Steelhead Spawner Enumeration in akskʷəkʷant (Inkaneep Creek) – 2010

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EXECUTIVE SUMMARY

Anadromous steelhead salmon (*Oncorhynchus mykiss*) return to the Canadian portion of the q̓awsitkʷ from the Pacific Ocean by migrating up the nx̌ʷəntkʷitkʷ (Columbia River). In 2010, the Okanagan Nation Alliance, working with the Colville Confederated Tribes, surveyed the presence and distribution of steelhead spawners in the accessible portions of the Canadian q̓awsitkʷ Basin as part of the Okanagan Basin Monitoring and Evaluation Program (OBMEP). These surveys included fish fence enumeration and biosampling in akskʷəkʷant (Inkaneep Creek), as well as, PIT tag detection at Vertical Drop Structure 3 in q̓awsitkʷ.

The fish fence in akskʷəkʷant was installed and monitored from March 24th to May 25th, 2010 and was located 600m upstream of the confluence with suwiw̓s (Osoyoos Lake). During the sampling period a total of 72 steelhead/rainbow trout were enumerated and peak migration occurred between April 21st and April 27th. Seven *O. mykiss* were adipose clipped and of hatchery origin, with the remainder being of wild origin. Of the captured fish, 48 were females, 21 were males, and 3 were unknown. The sex ratio was 2.29:1, which is very different from previous years. The mean fork length of all fish captured measured 49.0 ± 10.0cm. The mean fork length for females was 48.7 ± 9.0cm, and 51.4 ± 9.4cm for males. Redds were not surveyed due to flow conditions.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

1.1 Project Background

According to Traditional Ecological Knowledge (TEK) as well as a series of historical accounts, anadromous steelhead salmon (*Oncorhynchus mykiss*) were found throughout the q̓awsitkʷ (Okanagan River)[1] Basin (Clemens *et a.*., 1939; Atkinson, 1967; Fulton, 1970; Ernst, 2000; Rae, 2005), a sub-basin of the nx̌ʷəntkʷitkʷ (Columbia River)[2] Basin. Okanagan steelhead, also known as Upper Columbia summer steelhead, are anadromous populations of rainbow trout that spend a portion of their life history in the ocean but return to freshwater habitat to spawn. Freshwater rainbow trout remain in their native freshwater rivers and streams throughout their entire life cycle. Anadromous steelhead and rainbow trout belong to the same species, *Oncorhynchus mykiss*, and there are no major physical differences between them other than the general difference in size and subtle difference in color.

Okanagan steelhead numbers have declined to such an extent that they were re-listed as an endangered species in 2007 (NOAA, 2007). There is limited data about the population size and distribution of steelhead in the Canadian portion of the q̓awsitkʷ Basin (Rae, 2005).

In 2010, the Okanagan Nation Alliance (ONA), working with the Colville Confederated Tribes, surveyed the presence and distribution of steelhead spawners in the accessible portions of the Canadian q̓awsitkʷ Basin as part of the Okanagan Basin Monitoring and Evaluation Program (OBMEP). OBMEP was created to establish a basin wide status and trend monitoring program with a 20 year life-span (Colville Confederated Tribes, 2009). Within this program an annual estimation of steelhead spawner numbers is completed to complement habitat surveys (including water quality and quantity surveys) and other biological surveys. This is the sixth year of the OBMEP program, while being the fifth year of steelhead spawner surveys in the Canadian portion of the q̓awsitkʷ Basin. Only four years of the spawner surveys have included the use of a fish fence.

[1] Commonly known as Okanagan River, but for the remainder of this report referred to as q̓awsitkʷ.
[2] Commonly known as Columbia River, but for the remainder of this report referred to as nx̌ʷəntkʷitkʷ.

1.2 Project Objectives

To annually enumerate adult steelhead spawners returning to the q̓awsitkʷ Basin, a fish fence in akskʷəkʷant (Inkaneep Creek)[3] was constructed and monitored. The end goal was to determine the timing and distribution of the steelhead spawning run. Specific objectives for operating the akskʷəkʷant fish fence included:

- Re-installation and maintenance of the fish fence on the lower reach of akskʷəkʷant throughout the spawner returns (end of March to late May),
- Enumeration of all fish migrating upstream (primarily steelhead and rainbow trout),
- Collection of biological information including fish length and gender ratios, and
- Collection of fin samples for stable isotope analyses ($\delta^{13}C$ and $\delta^{15}N$).

1.3 Study Area

The area of the Canadian q̓awsitkʷ Basin currently accessible to migrating steelhead salmon occurs downstream of nˤaylintən (McIntyre Dam)[4] (Figure 1). nˤaylintən is located 24 km upstream of suwiw̓s (Osoyoos Lake)[5] on the main stem q̓awsitkʷ (Figure 1). The dam was constructed in 1920 without allowing for fish passage (Long 2005a). Downstream of nˤaylintən, two large tributaries flow into the Okanagan system; nSaxʷl'qaxiyaʔ (Vaseux Creek)[6] flows into the q̓awsitkʷ main stem while further downstream akskʷəkʷant flows into the north basin of suwiw̓s.

In 2006, it was determined that akskʷəkʷant was the most productive spawning creek of those surveyed (Long *et al.,* 2006). Enumerating migrating steelhead salmon on akskʷəkʷant allows for maximum enumeration efficiency. akskʷəkʷant was again the focus of this year's steelhead spawner surveys which were conducted in the spring of 2010 based on previous years sampling.

In akskʷəkʷant, 3.7 km of its 23.5 km length is accessible to migrating salmon. The remainder is blocked by a 6 m high waterfall (Walsh and Long, 2005). This survey year, the accessible 3.7 km

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[3] Commonly known as Inkaneep Creek, but for the remainder of this report referred to as akskʷəkʷant.
[4] Commonly known as McIntyre Dam, but for the remainder of this report referred to as nˤaylintən.
[5] Commonly known as Osoyoos Lake, but for the remainder of this report referred to as suwiw̓s.
[6] Commonly known as Vaseux Creek, but for the remainder of this report referred to as nSaxʷl'qaxiyaʔ.

length of akskʷəkʷant was surveyed for steelhead redds. In addition, steelhead migrations were monitored through a fish fence located 600 m from the mouth of the creek.

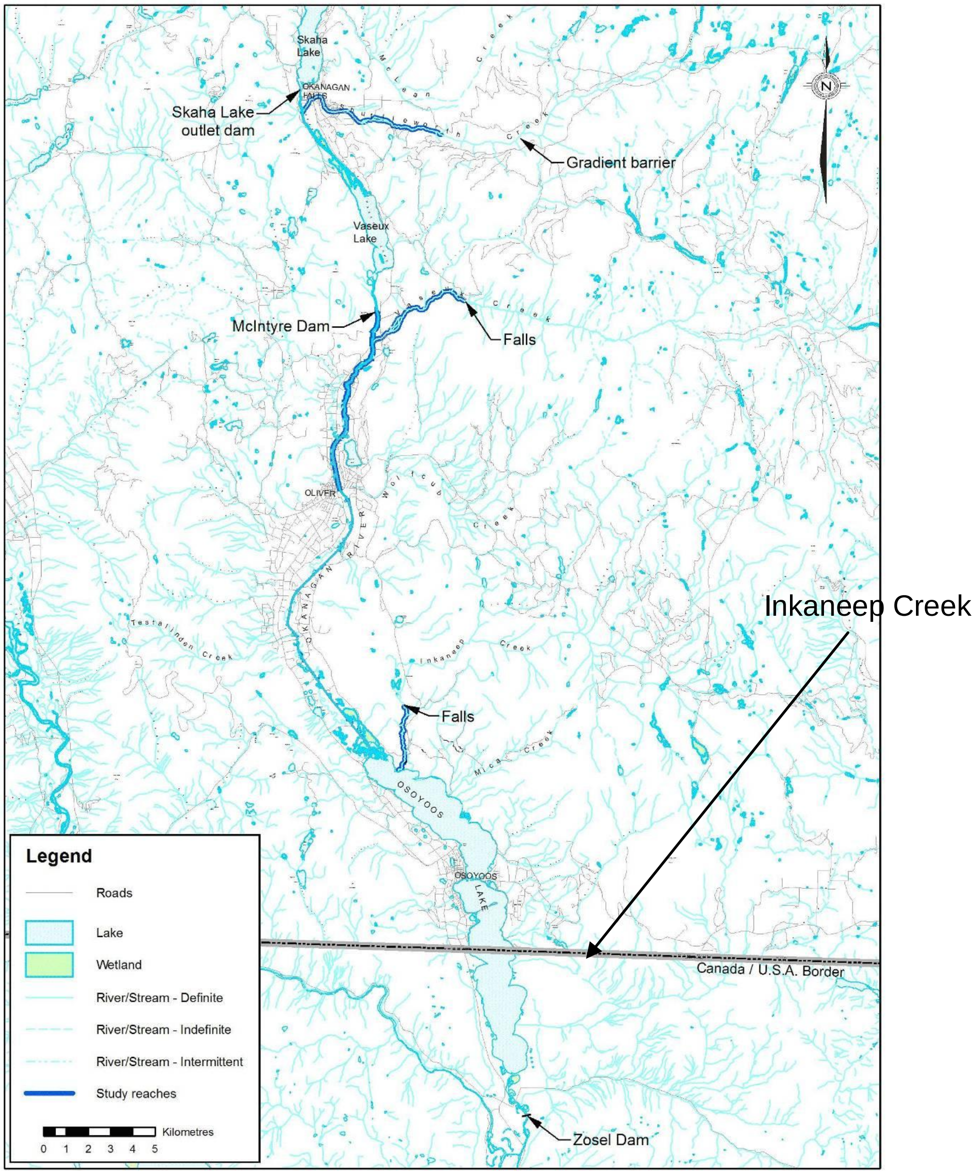

Figure 1. Canadian q̓awsitkʷ Basin steelhead/rainbow trout study area.

2.0 METHODS

2.1 akskʷəkʷant Fish Fence Monitoring and Biosampling

The akskʷəkʷant fish fence was installed on March 24th, 2010 and was located 600m upstream of the confluence with suwiẁs. The fence was constructed during low flow conditions when the mean depth of the stream was approximately 1.80m (Water Survey of Canada, 2010). The fence was located at the top of a riffle, where the capture box could sit in the deeper waters of a pool (Fig. 2, Fig. 3). The fence panels were set up across the creek to guide the fish into the capture box. akskʷəkʷant typically experiences flash flood flow dynamics where the water levels in the creek are prone to rapid changes over a short time period (Long *et al.,* 2006). In response to this, the orientation of the fish fence was occasionally altered to adapt to changing flows in order to reduce the likelihood of failure.

Figure 2. akskʷəkʷant fish fence March 23, 2010.

Figure 3. akskʷəkʷant fish fence April 23, 2010.

The timing of the fish fence operation was determined based on run timing and peak dates from previous years (Long *et al.,* 2006; Benson and Squakin, 2009; Folks and Kozlova, 2010). Counts of *O. mykiss* migrating into akskʷəkʷant to spawn were conducted from March 24th to May 25th, 2010. Installation of the fish fence occurred before the early spawners migrated into the system.

The fish fence was checked daily from March 24th to May 25th, 2010. At each check the sampling box was monitored for fish presence. All fish were noted, irrespective of species, and *O. mykiss* were bio-sampled (Figure 4, Figure 5). Biological sample data included: fork length (cm), sex, adipose fin presence, fin tissue and scale samples[7]. All diligence was taken in order to minimize both handling and stressing fish. The fish were then released into a pool within close proximity to the sampling box and were monitored during recovery. Wenatchee Hatchery fish were identified by their red-dye eye marks and unclipped adipose fins and were subsequently not released into akskʷəkʷant. As well, daily fence maintenance occurred ensuring there were no breaches in the fence.

[7] These samples will be processed in 2010/2011 for aging and stable isotope analysis to determine exposure to marine environments.

Figure 4. Female hatchery *O. mykiss* sampled April 16, 2010.

Figure 5. Male *O. mykiss* sampled May 10, 2010.

2.2 Stable isotope analyses

Because of the physical similarities between anadromous steelhead and adfluvial freshwater rainbow trout, stable isotope analyses were done in order to determine exposure to marine environment. For biological samples taken at the akskʷəkʷant fish fence, stable isotope analyses (carbon $\delta^{13}C$ and nitrogen $\delta^{15}N$) were done for 2008 and 2009 samples. A total of 58 non-destructive fin tissue samples were taken in 2008 and 19 in 2009. Samples were sent to the University of Regina for stable isotope analyses. The principal investigator was Dr. Bjoern Wissel.

Migratory fish differ greatly in their stable isotope values (up to 10-15 ‰) when they migrate between marine and freshwater systems making stable isotope analyses easier (Peterson and Fry, 1987; Doucett *et al.*, 1999). Marine food webs are typically enriched in the heavier carbon isotope ($\delta^{13}C$) compared to freshwater food webs, and these distinct signatures are reflected in the tissue of animals living in these ecosystems. It usually takes from several weeks to several months for the isotope ratio to change in fish muscle tissue (Hesslein *et al.*, 1993).

2.3 Passive Integrated Transponder (PIT) arrays

In the fall of 2009 a Passive Integrated Transponder (PIT) pass by array was installed downstream of Vertical Drop Structure (VDS) 3, Road 18, Oliver BC. The site is 45m downstream of the drop structure in the riffle tail-out. The PIT array consists of four 6m x 1.8m x 0.3m arrays aligned perpendicular to the river channel. Coverage is essentially 100% of the wetted width of the channel at flows between 0-10cms. Historically the q̓awsitkʷ has a mean peak flow of less than $50m^3/s$, meaning the array is well situated to detect all passing fish.

While the focus of the array is to detect migrating sockeye in the fall seasons, additional data including that of migrating *O. mykiss* will be detected by the array. This data will contribute to the migratory distribution and timing of Okanagan Basin *O. mykiss*. Data from the PIT array can be found on the PTAGIS website (http://www.ptagis.org/ptagis/) with the listing as OKC (Okanagan Channel VDS-3) small system detection arrays. The PIT array was fully monitored for the 2011 season.

2.4 Redd Surveys

Redd surveys were not completed in 2010. A dry winter (low snow levels) followed by a very wet spring with significant rainfall events made for a quick freshet and the onset of flash floods (which are typical for these creeks). These conditions made the completion of redd surveys impractical as redd detection would most likely have been very difficult due to high freshet flows and high turbidity.

3.0 RESULTS

3.1 akskʷəkʷant Fish Fence Monitoring and Biosampling

The akskʷəkʷant fish fence was monitored for 63 days (March 24th to May 25th, 2010). After which, the fence was disassembled due to high flows, warmer water temperatures and dates beyond typical migration and spawning peak times. During the sampling period a total of 72 steelhead/rainbows were enumerated (Table 1). Fish were caught between Apr 3rd and May 14th 2010. The highest daily catch was 10 fish.

Table 1. Counts of *O. mykiss* through the akskʷəkʷant fish fence.

Date	Number of fish
3-Apr-10	1
14-Apr-10	1
15-Apr-10	1
16-Apr-10	7
17-Apr-10	1
18-Apr-10	3
19-Apr-10	3
20-Apr-10	2
21-Apr-10	6
23-Apr-10	4
24-Apr-10	1
25-Apr-10	2
26-Apr-10	5
27-Apr-10	10
2-May-10	3
3-May-10	2
4-May-10	3
6-May-10	4
7-May-10	2
8-May-10	1
9-May-10	1
10-May-10	1
11-May-10	2
12-May-10	2
13-May-10	1
14-May-10	1

Peak *O. mykiss* migration occurred between April 21st (6 fish) and April 27th (10 fish). Typically, migration has occurred in the latter half of April or the first week of May in previous years (Benson and Squakin, 2008; Folks *et al.,* 2009). Arterburn *et al.* (2007) makes mention that this time period is also experienced in tributaries to the q̓awsitkʷ in Washington State. Peak dates have previously tended to correlate with peak water flows through akskʷəkʷant. Discharge was monitored at the Water Survey of Canada water gauge 08NM200 (Figure 6).

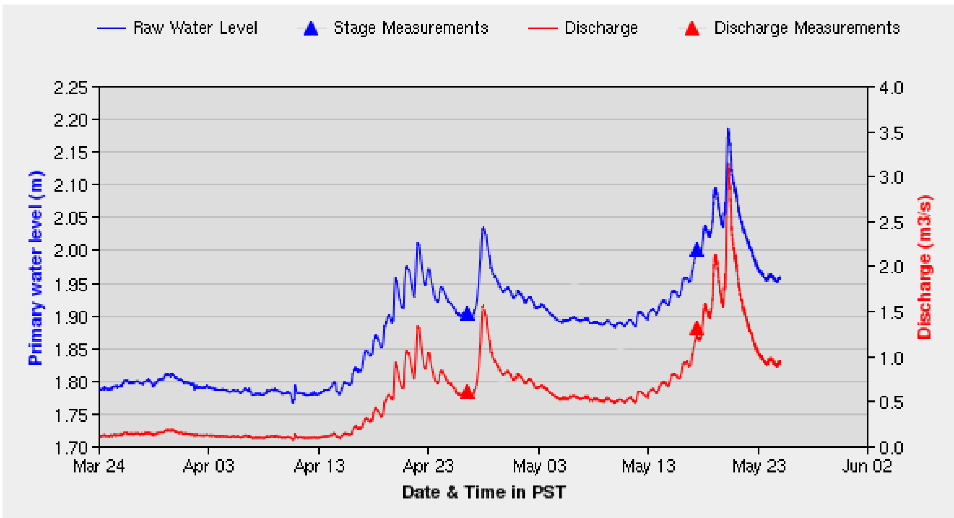

Figure 6. Water levels (blue) and discharge (red) in akskʷəkʷant at station 08NM200 (Water Survey of Canada, 2010).

This year, as in previous years (with 2009 as the exception), the fish fence experienced stability issues during freshet flows. Flows in akskʷəkʷant in 2010 rose on April 22nd with a discharge of approximately 1.35m^3/s, and on April 28th with just under 1.6m^3/s (Fig.6). While this year's flows were greater than those in 2009, previous years' peak flows have exceeded 2.0 m^3/s.

Due to high flows, the fence was not operational on April 22nd, and was reconstructed on April 23rd at a location approximately 25m upstream. The fence was also tampered with during the night of April 27th, with pickets removed (Figure 7). It was reconstructed on April 29th. It is also possible that unrecorded *O. mykiss* passage occurred on May 16th, 17th, and 22nd as the water was over the edge of the trap box during high flows (Fig. 8).

Figure 7. Tampered fence on the morning of April 28, 2010 showing missing pickets.

Figure 8. Submerged fence on May 17, 2010 during high flows.

The fish fence data from Long *et al.* (2006) corroborates the timing witnessed this season, with peak migration periods occurring broadly during the last week of April into the first week of May. Peak timing this season was based on consistency of larger number of fish movement over a number of days. In 2006, the fish fence was operated over a longer time period to note pre and post-peak spawning events.

3.1.1 Biological sampling of akskʷəkʷant *O. mykiss*

Of the 70 fish checked for adipose fin clips (72 captured total), 7 were clipped and of hatchery origin (Appendix I) including one Wenatchee Hatchery fish. As per previous years, the majority (90% in both 2010 and 2009, 91.53% in 2008; Folks *et al.* 2009) of the fish enumerated were most likely a wild population of *O. mykiss*.

In the 2010 season, the female to male sex ratio observed at the fish fence differed greatly from previous years with 48 females, 21 males and 3 of unknown sex. This results in a female to male sex ratio of 2.29:1 compared to previous years where female to male sex ratios were observed at 0.69 in 2008 and 0.85 in 2007 (no data for 2009). Sex ratios may also be influenced by the fact that suwiw̓s is also known for having a resident adfluvial rainbow population (Long *et al.,* 2006). The interaction and influence of this population on the anadromous steelhead spawning population is still unknown. Stable isotope analyses (carbon δ13C and nitrogen $\delta^{15}N$) on fin tissue samples are ongoing attempts to answers these unknowns.

The average length of all the *O. mykiss* that passed through the fish fence was 49.0 ± 10.0cm. Average length for females was 48.7 ± 9.0cm; average length for males was 51.4 ± 9.4cm (Table 2). This is very similar to previously observed values (Long *et al.,* 2006; Benson & Squakin, 2008, Folks *et al.,* 2009). In 2009, the average length for all *O. mykiss* that passed through the fence was 50.8 ± 8.08cm.

Table 2. Length of Canadian q̓awsitkʷ male and female *O. mykiss* in 2006, 2008, 2009, and 2010.

		Count	Length			
			Mean	Min	Max	St Dev
Female	2006	27	45	16	59	9
	2008	32	44	16	60	11
	2009	-	-	-	-	-
	2010	48	48.7	32.0	66.0	9.0
Male	2006	23	49	31	76	11
	2008	22	46	20	67	11
	2009	-	-	-	-	-
	2010	21	51.4	35.9	65.0	9.4
Unknown	2006	14	-	-	-	-
	2008	5	-	-	-	-
	2009	20	50.8	37	75	8.07
	2010	3	38.8	17.5	62.0	22.3

3.2 Stable Isotope Analyses for 2008 and 2009

As stable isotope results show (Table 3), mean $\delta^{13}C$ and $\delta^{15}N$ of the resident rainbow trout fins were significantly depleted compared with the anadromous steelhead fins ($\delta^{13}C$, -25.1 ±0.79‰ cf. -19.2±0.84‰; $\delta^{15}N$, 15.4±1.25‰ cf. 11.9±0.96‰).

Table 3. Mean values (± standard deviation) for δ13C and δ15N in fins of *O. mykiss* sampled in the akskʷəkʷant fish fence in 2008 and 2009.

	Rainbow trout	Steelhead
$\delta^{13}C$	-25.1 (0.79)	-19.2 (0.84)
$\delta^{15}N$	15.4 (1.25)	11.9 (0.96)
Number of fish	67	10

The akskʷəkʷant fish fence data are within the range of $\delta^{13}C$ known for freshwater and migratory fish. For example, $\delta^{13}C$ in freshwater *Salmo trutta* and *Salvelinus alpines* was -28.1±0.7‰ and -27.5±0.7‰, respectively, whereas in migratory *S.alpinus*, *Salmo salar*, and *Oncorhynchus kisutch* it was -22.1±1.3‰, -19.5±1.0‰, and -17.9±0.3‰, respectively (McCarthy and Waldron, 2000).

Resident freshwater rainbow trout and anadromous steelhead were clearly identifiable as two distinct groups and are displayed on Figure 10 using a combined δ13C and δ15N scatter plot. All rainbow trout has a carbon value of from -27 to -23‰, whereas steelhead of from -21 to -18‰.

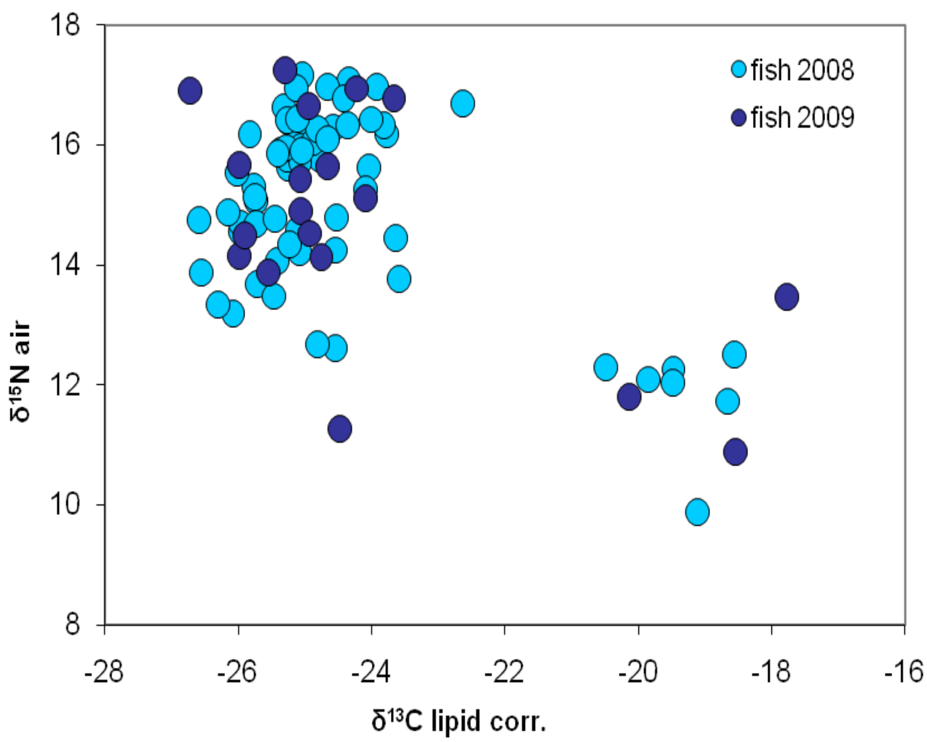

Figure 9.Combined δ13C and δ15N signatures of fin samples from *O. mykiss* (sampled in akskʷəkʷant fish fence in 2008 and 2009) identified as either resident freshwater rainbow trout (left group) or anadromous steelhead (right group).

According to stable isotope data, *O. mykiss* enumerated in the akskʷəkʷant fish fence in 2008 and 2009 were mostly represented by freshwater rainbow trout (51 rainbows out of 58 fish in 2008 and 16 rainbows out of 19 fish in 2009). The results of this study show that the measurement of $\delta^{13}C$ and $\delta^{15}N$ signatures can clearly distinguish between non-anadromous and anadromous populations *O. mykiss*.

3.3 Passive Integrated Transponder (PIT) arrays at VDS 3

During the 2010 season, the Passive Integrated Tag (PIT) array detected six tagged adult *O. mykiss* (Table 4). As there are no downstream detections of these fish, it is thought that these fish would have spawned in either the q̓awsitkʷ, nSaxʷl'qaxiyaʔ, or in Shuttleworth Creek, although this latter option is not believed to be likely because of the poor spawning habitat conditions caused by the sediment basin located at the mouth of Shuttleworth Creek.

Table 4. Summary of *O. mykiss* detected at VDS 3.

Fish ID	Date Detected	Release Date	Released At:	Hatchery Fish?
3D9.1C2D1BF50D	3/20/2010 4:04	9/3/2009	RKm 639	No
3D9.1C2D290535	3/24/2010 3:55	8/18/2009	RKm 639	No
3D9.1C2D3C6B45	5/2/2010 8:54	9/28/2009	Rkm 830	Yes
3D9.1C2D1C771D	5/6/2010 23:12	7/23/2008	RKm 639	No
3D9.1C2D09B18E	5/6/2010 8:49	7/28/2009	RKm 234	No
3D9.1C2D1C1D31	5/12/2010 18:05	9/3/2009	RKm 639	No

4.0 DISCUSSION

Steelhead returning to the Canadian q̓awsitkʷ Basin migrate up the nx̌ʷəntkʷitkʷ and enter the q̓awsitkʷ River in Washington, USA. They then pass through Zosel Dam at the suwiw̓s outlet. The video counter at Zosel Dam counted a total of 424 hatchery and wild adult *O. mykiss* in 2009: a 38% increase over the same time period in 2008, and the single largest return in the past 4 season's worth of enumeration data (Figure 10).

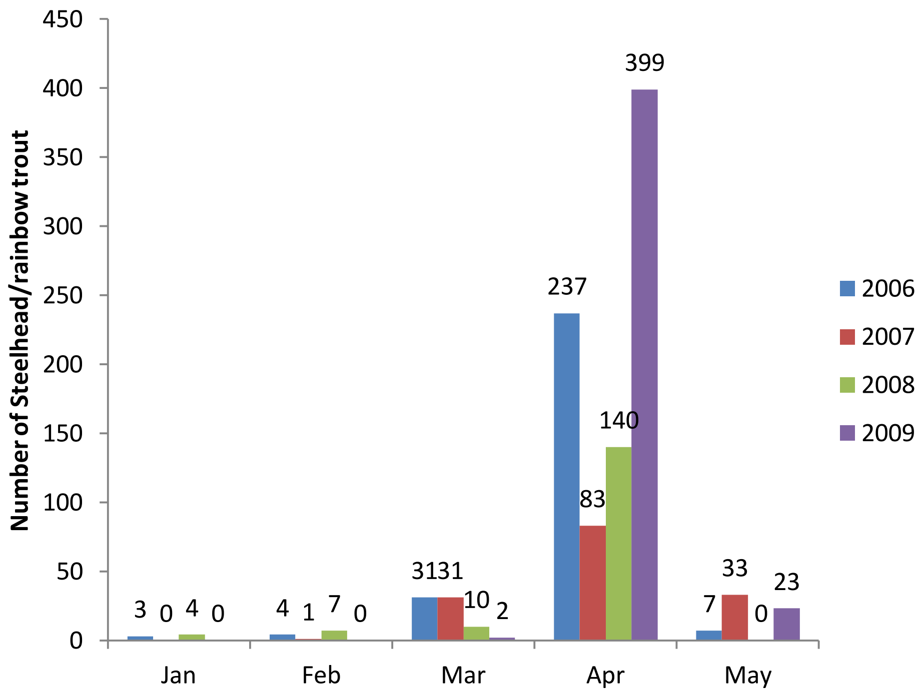

Figure 10. Adult steelhead (hatchery and wild) migrations through the Zosel Dam fish counter for 2006-2009 (Long *et al.*, 2006; Benson and Squakin, 2008; Columbia River DART, 2009).

Within the American portion of the Southern Basin of suwiw̓s both Nine Mile and Tonasket creeks host populations of spawning steelhead/rainbow trout (Arterburn and Miller, 2008). These numbers should be subtracted from the numbers presented as Zosel dam counts; however, as mentioned in Arterburn and Miller (2008), enumerations within these creeks has proven difficult due to private land ownership and lack of access to the creeks. The use of the fish counter on Nine Mile Creek, and counts from Tonasket Creek during flow years would be helpful to improve both the estimates of escapement within these creeks as well as anadromous steelhead possibly entering the Canadian q̓awsitkʷ Basin.

Of the *O. mykiss* entering the Canadian q̓awsitkʷ Basin, it has been noted by Long *et al.* (2006) and Benson and Squakin (2008) that the majority return to akskʷəkʷant. In 2010 (as in 2008 and

2009), most of the sampling effort was allocated to this stream. Enumeration results provided a count of 72 adults migrating past the akskʷəkʷant fish fence. These results demonstrate a consistent migration pattern to that of previous years (late April to early May peak). However, sampling in 2010 continued to demonstrate limitations of the current fish fence. Structural failures occurred due to freshet flows, and the fence had to be moved to a different location and re-built on April 23rd. The fence also had to be repaired on April 27th because of vandalism (pickets removed). Steelhead/rainbow trout were thought to have been able to escape the trap box on May 16th, 17th, and 22nd because of very high water levels. Despite the flaws of the fish fence, an improved version should continue to be employed as an enumeration technique within akskʷəkʷant.

In addition to distribution and population estimates, the interaction and role of adfluvial rainbow trout is an ongoing question. The level of interaction between resident rainbow trout and anadromous steelhead is currently unknown. Our first data from stable isotope analyses (carbon $\delta^{13}C$ and nitrogen $\delta^{15}N$) showed that *O. mykiss* enumerated in akskʷəkʷant fish fence in 2008 and 2009 was mostly represented by freshwater rainbow trout (67 rainbow trout out of 77 fish). Assessing the interactions of these different life history roles of *O. mykiss* is important for listing Okanagan steelhead (Upper Columbia summer steelhead) with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

akskʷəkʷant continues to appear to have the most steelhead spawners in the entire Canadian q̓awsitkʷ Basin (Long *et al.*, 2006; Arterburn *et al.*, 2007b). Due to budget constraints future steelhead research and management will focus on this tributary. We have included the use of Passive Integrated Transponder (PIT) tag technology, so that passage and timing of steelhead/rainbow trout will be improved in the q̓awsitkʷ (Okanagan River), Zosel Dam, and akskʷəkʷant.

In response to the blockage of fish migration at nˤaylintən, the ONA and other groups have lobbied for fish passage. Construction has taken place to install 5 overshot gates at nˤaylintən which now provide access upriver. Upstream migration was possible for the 2010 sockeye salmon (*Oncorhynchus nerka*) migration period through October. Also, historically, prior to overshot gate installation, nˤaylintən could be operated for short periods of time during the spring freshet in such a way that migration of salmon was possible. For these reasons, a main tributary upstream of nˤaylintən, Shuttleworth Creek, was occasionally included in enumerations. With fish passage now possible Shuttleworth Creek may be also included in surveys in future. This would help to assess the effectiveness of steelhead passage at nˤaylintən.

5.0 RECOMMENDATIONS

1. Future steelhead surveys should continue to focus on akskʷəkʷant, as this tributary has the strongest spawning run. An improved fish counting fence used in conjunction with improved Zosel Dam counts and/or future PIT tag readers could be used to obtain a population estimate.

2. Operation of the akskʷəkʷant fish fence should follow the recommendations outlined by Long *et al.*, (2006).

3. The akskʷəkʷant fish fence should be reinforced to better cope with spring freshet flows and should be installed with more vertical slots so as to minimize fish passage under the fence.

4. Bio-sample collection and stable isotope analyses should continue in 2010 to move towards better understanding the adfluvial/anadromous interaction and life history of Okanagan steelhead/rainbow trout. Also, sex ratio data should be collected in the future.

5. Redd surveys on all Canadian q̓awsitkʷ Basin tributaries and streams should be utilized to determine fish distribution and to strengthen information collected at the fish fence.

6. Continue to examine alternative enumeration methods to better determine distribution results of steelhead/rainbow trout within the Canadian q̓awsitkʷ Basin, including PIT tag technologies.

7. The public should be informed about the reason for the fish fence to help prevent future vandalism. Perhaps a fixed sign on site explaining both the structure and the project would help. In addition, a press release should be produced for the Community of Oliver and for the Osoyoos Indian Band.

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APPENDICES

APPENDIX I – 2010 Fish Fence Biosampling Data

Steelhead Biosampling								
Fish #	Length (mm)			Adipose clip	Fin sample	Scale# book-box	Sex	Photo #
	Head-fork	Tail	Head					
48100	340	50	70	N	Y	70916-1	F	54,55
48101	620	100	140	Y	Y		F	56
48102	395	65	94	N	Y	70916-2	M	80 to 84
48103	497	75	105	Y	Y	70916-3	F	85, 86
48104	500	80	110	N	Y	70916-4	F	87, 88
48105	590	75	125	Y	Y	70916-5	F	89
48106	430	50	110	N	Y	70916-6	F	90
48107	420	40	110	N	Y	70916-7	M	92
48108	340	50	80	N	Y	70916-8	F	93, 94
48109	320	50	75	N	Y	70916-9	F	97
48110	395	65	85	N	Y	70916-10	F	98, 99
48111	570	70	180	N	Y	70916-11	M	116, 117
48112	520	90	120	N	Y	70916-12	M	17, 18
48113	555	110	130	N	Y	70916-13	M	19
48114	650	115	140	N	Y	70916-14	M	20, 21
48115	564	100	120	N	Y	70916-15	F	124, 125
48116	370	65	77	N	N	70916-16	F	126
48117	620	85	150	N	N		F?	
48118	508	80	105	N	Y	70916-17	F	131
48119	602	130	153	N	Y	70916-18	M	132
48120	605	110	160	N	Y	70916-19	M	133
48122	430	65	95	N	Y	70916-20	F	134
	175	25	45	N	N	70916-21	F?	135, 137, 138
48123	410	60	95	N	Y	70916-22	F	139
48124	660	70	142.5			70916-23	F	140, 141

48125	580	95	125			70916-24	F	142
48126	576	80	130	N	Y	70916-25	M	

APPENDIX I - Continued

Steelhead Biosampling								
Fish #	Fish Length (mm)			Adipose clip	Fin sample	Scale# book-box	Sex	Photo #
	Head-fork	Tail	Head					
48127	537	60	107	N	Y	70917-1	F	
48128	500	67	90	N	Y	70917-2	F	
48129	359	60	75	N	Y	70917-3	M	
48130	470	70	130	N	Y	70917-4	M	168, 169
48120	535	75	135	N	Y	70917-5	M	174
48121	485	65	105	N	Y	70917-6	F	175
48132	423	60	85	N	Y	70917-7	F	176
	460	63	95	N	N		F	
48133	525	70	110	N	Y	70917-8	F	177
48134	500	60	110	N	Y	70917-10	F	178
48135	400	65	95	N	Y	70917-11	F	180
48136	573	100	135	N	Y	70917-12	F	181
48137	580		115	N	N		F	
48138	454	65	100	N		70917-13	F	182
	440	60	80	N	N	70917-14	F	184, 185
48137	580	95	120	N	Y	70917-15	F	186
48139	590	90	150	N	Y	70917-16	M	187
48140	560	80	140	N	Y		M	188
48141	470	65	110	N	Y		F	189
48142	370	60	80	N	Y		F?	191
48143	590	90	115	N	Y		F	192
48145	429	75	105	N	Y	70917-17	M	214
48146	488	75	110	N	Y	70917-18	F	215, 216
48147	625	105	135	N	Y	70917-19	M	217, 218
48148	505	70	90	N	Y	70917-20	F	219

48144	440	45	90	N	Y	70917-21	F	220
48149	497	70	105	N	Y	70917-22	F	221
48150	471	73	104	N	Y	70917-23	F	222

APPENDIX I – Continued

Steelhead Biosampling								
Fish #	Fish Length (mm)			Adipose clip	Fin sample	Scale# book-box	Sex	Photo #
	Head-fork	Tail	Head					
48151	565	80	130	N	Y	70917-24	F	223, 224
48152	382	65	95	N	Y	70917-25	M	225
48153	395	64	90	N	Y	70917	F	226, 227
48154	606	92	123	Y	Y	70914-1	M	230, 231
48155	595	85	115	Y	Y	70914-2	F	233, 236
48156	385	65	90	N	Y	70914-3	F	238
48157	550	85	130	N	Y	70914-4	M	239
48158	360	57	72	N	Y	70914-4	F	240, 241
48159	625	95	130	N	Y	70914-5	F	242, 243
48160	404	68	97	N	Y	70914-6	M	244
48161	586	85	110	Y	Y	70914-7	F	252
48162	381	58	78	N	Y	70914-8	M	253
48163	374	71	82	N	Y	70914-9	F	254
48164	650	70	95	Y	Y	70914-9	F	262
48168	570	85	115	N	Y	70914-10	F	263
48165	380	50	80	N	Y	70914-11	F	267
48166	405	67	96	N	Y	70914-12	F	269, 270

APPENDIX II – Carbon and nitrogen isotope data in steelhead and rainbow trout

Sample ID	type	date	$\delta^{15}N_{AIR}$	$\delta^{13}C_{VPDB}$	%N	%C	C/N	% fat	$\delta^{13}C_{VPDB}$
									lipid corr.
									Sweeting
27950	fish fin	spring 2009	15.67	-26.23	14.22	43.69	3.58	0.04	-26.0
27951	fish fin	spring 2009	13.88	-26.39	6.85	23.46	3.99	0.14	-25.6
27952	fish fin	spring 2009	14.15	-26.56	64.85	211.44	3.80	0.10	-26.0
27953	fish fin	spring 2009	11.81	-20.71	12.31	40.14	3.80	0.10	-20.1
27954	fish fin	spring 2009	13.47	-17.81	10.87	32.26	3.46	0.01	-17.8
27955	fish fin	spring 2009	14.13	-25.39	7.28	24.02	3.85	0.11	-24.8
27957	fish fin	spring 2009	10.89	-19.08	9.69	31.38	3.78	0.09	-18.5
27959	fish fin	spring 2009	16.91	-28.06	8.64	32.76	4.42	0.22	-26.7
27960	fish fin	spring 2009	17.25	-25.50	11.32	34.55	3.56	0.03	-25.3
27962	fish fin	spring 2009	15.65	-25.00	9.03	28.22	3.65	0.06	-24.7
27963	fish fin	spring 2009	16.64	-25.29	8.35	26.07	3.64	0.06	-24.9
27964	fish fin	spring 2009	16.78	-24.08	5.30	16.80	3.70	0.07	-23.7
27965	fish fin	spring 2009	16.94	-24.62	6.90	21.77	3.68	0.07	-24.2
27970	fish fin	spring 2009	15.11	-24.54	107.11	341.83	3.72	0.08	-24.1
27971	fish fin	spring 2009	14.89	-25.47	9.91	31.28	3.68	0.07	-25.1
27972	fish fin	spring 2009	14.50	-26.13	7.47	22.91	3.58	0.04	-25.9
27973	fish fin	spring 2009	14.52	-24.95	11.66	34.50	3.45	0.00	-24.9
27992	fish fin	spring 2009	15.44	-25.99	11.14	38.74	4.06	0.15	-25.1
27993	fish fin	spring 2009	11.27	-25.57	7.19	25.92	4.21	0.18	-24.5
36541 01	fish fin	spring 2008	12.26	-19.75	13.31	41.09	3.60	0.05	-19.5
36541 02	fish fin	spring 2008	16.18	-24.23	10.06	32.05	3.72	0.07	-23.8
36541 03	fish fin	spring 2008	12.61	-24.70	7.20	21.78	3.53	0.03	-24.5
36541 03	fish fin	spring 2008	12.68	-24.86	7.42	22.03	3.46	0.01	-24.8
36541 04	fish fin	spring 2008	14.22	-25.44	8.88	27.88	3.66	0.06	-25.1
36541 05	fish fin	spring 2008	11.73	-18.85	10.53	32.01	3.55	0.03	-18.7
36541 06	fish fin	spring 2008	15.63	-24.62	7.65	24.97	3.81	0.10	-24.0
36541 07	fish fin	spring 2008	16.62	-25.43	15.19	45.63	3.50	0.02	-25.3
36541 07a	fish fin	spring 2008	12.09	-20.25	14.45	45.63	3.68	0.07	-19.9
36541 07a	fish fin	spring 2008	12.03	-20.00	14.45	46.70	3.77	0.09	-19.5

36541 08	fish fin	spring 2008	14.56	-26.46	8.83	28.33	3.74	0.08	-26.0
sample	**type**	**date**	$\delta^{15}N_{AIR}$	$\delta^{13}C_{VPDB}$	**%N**	**%C**	**C/N**	**% fat**	$\delta^{13}C_{VPDB}$
ID								**lipid corr.**	
									Sweeting
36541 09	fish fin	spring 2008	15.07	-26.45	10.47	35.06	3.91	0.12	-25.7
36541 10	fish fin	spring 2008	12.51	-18.76	9.18	27.99	3.56	0.03	-18.6
36541 11	fish fin	spring 2008	14.45	-24.50	6.21	21.38	4.01	0.14	-23.6
36541 12	fish fin	spring 2008	17.08	-24.68	11.33	35.36	3.64	0.05	-24.3
36541 13	fish fin	spring 2008	15.62	-26.00	10.87	36.58	3.93	0.12	-25.3
36541 14	fish fin	spring 2008	12.29	-21.39	13.38	46.33	4.04	0.15	-20.5
36541 15	fish fin	spring 2008	16.18	-25.95	10.31	31.02	3.51	0.02	-25.8
36541 16	fish fin	spring 2008	16.69	-22.70	9.89	29.52	3.48	0.01	-22.6
36541 17	fish fin	spring 2008	15.77	-25.80	9.95	32.23	3.78	0.09	-25.3
36541 18	fish fin	spring 2008	14.07	-25.72	10.32	32.07	3.62	0.05	-25.4
36541 19	fish fin	spring 2008	9.87	-19.38	12.16	37.51	3.60	0.04	-19.1
36541 20	fish fin	spring 2008	17.17	-25.12	21.95	65.59	3.49	0.01	-25.0
36541 21	fish fin	spring 2008	14.58	-25.57	8.89	28.37	3.72	0.08	-25.1
36541 22	fish fin	spring 2008	16.98	-24.82	11.16	33.77	3.53	0.03	-24.7
36541 22	fish fin	spring 2008	16.77	-24.67	10.43	32.11	3.59	0.04	-24.4
36541 23	fish fin	spring 2008	16.33	-24.00	9.98	30.38	3.55	0.03	-23.8
36541 23	fish fin	spring 2008	16.43	-24.31	10.28	31.90	3.62	0.05	-24.0
36541 24	fish fin	spring 2008	14.25	-25.14	8.94	29.23	3.81	0.10	-24.5
36541 25	fish fin	spring 2008	14.35	-25.70	8.79	28.12	3.73	0.08	-25.2
36542 01	fish fin	spring 2008	16.95	-25.36	14.78	45.33	3.58	0.04	-25.1
36542 02	fish fin	spring 2008	16.38	-25.83	14.14	46.12	3.81	0.10	-25.3
36542 02	fish fin	spring 2008	16.22	-25.52	9.10	28.92	3.71	0.07	-25.1
36542 03	fish fin	spring 2008	16.29	-24.85	14.73	45.54	3.61	0.05	-24.6
36542 04	fish fin	spring 2008	16.97	-24.24	10.66	33.12	3.63	0.05	-23.9
36542 06	fish fin	spring 2008	16.41	-25.61	14.41	45.10	3.65	0.06	-25.3
36542 07	fish fin	spring 2008	13.76	-24.18	5.94	19.43	3.81	0.10	-23.6
36542 08	fish fin	spring 2008	15.31	-26.17	10.84	34.29	3.69	0.07	-25.8
36542 10	fish fin	spring 2008	15.96	-25.35	13.09	40.52	3.61	0.05	-25.1
36542 10	fish fin	spring 2008	15.78	-25.21	10.61	33.65	3.70	0.07	-24.8
36542 11	fish fin	spring 2008	13.68	-26.00	10.50	32.49	3.61	0.05	-25.7
36542 12	fish fin	spring 2008	15.90	-25.59	11.00	33.69	3.57	0.04	-25.4
36542 13	fish fin	spring 2008	15.27	-24.62	10.01	32.36	3.77	0.09	-24.1

36543 01	fish fin	spring 2008	13.48	-26.17	7.69	25.68	3.90	0.12	-25.5
sample ID	**type**	**date**	$\delta^{15}N_{AIR}$	$\delta^{13}C_{VPDB}$	**%N**	**%C**	**C/N**	**% fat lipid corr.**	$\delta^{13}C_{VPDB}$ **Sweeting**
36543 02	fish fin	spring 2008	15.71	-25.54	10.06	32.16	3.73	0.08	-25.1
36543 03	fish fin	spring 2008	14.69	-26.53	13.84	44.93	3.79	0.09	-26.0
36543 04	fish fin	spring 2008	16.34	-24.89	9.72	31.38	3.77	0.09	-24.4
36543 05	fish fin	spring 2008	15.54	-26.31	14.36	44.50	3.62	0.05	-26.0
36543 06	fish fin	spring 2008	14.75	-27.23	13.63	45.01	3.85	0.11	-26.6
36543 07	fish fin	spring 2008	13.18	-27.24	11.82	43.19	4.26	0.19	-26.1
36543 08	fish fin	spring 2008	14.80	-24.62	11.71	35.05	3.49	0.02	-24.5
36543 09	fish fin	spring 2008	16.05	-25.00	14.37	43.18	3.51	0.02	-24.9
36543 10	fish fin	spring 2008	14.69	-25.96	9.21	28.22	3.57	0.04	-25.7
36543 11	fish fin	spring 2008	16.26	-25.16	11.43	35.75	3.65	0.06	-24.8
36543 12	fish fin	spring 2008	15.96	-25.49	9.95	30.41	3.57	0.04	-25.3
36543 13	fish fin	spring 2008	14.77	-25.82	8.67	27.24	3.67	0.06	-25.5
36543 14	fish fin	spring 2008	15.85	-26.16	13.54	45.66	3.93	0.13	-25.4
36543 15	fish fin	spring 2008	13.88	-27.53	6.83	24.03	4.10	0.16	-26.6
36543 16	fish fin	spring 2008	14.88	-27.08	13.53	47.12	4.06	0.15	-26.2
36543 17	fish fin	spring 2008	16.43	-25.39	14.30	44.18	3.60	0.05	-25.1
36543 18	fish fin	spring 2008	15.90	-25.92	11.65	40.17	4.02	0.14	-25.1
36543 19	fish fin	spring 2008	16.10	-25.17	11.35	36.56	3.76	0.08	-24.7
36543 20	fish fin	spring 2008	15.13	-27.68	11.46	49.82	5.07	0.32	-25.7
36543 23	fish fin	spring 2008	13.34	-27.43	11.88	43.12	4.23	0.19	-26.3