13	1.08	100	8.32	128	10.65	5	0.42	246	20.47
12	3.48	18	2.59	50	7.18	46	6.61	0	0.00	114	16.38
11	3.31	4	0.60	38	5.74	82	12.39	2	0.30	126	19.03
10	0.74	3	2.03	8	5.41	5	3.38	1	0.68	17	11.49
9	2.49	3	0.60	32	6.43	30	6.02	0	0.00	65	13.05
8	1.98	0	0.00	23	5.81	65	16.41	1	0.25	89	22.47
7	2.51	23	4.58	42	8.37	36	7.17	1	0.20	102	20.32
6	0.96	2	1.04	18	9.38	36	18.75	2	1.04	58	30.21
5	2.49	1	0.20	8	1.61	24	4.82	0	0.00	33	6.63
4	2.86	0	0.00	23	4.02	23	4.02	1	0.17	47	8.22
3	2.92	36	6.16	77	13.18	110	18.84	9	1.54	232	39.73
2	2.63	6	1.14	51	9.70	84	15.97	10	1.90	151	28.71
Total	**36.85**	**153**	**2.08**	**542**	**7.35**	**713**	**9.67**	**34**	**0.46**	**1442**	**19.57**

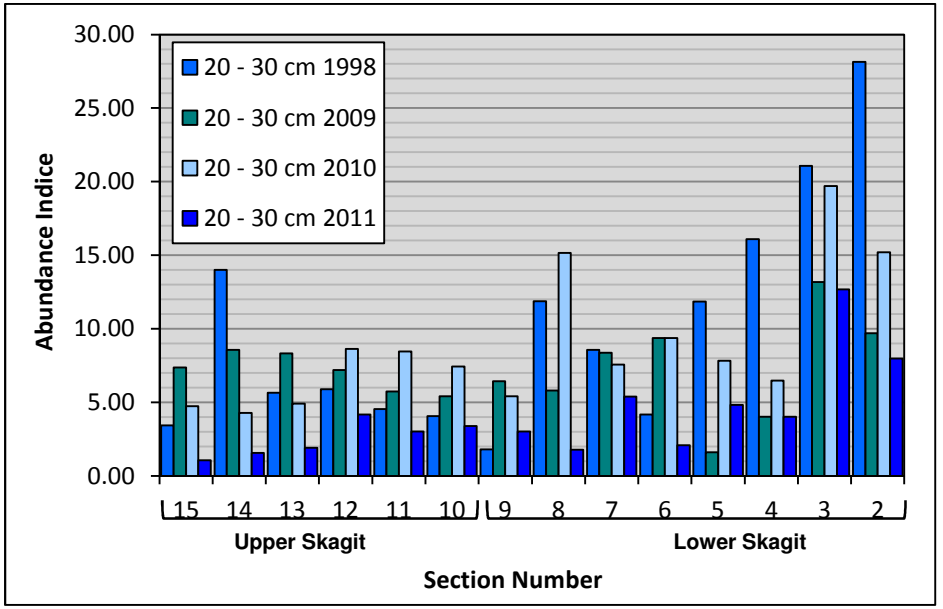
*Abundance index (No.of rainbow trout per km per floater) = Count for section/(section length (km) x floater equivalent). Floater equivalent = 2.0 (Burrows and Neuman, 1995).

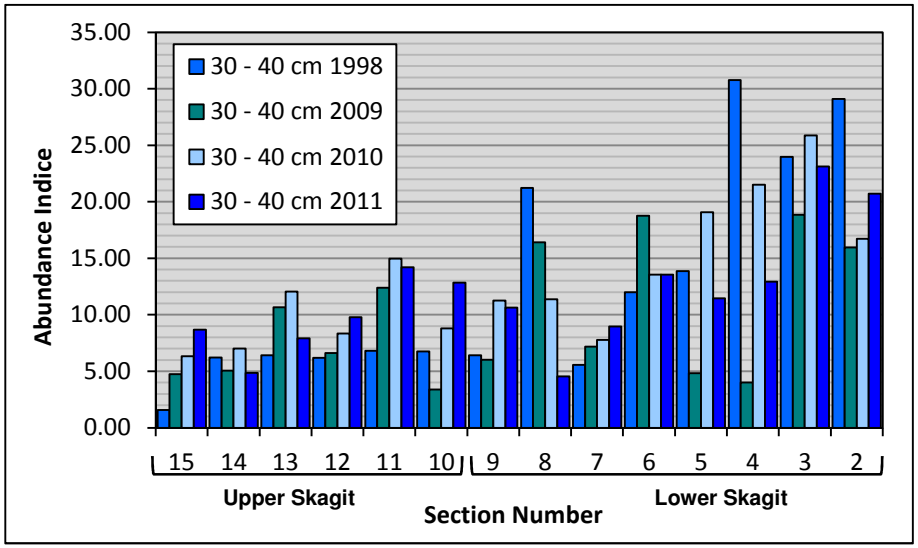
2010 Rainbow Trout Abundance Indices											
Section Number	Length of Section (km)	10 - 20 cm 2010		20 - 30 cm 2010		30 - 40 cm 2010		> 40 cm 2010		2010	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	33	8.68	18	4.74	24	6.32	1	0.26	76	20.00
14	2.57	53	10.31	22	4.28	36	7.00	5	0.97	116	22.57
13	6.01	6	0.50	59	4.91	145	12.06	8	0.67	218	18.14
12	3.48	9	1.29	60	8.62	58	8.33	2	0.29	129	18.53
11	3.31	3	0.45	56	8.46	99	14.95	9	1.36	167	25.23
10	0.74	1	0.68	11	7.43	13	8.78	0	0.00	25	16.89
9	2.49	0	0.00	27	5.42	56	11.24	0	0.00	83	16.67
8	1.98	15	3.79	60	15.15	45	11.36	7	1.77	127	32.07
7	2.51	13	2.59	38	7.57	39	7.77	3	0.60	93	18.53
6	0.96	1	0.52	18	9.38	26	13.54	0	0.00	45	23.44
5	2.49	0	0.00	39	7.83	95	19.08	1	0.20	135	27.11
4	2.86	0	0.00	37	6.47	123	21.50	3	0.52	163	28.50
3	2.92	12	2.05	115	19.69	151	25.86	5	0.86	283	48.46
2	2.63	20	3.80	80	15.21	88	16.73	1	0.19	189	35.93
Total	**36.85**	**166**	**2.25**	**640**	**8.68**	**998**	**13.54**	**45**	**0.61**	**1849**	**25.09**

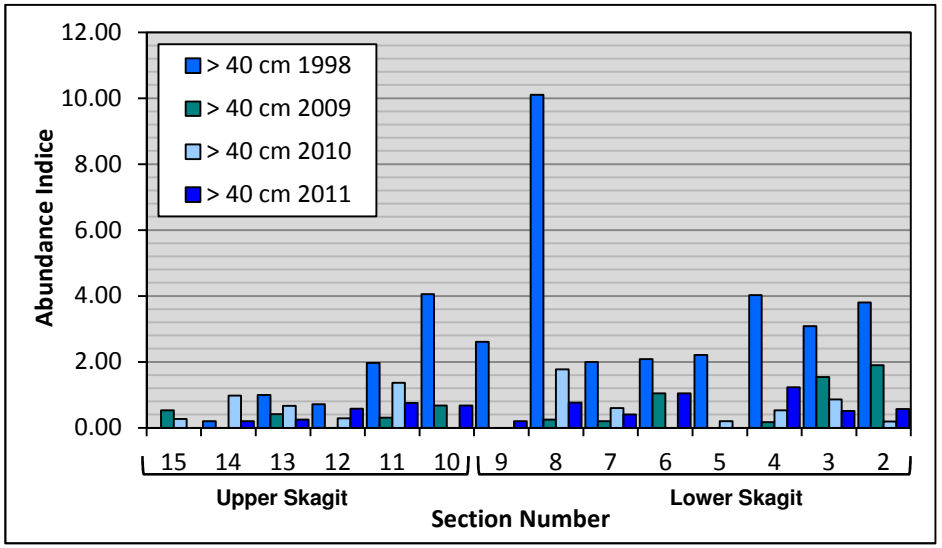
*Abundance index (No.of rainbow trout per km per floater) = Count for section/(section length (km) x floater equivalent). Floater equivalent = 2.0 (Burrows and Neuman, 1995).

Figures of rainbow trout abundance indices, 1998 and 2009 to 2011





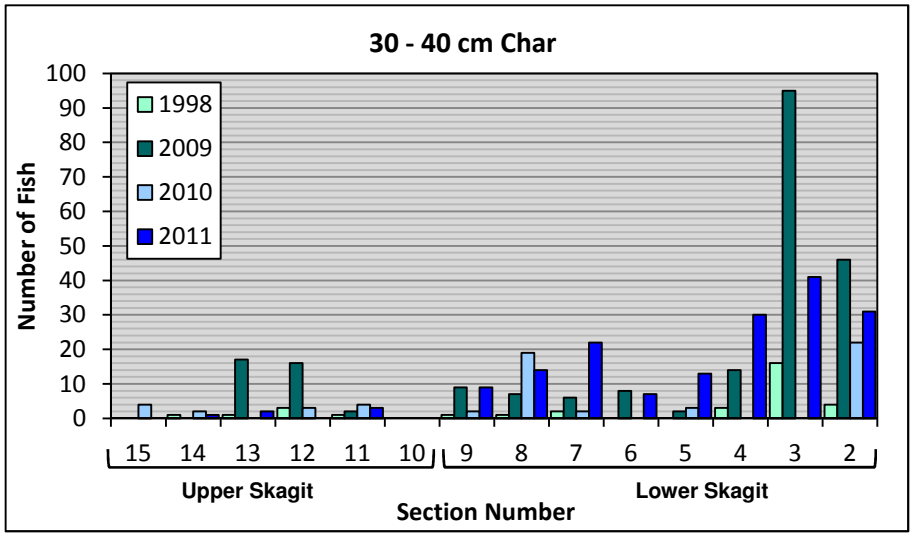


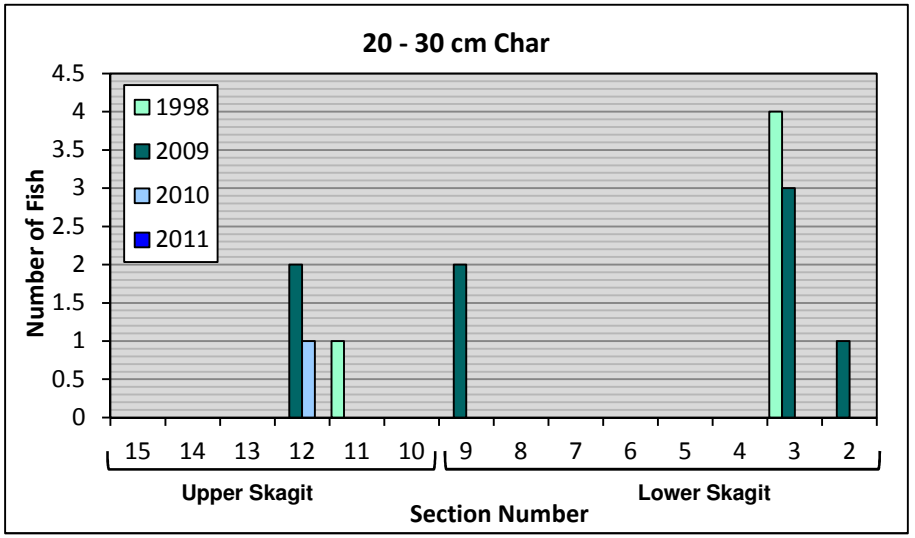


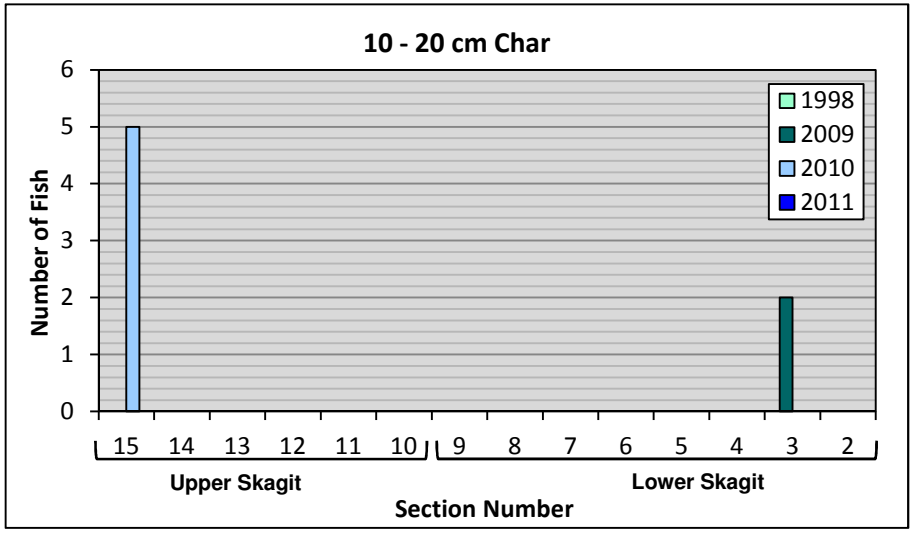
Char count numbers, 1998 and 2009 to 2011

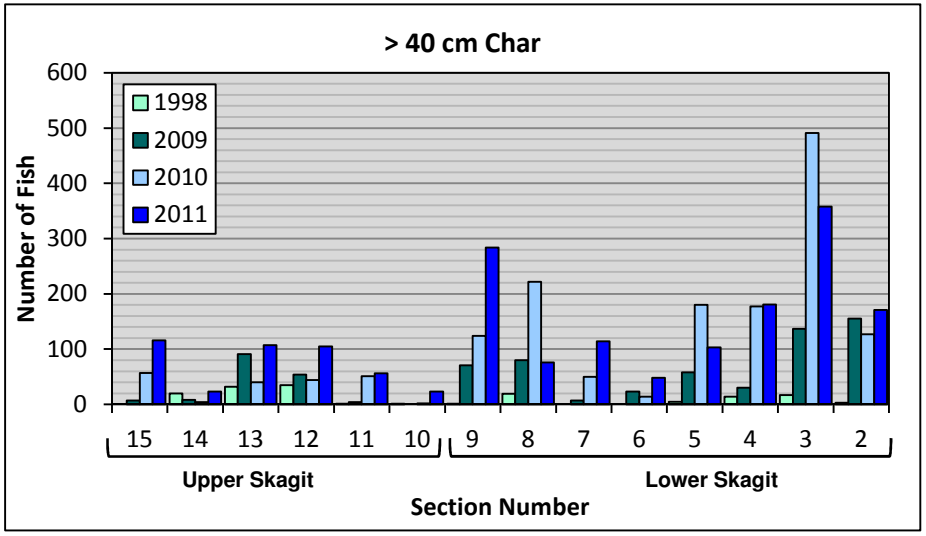
Skagit River Float Count 2009 - 2011																				
Section Number	Char																			
	10 to 20 cm				20 to 30 cm				30 to 40 cm				> 40 cm				Total			
	1998	2009	2010	2011	1998	2009	2010	2011	1998	2009	2010	2011	1998	2009	2010	2011	1998	2009	2010	2011
15	0	0	5	0	0	0	0	0	0	0	0	0	0	7	57	116	**0**	**7**	**62**	**116**
14	0	0	0	0	0	0	0	0	1	0	0	1	20	8	4	23	**21**	**8**	**4**	**24**
13	0	0	0	0	0	0	0	0	1	17	17	2	32	91	40	107	**33**	**108**	**57**	**109**
12	0	0	0	0	0	2	1	0	3	16	16	0	35	54	44	105	**38**	**72**	**61**	**105**
11	0	0	0	0	1	0	0	0	1	2	2	3	1	4	51	56	**3**	**6**	**53**	**59**
10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	23	**1**	**0**	**2**	**23**
9	0	0	0	0	0	2	0	0	1	9	9	9	1	71	124	284	**2**	**82**	**133**	**293**
8	0	0	0	0	0	0	0	0	1	7	7	14	19	80	222	76	**20**	**87**	**229**	**90**
7	0	0	0	0	0	0	0	0	2	6	6	22	0	7	50	114	**2**	**13**	**56**	**136**
6	0	0	0	0	0	0	0	0	0	8	8	7	0	23	14	48	**0**	**31**	**22**	**55**
5	0	0	0	0	0	0	0	0	0	2	2	13	5	58	180	103	**5**	**60**	**182**	**116**
4	0	0	0	0	0	0	0	0	3	14	14	30	14	30	177	181	**17**	**44**	**191**	**211**
3	0	2	0	0	4	3	0	0	16	95	95	41	17	137	491	358	**37**	**237**	**586**	**399**
2	0	0	0	0	0	1	0	0	4	46	46	31	3	155	127	171	**7**	**202**	**173**	**202**
Total	**0**	**2**	**5**	**0**	**5**	**8**	**1**	**0**	**33**	**222**	**222**	**173**	**148**	**725**	**1583**	**1765**	**186**	**957**	**1811**	**1938**
Percent of Total	**0.0**	**0.2**	**0.3**	**0.0**	**2.7**	**0.8**	**0.1**	**0.0**	**17.7**	**23.2**	**12.3**	**8.9**	**79.6**	**75.8**	**87.4**	**91.1**				

Figures of char count numbers by size class, 1998 and 2009 to 2011









Char abundance indices, 1998 and 2009 to 2011

1998 Char Abundance Indices											
Section Number	Length of Section (km)	10 - 20 cm 1998		20 - 30 cm 1998		30 - 40 cm 1998		> 40 cm 1998		1998	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
14	2.57	0	0.00	0	0.00	1	0.19	20	3.89	21	4.09
13	6.01	0	0.00	0	0.00	1	0.08	32	2.66	33	2.75
12	3.48	0	0.00	0	0.00	3	0.43	35	5.03	38	5.46
11	3.31	0	0.00	1	0.15	1	0.15	1	0.15	3	0.45
10	0.74	0	0.00	0	0.00	0	0.00	1	0.68	1	0.68
9	2.49	0	0.00	0	0.00	1	0.20	1	0.20	2	0.40
8	1.98	0	0.00	0	0.00	1	0.25	19	4.80	20	5.05
7	2.51	0	0.00	0	0.00	2	0.40	0	0.00	2	0.40
6	0.96	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
5	2.49	0	0.00	0	0.00	0	0.00	5	1.00	5	1.00
4	2.86	0	0.00	0	0.00	3	0.52	14	2.45	17	2.97
3	2.92	0	0.00	4	0.68	16	2.74	17	2.91	37	6.34
2	2.63	0	0.00	0	0.00	4	0.76	3	0.57	7	1.33
Total	**36.85**	**0**	**0.00**	**5**	**0.07**	**33**	**0.45**	**148**	**2.01**	**186**	**2.52**

*Abundance index (No.of rainbow trout per km per floater) = Count for section/(section length (km) x floater equivalent). Floater equivalent = 2.0 (Burrows and Neuman, 1995).

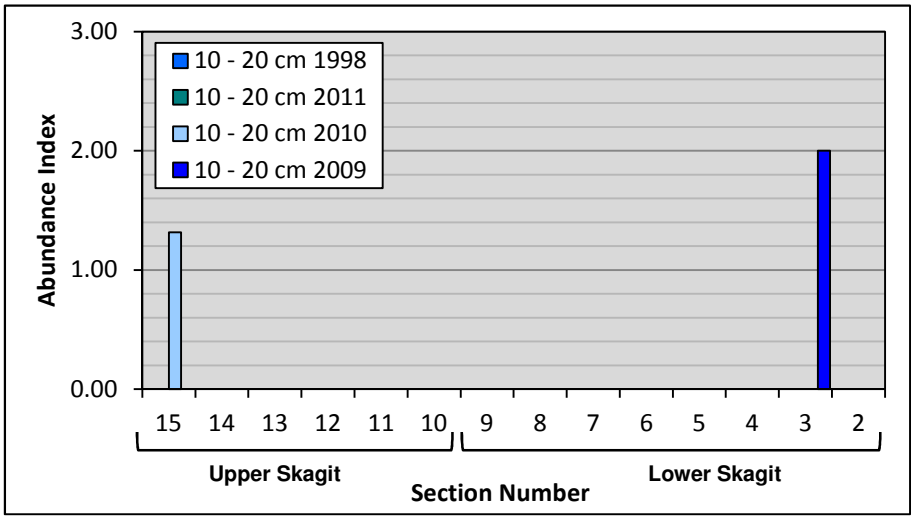
2009 Char Abundance Indices											
Section Number	Length of Section (km)	10 - 20 cm 2009		20 - 30 cm 2009		30 - 40 cm 2009		> 40 cm 2009		2009	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	0	0.00	0	0.00	0	0.00	7	1.84	7	1.84
14	2.57	0	0.00	0	0.00	0	0.00	8	1.56	8	1.56
13	6.01	0	0.00	0	0.00	17	1.41	91	7.57	108	8.99
12	3.48	0	0.00	2	0.29	16	2.30	54	7.76	72	10.34
11	3.31	0	0.00	0	0.00	2	0.30	4	0.60	6	0.91
10	0.74	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
9	2.49	0	0.00	2	0.40	9	1.81	71	14.26	82	16.47
8	1.98	0	0.00	0	0.00	7	1.77	80	20.20	87	21.97
7	2.51	0	0.00	0	0.00	6	1.20	7	1.39	13	2.59
6	0.96	0	0.00	0	0.00	8	4.17	23	11.98	31	16.15
5	2.49	0	0.00	0	0.00	2	0.40	58	11.65	60	12.05
4	2.86	0	0.00	0	0.00	14	2.45	30	5.24	44	7.69
3	2.92	2	0.34	3	0.51	95	16.27	137	23.46	237	40.58
2	2.63	0	0.00	1	0.19	46	8.75	155	29.47	202	38.40
Total	**36.85**	**2**	**0.03**	**8**	**0.11**	**222**	**3.01**	**725**	**9.84**	**957**	**12.99**

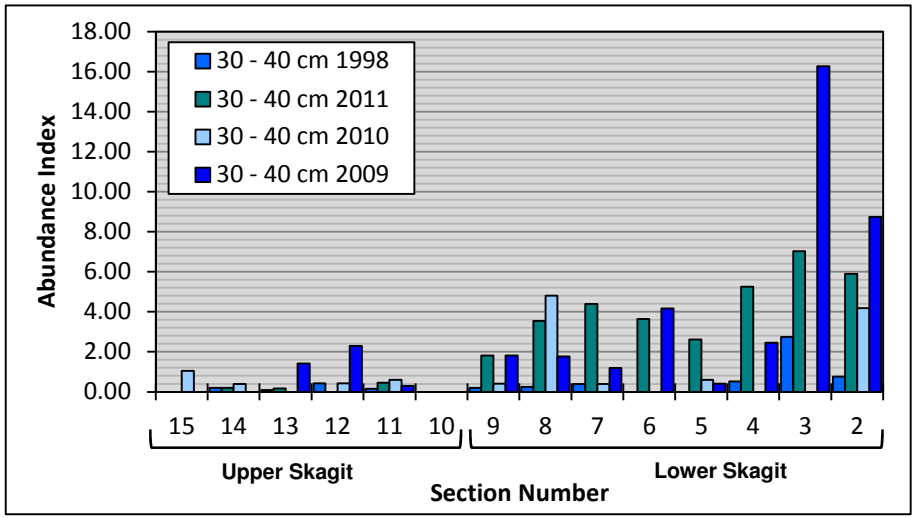
*Abundance index (No.of rainbow trout per km per floater) = Count for section/(section length (km) x floater equivalent). Floater equivalent = 2.0 (Burrows and Neuman, 1995).

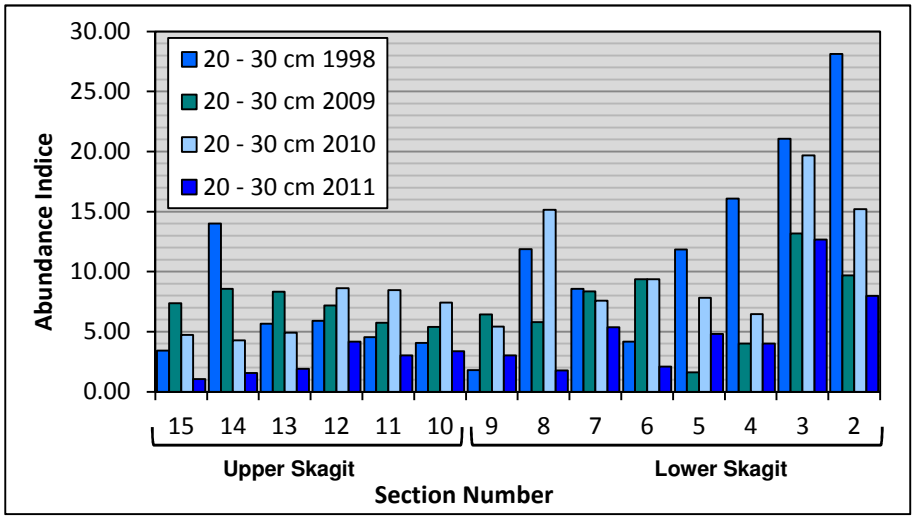
2010 Char Abundance Indices											
Section Number	Length of Section (km)	10 - 20 cm 2010		20 - 30 cm 2010		30 - 40 cm 2010		> 40 cm 2010		2010	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	5	1.32	0	0.00	4	1.05	57	15.00	66	17.37
14	2.57	0	0.00	0	0.00	2	0.39	4	0.78	6	1.17
13	6.01	0	0.00	0	0.00	0	0.00	40	3.33	40	3.33
12	3.48	0	0.00	1	0.14	3	0.43	44	6.32	48	6.90
11	3.31	0	0.00	0	0.00	4	0.60	51	7.70	55	8.31
10	0.74	0	0.00	0	0.00	0	0.00	2	1.35	2	1.35
9	2.49	0	0.00	0	0.00	2	0.40	124	24.90	126	25.30
8	1.98	0	0.00	0	0.00	19	4.80	222	56.06	241	60.86
7	2.51	0	0.00	0	0.00	2	0.40	50	9.96	52	10.36
6	0.96	0	0.00	0	0.00	0	0.00	14	7.29	14	7.29
5	2.49	0	0.00	0	0.00	3	0.60	180	36.14	183	36.75
4	2.86	0	0.00	0	0.00	0	0.00	177	30.94	177	30.94
3	2.92	0	0.00	0	0.00	0	0.00	491	84.08	491	84.08
2	2.63	0	0.00	0	0.00	22	4.18	127	24.14	149	28.33
Total	**36.85**	**5**	**0.07**	**1**	**0.01**	**61**	**0.83**	**1583**	**21.48**	**1650**	**22.39**

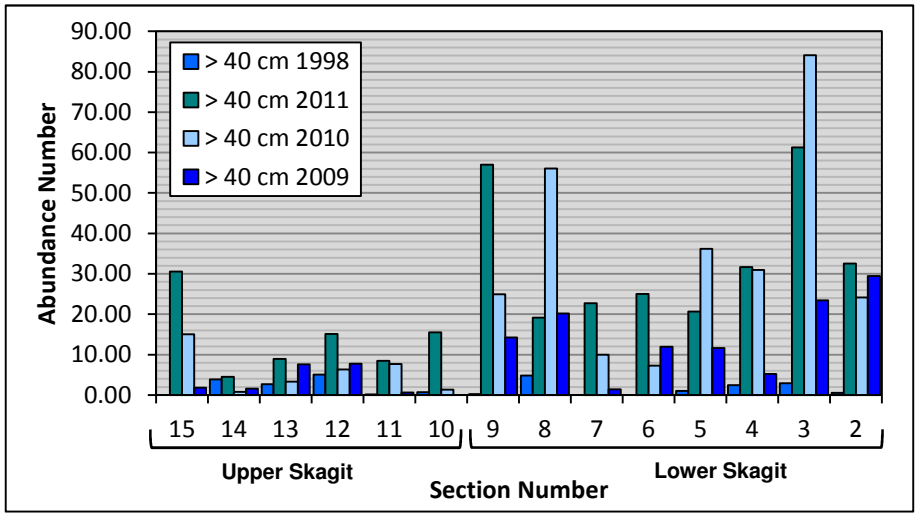
*Abundance index (No.of rainbow trout per km per floater) = Count for section/(section length (km) x floater equivalent). Floater equivalent = 2.0 (Burrows and Neuman, 1995).

Figures of char abundance indices by size class, 1998 and 2009 to 2011









Non – Catchable versus Catchable Rainbow Trout, 1998 and 2009 to 2011

Section Number	Length of Section (km)	Non – Catchable (< 20 cm) 1998		Catchable (> 20 cm) 1998	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	2	0.53	19	5.00
14	2.57	43	8.37	105	20.43
13	6.01	20	1.66	157	13.06
12	3.48	15	2.16	89	12.79
11	3.31	16	2.42	88	13.29
10	0.74	6	4.05	22	14.86
9	2.49	0	0.00	54	10.84
8	1.98	9	2.27	171	43.18
7	2.51	15	2.99	81	16.14
6	0.96	1	0.52	35	18.23
5	2.49	5	1.00	139	27.91
4	2.86	2	0.35	291	50.87
3	2.92	132	22.60	281	48.12
2	2.63	30	5.70	321	61.03
Total	**36.85**	**296**	**4.02**	**1853**	**25.14**

Section Number	Length of Section (km)	Non – Catchable (< 20 cm) 2009		Catchable (> 20 cm) 2009	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	13	3.42	48	12.63
14	2.57	31	6.03	70	13.62
13	6.01	13	1.08	233	19.38
12	3.48	18	2.59	96	13.79
11	3.31	4	0.60	122	18.43
10	0.74	3	2.03	14	9.46
9	2.49	3	0.60	62	12.45
8	1.98	0	0.00	89	22.47
7	2.51	23	4.58	79	15.74
6	0.96	2	1.04	56	29.17
5	2.49	1	0.20	32	6.43
4	2.86	0	0.00	47	8.22
3	2.92	36	6.16	196	33.56
2	2.63	6	1.14	145	27.57
Total	**36.85**	**153**	**2.08**	**1289**	**17.50**

Section Number	Length of Section (km)	Non - Catchable (< 20 cm) 2010		Catchable (> 20 cm) 2010	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	33	8.68	43	11.32
14	2.57	53	10.31	63	12.26
13	6.01	6	0.50	212	17.64
12	3.48	9	1.29	120	17.24
11	3.31	3	0.45	164	24.77
10	0.74	1	0.68	24	16.22
9	2.49	0	0.00	83	16.67
8	1.98	15	3.79	112	28.28
7	2.51	13	2.59	80	15.94
6	0.96	1	0.52	44	22.92
5	2.49	0	0.00	135	27.11
4	2.86	0	0.00	163	28.50
3	2.92	12	2.05	271	46.40
2	2.63	20	3.80	169	32.13
Total	**36.85**	**166**	**2.25**	**1683**	**22.84**

Section Number	Length of Section (km)	Non - Catchable (< 20 cm) 2011		Catchable (> 20 cm) 2011	
		No. of Fish	Abundance Index	No. of Fish	Abundance Index
15	1.90	0	0.00	37	9.74
14	2.57	3	0.58	34	6.61
13	6.01	0	0.00	121	10.07
12	3.48	2	0.29	101	14.51
11	3.31	0	0.00	119	17.98
10	0.74	0	0.00	25	16.89
9	2.49	0	0.00	69	13.86
8	1.98	0	0.00	28	7.07
7	2.51	0	0.00	74	14.74
6	0.96	0	0.00	32	16.67
5	2.49	1	0.20	81	16.27
4	2.86	0	0.00	104	18.18
3	2.92	17	2.91	212	36.30
2	2.63	1	0.19	154	29.28
Total	**36.85**	**24**	**0.33**	**1191**	**16.16**

Figures of non – catchable versus catchable rainbow trout, 1998 and 2009 to 2011