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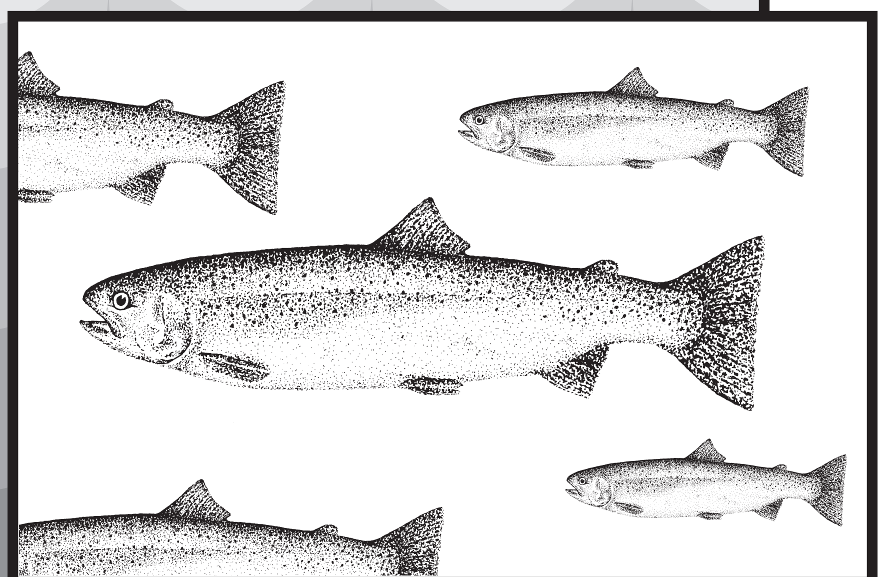
Steelhead Spawning Ground Surveys, Temperature, and Discharge Monitoring in Small Tributaries of the Columbia River Upper Middle Mainstem Subbasin, 2005-2007



by Casey M. Baldwin

Washington Department of
FISH AND WILDLIFE
Fish Program
Science Division

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Steelhead Spawning Ground Surveys, Temperature, and Discharge Monitoring in Small Tributaries of the Columbia River Upper Middle Mainstem Subbasin, 2005-2007

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3 December 2007

Abstract

The primary objective of this project was to determine the distribution and abundance of summer steelhead redds, monitor temperature, and discharge in 12 small tributaries to the Columbia River in the Upper Middle Mainstem Subbasin. This area is included in the Upper Columbia summer steelhead DPS and adult steelhead distribution in these creeks has been identified as a data gap for determining abundance and spatial structure. Tributaries that were monitored as part of this study included Swakane, Squilchuck, Stemilt, Colockum, Tarpiscan (North and South Forks), Tekison, Trinidad, Quilomene, Brushy, Skookumchuck, Whiskey Dick, and Johnson Creeks. Additional information was also included for Rock Island Creek and Sand Hollow; however, they were surveyed by the Foster Creek Conservation District and the USBR, respectively. The spawning ground surveys identified steelhead spawning, live adult steelhead, or carcasses recovered in Squilchuck, Tarpiscan, Trinidad, Tekison, Quilomene, Brushy, Skookumchuck, and Johnson Creeks. However, no consistent spawning locations were identified between years in any of the creeks. The highest abundance of steelhead spawners occurred in Trinidad Creek in 2005. Eleven redds and as many as 23 adult steelhead were identified in Trinidad Creek between 31 March and 2 May 2005. Of the 3 carcasses recovered in 2005, two of them (one in Tarpiscan Creek and one in Trinidad Creek) had elastomer tags and were from a release at the Chiwawa River Hatchery. The temperature regime was variable, some creeks had a pattern of consistent temperatures (10-12 °C) throughout the spawning period (Trinidad, Skookumchuck, Whiskey Dick) combined with relatively cool conditions in late summer. Many other creeks started off cold (~5 °C in mid-late March) and warmed up to 12-14 °C by the end of the spawning period in mid May. Spring temperatures were within the preferred range for egg incubation and smoltification. Late-summer mean weekly temperatures were generally within the preferred range for juvenile steelhead rearing, though some creeks did have mean weekly maximum temperatures that exceeded 20 °C. The discharge measurements recorded in this study were not measured often enough to serve as a comprehensive evaluation of seasonal flow patterns. However, our data indicate that some creeks had relatively flashy spring runoff patterns and tended to go dry near their mouths such as Brushy, Tekison, and Tarpiscan Creeks. Other creeks (Swakane, Skookumchuck, Whiskey Dick) had relatively low flows in the spring but retained some flow during late summer. Trinidad Creek was the exception with moderate but consistent flows. The information in this study is relevant for evaluating the abundance and spatial distribution of steelhead in the Upper Columbia ESU. It should also be helpful for managers and researchers to determine if and how to include these creeks into future sampling designs for the Wenatchee summer steelhead population monitoring.

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Introduction

Upper Columbia summer steelhead *Oncorhynchus mykiss* were listed for protection under the Endangered Species Act in 1997. Until 2005, they were listed as endangered; however, a recent review resulted in an improvement of their status to threatened. Subsequently, National Oceanic and Atmospheric Administration (NOAA) Fisheries developed the recovery concept of achieving Viable Salmonid Populations (McElhaney et al. 2000). It is critical to understand the distribution and abundance of spawning adults in order to evaluate the viability of a population or Evolutionary Significant Unit (ESU). There are four independent populations of summer steelhead in the Upper Columbia ESU and each has a monitoring and evaluation program for spawning adult steelhead. However, these programs do not include the many small tributaries that drain into the mainstem Columbia River in Chelan, Douglas, Grant and Kittitas Counties. Determining existing and potential fish use was a primary objective identified for these small tributaries in the Upper Middle Mainstem (UMM) Subbasin Plan (NPPC 2004a). Although each tributary is relatively small, the cumulative effect of steelhead spawning and rearing in these tributaries could contribute to the viability of the Upper Columbia summer steelhead ESU, thereby contributing to recovery of the ESU (McElhaney et al. 2000; ICTRT 2007b).

The Interior Columbia Technical Recovery Team (ICTRT) identified four independent summer steelhead populations in the upper Columbia ESU; Wenatchee, Entiat, Methow, and Okanogan. Additionally, the ICTRT determined that Crab Creek, a tributary to the mainstem Columbia between the Yakima and Wenatchee River basins, may have been a historical population but the degree to which Crab Creek supported a viable anadromous component was not well established (ICTRT 2007a). Drainages outside each subbasin with intrinsic potential habitat that were too small to support an independent population were included with the next upstream population. Therefore, all of the small tributaries of the Columbia River between Crab Creek and the Wenatchee River were included as part of the Wenatchee population, and Swakane Creek was included as part of the Entiat population.

There are four aspects to a viable salmonid population; abundance, productivity, spatial structure, and diversity (McElhaney et al. 2000). It is critical to understand the distribution and abundance of spawning adults in order to evaluate the viability of a population or ESU (McElhaney et al. 2000). Complex spatial structure and diversity moderates extinction risk by achieving two goals identified by the ICTRT 1) maintaining natural rates and levels of spatially-mediated processes and 2) maintaining natural patterns of variation (ICTRT 2007b). Therefore, having multiple spawning areas provides a buffer against catastrophic events and having fish distribution across diverse habitat types (ecoregions) leads to genotypic and phenotypic diversity (Hendry et al. 1998; Hendry et al. 1999; Waples 2004). Most of the tributaries monitored in this study were classified as minor spawning areas by the ICTRT (ICTRT 2007b). Several of them did of them not have an adequate quantity of intrinsic potential to be classified as a minor spawning area but were included in the study because of ancillary information on salmonid presence. The importance of any one minor spawning area may be low to the overall spatial structure and diversity requirements of a population. However, when multiple minor spawning areas are present at the upper or lower distribution of a population their combined functionality becomes more relevant for connectivity to adjacent populations within the ESU. Additionally, some unique ecoregions were documented in these areas that contributed to the diversity of the population (ICTRT 2007b).

For abundance and productivity it is critical to enumerate the adults on the spawning grounds and, if possible, identify the origin of those spawners. Assessing full life cycle productivity (spawner-spawner) may not be valid for these small tributaries because they are not independent populations and they are more likely to be influenced by strays from one or more upstream populations. However, if natural origin adults were consistently using these tributaries, but no redd surveys were conducted, they might not be counted towards recovery abundance numbers.

The UMM tributaries have known juvenile *O. mykiss* distribution in habitat that ranges from several hundred feet to several miles, depending on natural or manmade barriers (Pfeifer et al. 2001; R2 Resource Consultants; WDFW unpublished data). A previous study in several of the streams identified a mixed origin of the juveniles including hatchery and wild steelhead and rainbow trout (Dresser et al. 2003). The mechanism of recruitment of these juveniles was not established because no spawning ground surveys were conducted. It is possible that these tributaries consistently recruit juveniles from multiple upstream populations and produce smolts that can only be attributed to the ESU, and not to the Wenatchee population. Without estimates of spawning adults we cannot begin to establish which tributaries might be producing juveniles and which ones are just rearing juveniles produced elsewhere in the ESU. A common limiting factor among the major subbasins of the Columbia Cascade Province (Wenatchee, Entiat, Methow, Okanogan) was that reduced habitat diversity leads to less capacity to rear salmonid parr to the smolt stage (NPPC 2004 b,c,d,e). However, if some of the juveniles that emigrate from the upstream subbasins can rear to smolt stage in these small tributaries then production from the upstream populations will be underestimated.

The objectives for this study were:

Objective 1. Determine the abundance and distribution of steelhead redds and presence of adult steelhead in 13 tributaries of the mainstem Columbia River between Crab Creek and the Entiat River.

Objective 2. Determine spawner origin and physical characteristics for recovered steelhead carcasses.

Objective 3. Monitor temperature during the spawning period (March-May 2005). Monitor temperature throughout the year in each of the tributaries (2006-2007).

Objective 4. Determine discharge near each creek mouth several times during the spawning period and during baseflow.

Study Area

The streams that were part of this study ranged from Johnson Creek (Columbia River km 669 just upstream of Wanapum Dam) to Swakane Creek (Columbia River km 763), which enters the Columbia between the Wenatchee and Entiat Rivers (Table 1). The majority of the creeks in this study drain the Eastern slope of the Cascade Mountains, with the two exceptions being Trinidad Creek (Grant County) and Rock Island Creek (Douglas County)(Figure 1). For a more detailed description of the study area and each of the creeks please see NPPC (2004a).

Methods

Spawning Ground Surveys

To determine the abundance and distribution of steelhead redds, WDFW staff followed the methods of Mosey and Murphy (2002), adapted for steelhead (Tonseth 2003, 2004) as recommended by Hillman (2006). All surveys were conducted on foot and WDFW staff visually inspected and enumerated redds in stream reaches with suitable spawning substrate within the lower five kilometers of each tributary, or until a barrier to adult anadromous migration was reached. Exceptions included creeks with a high proportion of private property with multiple landowners such as Squilchuck, Stemilt, and Colockum Creeks. In these cases, we obtained permission to survey the lower ¼ to 1 km and several other reaches upstream that appeared to have suitable conditions for spawning.

Each creek was surveyed approximately once per week, depending on water conditions (turbidity), the presence of redds the previous week, and time limitations of the survey crew. Survey dates for each Creek can be found in Appendix A. Each redd was marked with flagging tape and a GPS waypoint was recorded. Additional information was recorded as conditions allowed, including the approximate size (mm total length) and number of *O. mykiss* using it and whether the fish had an intact adipose fin. As a rule of thumb, we assumed that *O. mykiss* estimated to be <450 mm, with a more robust body form, were resident trout.

WDFW staff examined carcasses for external indicators of hatchery origin (fin clips, elastomer tags, disc tags, other). If the carcass showed no external indicators of hatchery origin, and was fresh enough, then a tissue sample was taken and archived for potential later genetic analysis. If the condition of the carcass was adequate, WDFW staff would remove scales and otoliths for age and origin analysis (Davis and Light 1985; Bernard and Meyers 1994), determine the total length and post-orbital hypural length to the nearest mm, gender, and egg voidance (Humling and Snow 2004, 2005).

Table 1. Small tributaries of the Columbia River, Washington, included in this study for monitoring of steelhead spawning ground surveys, temperature, and discharge in 2005-2007.

Creek Name	Columbia R. km	County	[4]Watershed Area (ha)	[4]Maximum Elevation (m)	[4]Public Ownership
[1]Swakane	763	Chelan	NA	NA	NA
Squilchuck	747	Chelan	7,022	2,073	27%
[1]Stemilt	740	Chelan	8,440	2,049	58%
[2]Rock Island	730	Douglas	21,929	1,294	11%
Colockum	724	Chelan	10,098	1,773	62%
Tarpiscan	716	Kittitas	NA	NA	NA
NF-Tarpiscan	716	Kittitas	3,272	1,713	65%
SF-Tarpiscan	716	Kittitas	2,890	1,655	52%
Trinidad	710	Grant	15,570	879	11%
[1]Tekison	703	Kittitas	8,455	1,663	70%
Quilomene	697	Kittitas	6,155	1,342	72%
Brushy	697	Kittitas	5,334	1,541	66%
Skookumchuck	687	Kittitas	3,784	1,116	38%
[1]Whiskey Dick	685	Kittitas	8,762	1,179	68%
[3]Sand Hollow	675	Grant	14,207	578	6%
Johnson	669	Kittitas	15,444	1,141	99%

[1]Not surveyed for redds due to insufficient flows that appeared to limit access by adult steelhead.
[2] The Foster Creek Conservation District has been monitoring Rock Island Creek.
[3] The USBR has been monitoring Sand Hollow Creek.
[4] Data taken from the Subbasin Plan (NPPC 2004a).

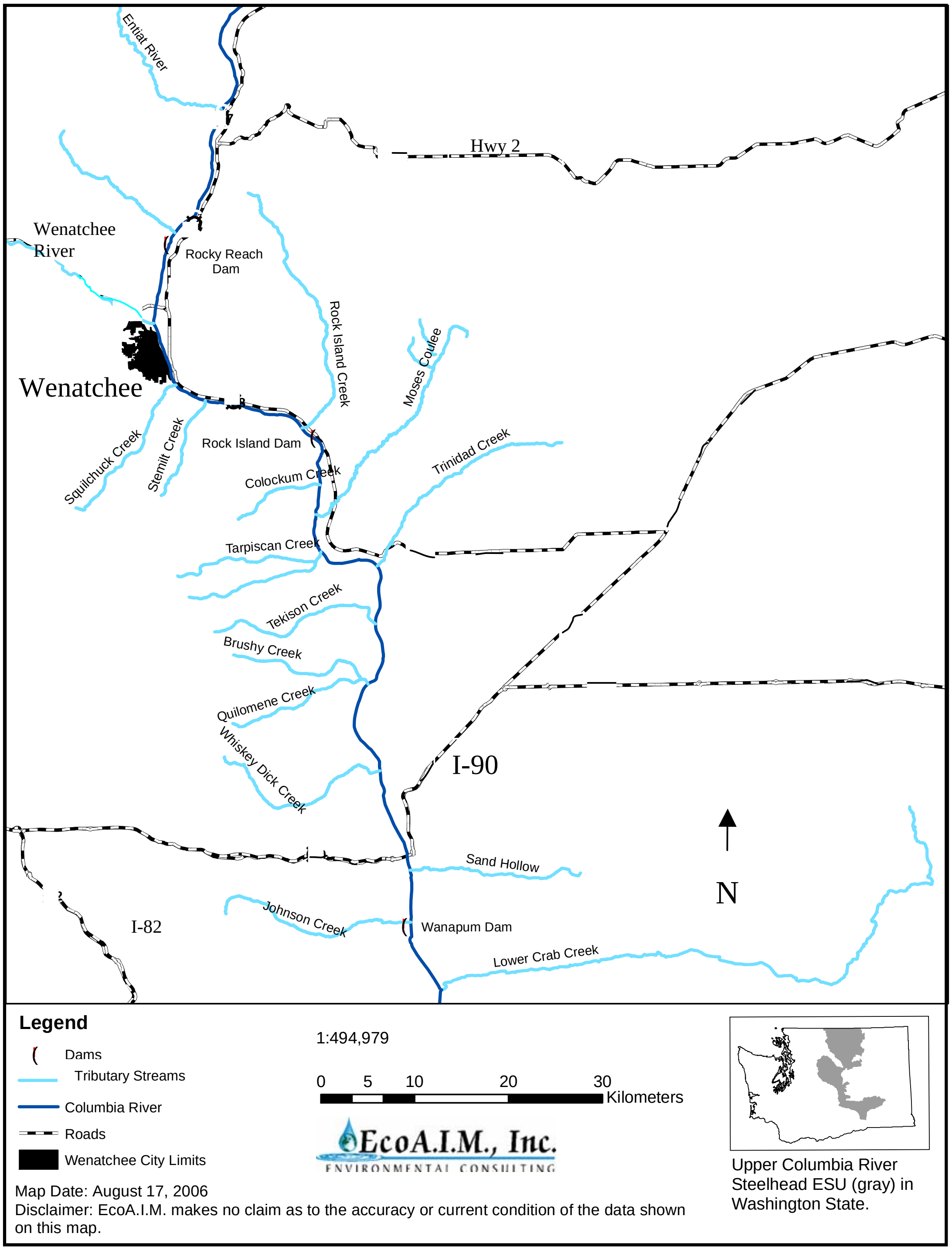

Figure 1. Map of the small tributaries of the Upper Middle Mainstem Columbia River, Washington.

Table 2. Locations of temperature probes in small streams of the Upper Middle Mainstem Subbasin, Washington.

Stream Name	Distance to Columbia R. confluence (km)	Elevation (m)	Latitude (degrees)	Longitude (degrees)
Swakane	0.15	230	47.54416667	-120.29291667
Squilchuck	0.05	225	47.39563333	-120.29120000
Stemilt	0.16	187	47.37885000	-120.24741667
Colockum	0.08	193	47.29991667	-120.09036667
Colockum	12.50	658	47.26683333	-120.20233333
Tarpiscan	0.05	161	47.23263333	-120.08716667
NF-Tarpiscan	1.10	194	47.22613333	-120.09401667
NF-Tarpiscan	4.70	423	47.22916660	-120.13401660
SF-Tarpiscan	1.10	216	47.22560000	-120.09398333
SF-Tarpiscan	6.30	491	47.21340000	120.14071660
Trinidad	0.10	182	47.22430000	-120.00215000
Trinidad	1.10	212	47.22835000	-119.99736667
Tekison	0.26	222	47.17213333	-120.02101667
Tekison	5.20	262	47.18356660	-120.06121660
Quilomene	0.09	175	47.11268333	-120.03088333
Quilomene	0.30	184	47.11220000	-120.03291667
Quilomene	6.10	350	47.10350000	-120.08628333
Brushy	0.20	175	47.11308333	-120.03183333
Brushy	5.60	339	47.12593330	-120.07030000
Skookumchuck	0.05	184	47.03886667	-120.02418333
Skookumchuck	5.80	346	47.05535000	-120.07536660
Whiskey Dick	0.37	178	47.02420000	-120.02226667

Temperature

During 2005, temperature was recorded with a hand thermometer to the nearest 1 degree Celsius each day that a creek was surveyed for steelhead spawning. In August of 2005, Onset temperature loggers were placed in Trinidad Creek and Quilomene Creek, approximately 100 m from their respective confluences with the Columbia River. In April of 2006, temperature loggers were installed near the confluences of most of the remaining creeks (Table 2). In 2007, additional temperature loggers were installed in several creeks at locations 5-12 km upstream of the creek mouths (Table 2). Temperature was recorded once every 2 hours in Trinidad and Quilomene Creeks and once every hour for all the other creeks. Temperature was reported as the maximum daily maximum temperature (MDMT), and the maximum weekly maximum temperature (MWMT), consistent with the protocols of the Upper Columbia Basin Monitoring Strategy (Hillman 2006). The MDMT was the single warmest daily maximum water temperature in a given year whereas the MWMT was the mean of daily maximum water temperatures each week. Additionally, we reported the average weekly temperature, which was the mean of all temperature recordings taken during each week.

Discharge

In 2006 and 2007, discharge was measured near the creek mouth of most of the tributaries on several occasions during the spawning period and at baseflow (mid August to early September). The velocity area method for measuring discharge was used (Peck et al. 2001) as recommended by Hillman (2006). Velocity was measured with a Flo-mate model 2000 flow meter (Marsh-McBirney Inc.). Discharge for the stream (Q) was calculated as the sum of the discharge estimates from each of the subsections (Q_n). Subsection discharge was calculated using an equation from Bain and Stevenson (1999), where:

$$Q_n = d_n \bullet \left(\frac{b_{n+1} - b_{n-1}}{2} \right) \bullet V_n$$

d_n = depth at subsection n
b_n = distance along the tape measure from the initial point on the left bank to point n
v_n = mean velocity of subsection n $\left(at 0.6 \bullet d_n\right)$

Results

Swakane Creek

Redd Surveys.— Swakane Creek was not surveyed for redds due to the extremely low flow conditions that were present throughout the late winter and spring. There is a double culvert that goes under Highway 97A, however, with adequate flows these culverts did not appear to prevent access by adult steelhead.

Temperature.— In 2006, Swakane Creek was 12 °C and 11 °C on 26 April and 10 May, respectively. In 2007, a thermister was deployed on 5 April 2007 and the average weekly temperature was between 10-12 °C during the remainder of the spawning period (Figure 2). The MWMT of 13.5 °C occurred the fourth week in July and the first week in August 2007 (Figure 2). The MDMT was x 14.1 °C on 19 July 2007.

Discharge.—In March of 2005, we visually observed wetted widths near the mouth of Swakane Creek of approximately 1-2 m with max depths of approximately 5-10 cm. However, formal surveys for stream width and depth were not conducted. Although Swakane Creek had the lowest spring discharge of all the monitored streams but it did not go completely dry at its confluence with the Columbia River, as did several other creeks in this study (Figures 3,4). Discharge in Swakane Creek ranged from 0.28 to 0.39 cfs during the spawning period (March-May) and 0.41 to 0.60 during baseflow (August-September) (Tables 3,4). On 2 September 2007, discharge was 0.60 cfs; however, within 1 km of the mouth the creek was dry.

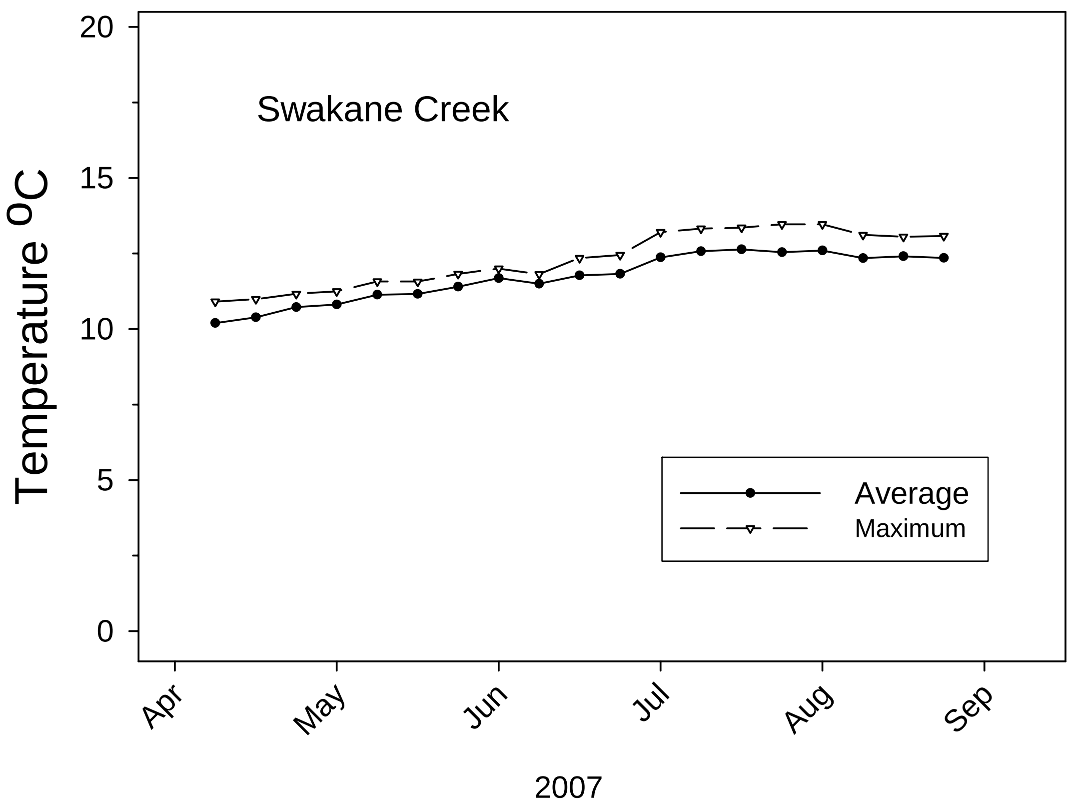

Figure 2. Mean weekly temperature and mean weekly maximum temperatures recorded at river kilometer 0.08 at one-hour intervals in Squilchuck Creek, Chelan County Washington.

Squilchuck Creek

Redd Surveys.— Only the very lower portion (~100 m) of Squilchuck Creek (between the confluence with the Columbia River and the first railroad culvert) was surveyed, due to access problems associated with the high number of private landowners and multiple partial or full fish barriers along Squilchuck Creek. Given the very poor spatial coverage of our survey these results were not adequate to define steelhead distribution in Squilchuck Creek, if they did in fact pass the railroad culvert and spawn further upstream.

In 2005, Squilchuck Creek was surveyed nine times between 14 March and 16 May (Appendix A). On 18 April 2005, we observed 1 pair of adult steelhead near the confluence with the Columbia. These fish each had intact adipose fins, were approximately 650 to 750 mm TL, and the female was observed digging. However, subsequent visits revealed no further redd development and the area where they were observed was inundated by the Rock Island pool at high water elevations.

In 2006, Squilchuck Creek was surveyed 8 times between 30 March and 16 May (Appendix A). No redds or fish were seen in Squilchuck Creek in 2006.

In 2007, Squilchuck Creek was surveyed 7 times between 30 March and 10 May. On 23 April 2007 two *O. mykiss* in spawning condition were observed just below the first culvert. These fish did not appear to be larger than 500 mm, and therefore could have been adfluvial resident rainbow trout. Subsequently, no redds or fish were observed in the area so we do not know if they moved up through the culvert into a reach we did not monitor or left Squilchuck Creek entirely.

Temperature.— In 2005, temperatures were taken manually during site visits. Stream temperatures ranged from a low of 4 °C on 14 March 2005 to a high of 11 °C on 18 April 2005. On 20 April 2006, a temperature logger was deployed in lower Squilchuck Creek. During the spawning period in 2006 and 2007 the maximum weekly temperatures were between 9-12 °C (Figure 5). During the summer months, the average weekly temperature peaked at 20.5 °C in 2006 and 18.3 °C in 2007. The MWMT was 22.8 °C during the last week in July 2006 and 20.1 °C the fourth week in July 2007. The MDMT was 25.7 °C on 8 August 2006 and 22.3 on 16 August 2007. On 12 April 2007 the temperature probe in Squilchuck Creek was found out of the water, apparently due to a high flow event. Temperature data displayed a pattern that appeared to be consistent with ambient air temperatures from 6-12 April 2007 and was excluded from the analysis.

Discharge.— Discharge was not measured in 2005. During the spawning period, discharge measurements in Squilchuck Creek ranged from 3.7 to 18.8 cfs (Tables 3,4). During baseflow, discharge measurements were 1.2 cfs on 9 August 2006 and 0.46 cfs on 2 September 2007.

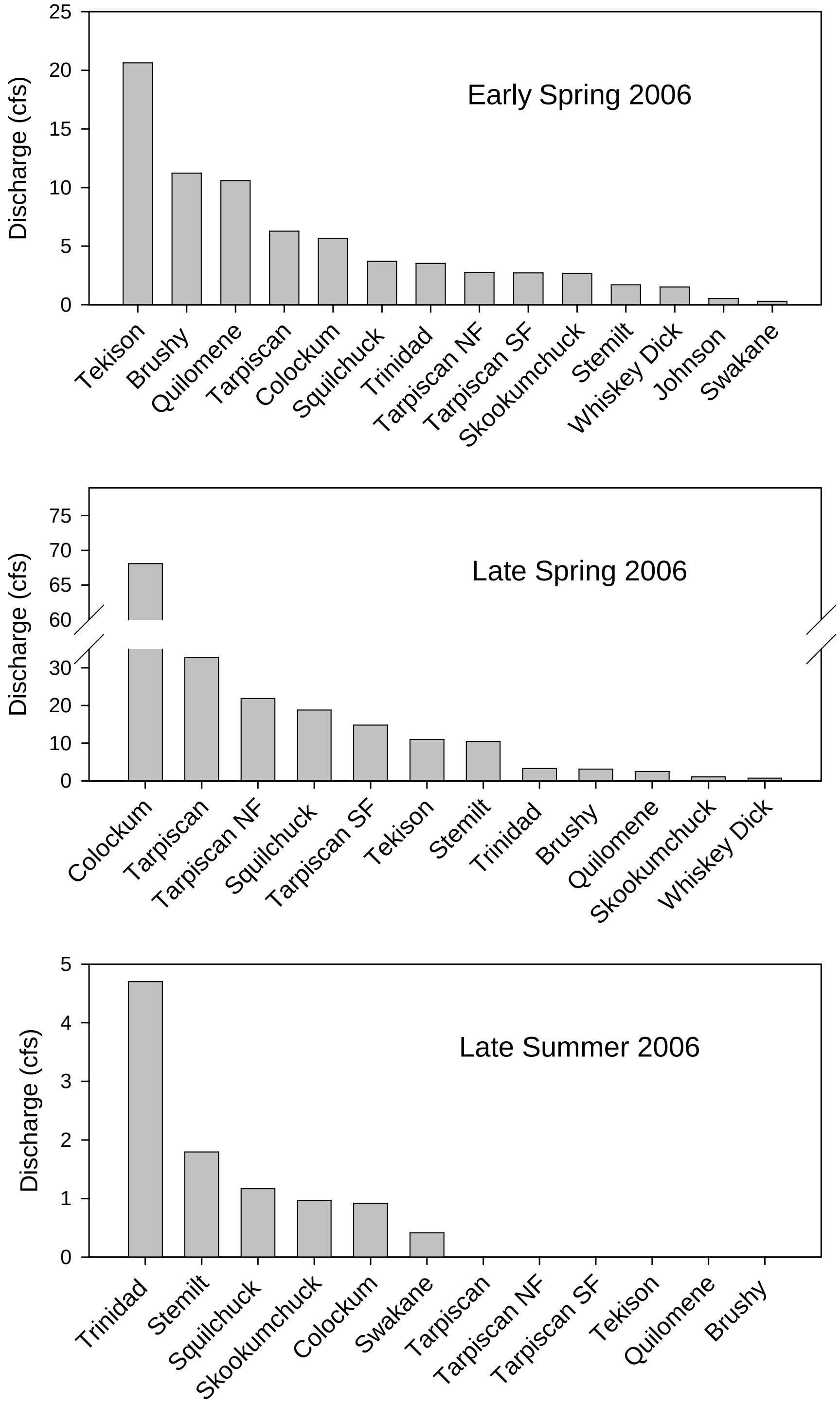

Figure 3. Discharge measurements (cfs) for some small tributaries of the Columbia River in Chelan, Kittitas, and Grant Counties, Washington in 2006. Discharge was only measured once per time strata in each Creek and Early Spring measurements occurred between16 March and 6 April. Late spring measurements occurred between 15 and 24 May, and Late Summer measurements occurred between 9 and 16 August.

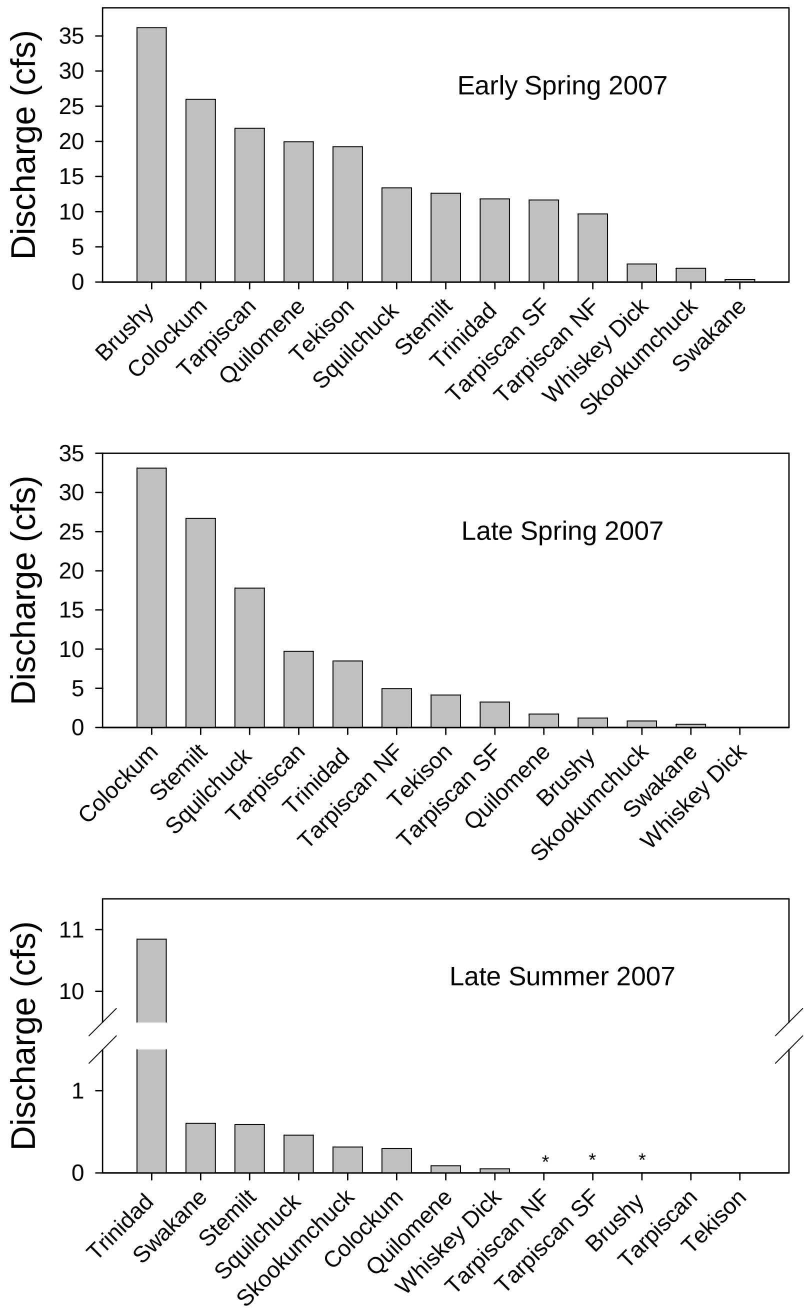

Figure 4. Discharge measurements (cfs) for some small tributaries of the Columbia River in Chelan, Kittitas, and Grant Counties, Washington in 2007. Discharge was only measured once per time strata in each Creek and Early Spring measurements occurred between 29 March and 5 April. Late spring measurements occurred between 10 and 16 May, and Late Summer measurements occurred between 29 August and 12 September. An asterisk (*) indicates some flow was present within 100-500 m upstream

Table 3. Discharge measurements from various small tributaries of the Columbia River in the Upper Middle Mainstem Subbasin, Washington during 2006.

Date 2006	Units	Swakane	Squilchuck	Stemilt	Colockum	Tarpiscan	Tarpiscan NF	Tarpiscan SF	Trinidad	Tekison	Quilomene	Brushy	Skookumchuck	Whiskey Dick	Johnson
16-Mar	m^3/s		0.10		0.16	0.18	0.08	0.08							
	cfs		3.69		5.65	6.26	2.76	2.72							
22-Mar	m^3/s			0.05					0.10						
	cfs			1.69					3.53						
31-Mar	m^3/s									0.58	0.30	0.32	0.08	0.04	
	cfs									20.63	10.58	11.21	2.66	1.51	
6-Apr	m^3/s	0.01													0.02
	cfs	0.28													0.53
15-May	m^3/s					0.93	0.62	0.42							
	cfs					32.77	21.88	14.79							
16-May	m^3/s		0.53	0.30	1.93										
	cfs		18.79	10.46	68.08										
17-May	m^3/s								0.09						
	cfs								3.30						
22-May	m^3/s									0.31	0.07	0.09		0.02	
	cfs									11.03	2.53	3.12		0.74	
24-May	m^3/s												0.03		
	cfs												1.06		
9-Aug	m^3/s		0.03	0.05	0.03										
	cfs		1.17	1.79	0.92										
15-Aug	m^3/s					0.00	0.00	0.00							
	cfs					0.00	0.00	0.00							
16-Aug	m^3/s	0.01							0.13	0.00	**	0.00	0.03	*	
	cfs	0.41							4.70	0.00	**	0.00	0.97	*	

* Water was present and flowing, but shallow depths and macrophytes made the velocity measurements unreliable.

** Water was present in some areas, but was not contiguous and was not flowing.

Table 4. Discharge measurements from various small tributaries of the Columbia River in the Upper Middle Mainstem Subbasin, Washington during 2007.

Date 2007	Units	Swakane	Squilchuck	Stemilt	Colockum	Tarpiscan	Tarpiscan NF	Tarpiscan SF	Trinidad	Tekison	Quilomene	Brushy	Skookumchuck	Whiskey Dick
29-Mar	m^3/s								0.33					
	cfs								11.82					
30-Mar	m^3/s		0.38	0.36	0.74									
	cfs		13.38	12.64	25.98									
2-Apr	m^3/s									0.54			0.06	
	cfs									19.24			1.94	
3-Apr	m^3/s										0.56	1.02		0.07
	cfs										19.93	36.19		2.54
4-Apr	m^3/s					0.62	0.27	0.33						
	cfs					21.84	9.67	11.66						
5-Apr	m^3/s	0.01												
	cfs	0.34												
10-May	m^3/s	0.01	0.50	0.76	0.94									
	cfs	0.39	17.79	26.68	33.10									
14-May	m^3/s									0.12			0.02	
	cfs									4.13			0.83	
15-May	m^3/s										0.05	0.03		
	cfs										1.70	1.20		
16-May	m^3/s					0.28	0.14	0.09	0.24					
	cfs					9.72	4.94	3.23	8.48					
29-Aug	m^3/s										0.00	*		0.00
	cfs										0.09	*		0.05
2-Sep	m^3/s	0.02	0.01	0.02	0.01									
	cfs	0.60	0.46	0.59	0.30									
5-Sep	m^3/s									0.00			0.01	
	cfs									0.00			0.31	
9-Sep	m^3/s					0.00	0.00	0.00						
	cfs					0.00	**	**						
12-Sep	m^3/s								0.31					
	cfs								10.85					

* There was no flow in the lower 1/2 km of Brushy Creek. Isolated pockets of water were present beginning at 1/2 km and there was a measurable flow level at km 5.

**No flow was present at the measurement site near the confluence of the North and South Forks. However, water and flow were present within 200-300 m upstream and throughout the lower 4-6 km of each fork. Depth or velocity were generally too low to get accurate measurements at the upstream sites.

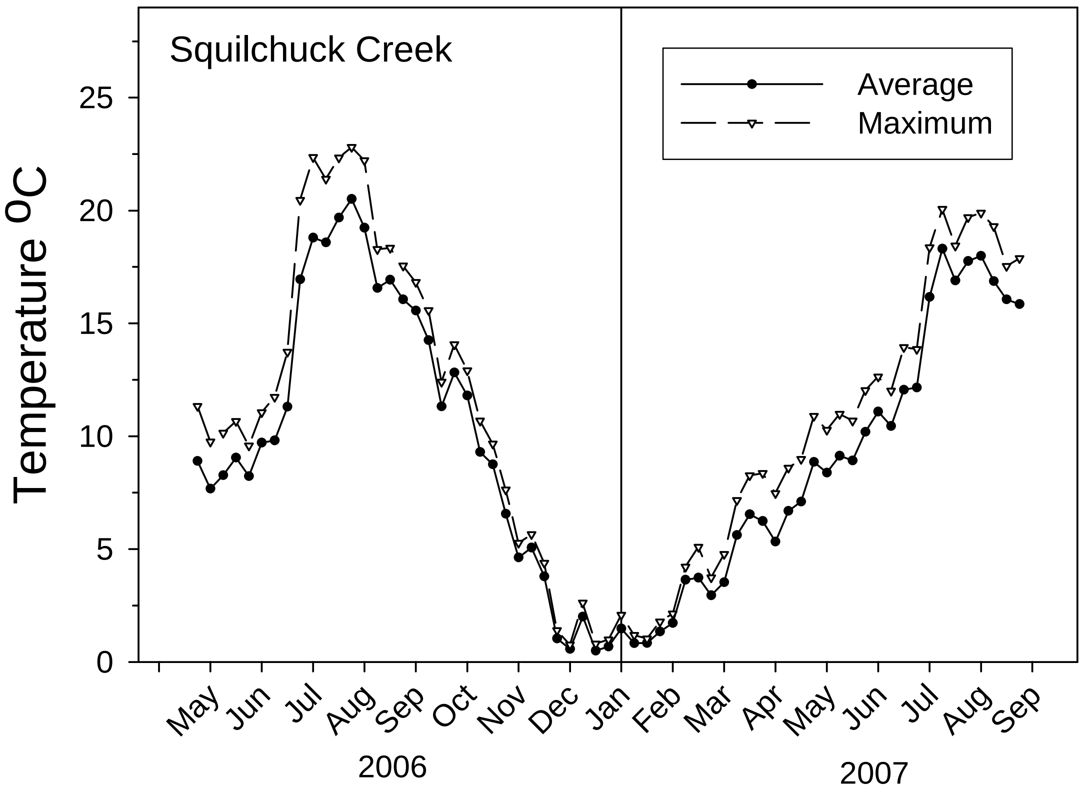

Figure 5. Mean weekly temperature and mean weekly maximum temperatures recorded at river kilometer 0.08 at one-hour intervals in Squilchuck Creek, Chelan County Washington.

Stemilt Creek

Redd Surveys.—In 2005, Stemilt Creek was not surveyed for redds due to the extremely low flow conditions that were present throughout the late winter and spring. In 2006, the lower 0.5 km of Stemilt Creek was surveyed four times between 30 March and 19 April (Appendix A). From 24 April to 16 May the lower 6.5 km of Stemilt Creek was surveyed 5 times. In 2007, the lower 6.5 km of Stemilt Creek was surveyed four times between 5 April and 10 May. The creek was also visited on a fifth day in 2007 (3 May) however, turbid conditions prohibited conducting a redd survey. No adult *O. mykiss*, redds, or carcasses were observed in Stemilt Creek during this study.

Temperature.—During the spawning period, the mean weekly temperature in Stemilt Creek increased from 5 to 10 °C. During summer baseflow the mean weekly temperature was below 20 °C in both 2006 and 2007 (Figure 6). The MWMT during baseflow occurred the fourth week of July in 2006 (20.9 °C) and the first week of August in 2007 (20.3 °C). The MDMT was 21.6 °C on 28 July 2006 and 20.7 °C on 2 August 2007.

Discharge.—Discharge was not measured in Stemilt Creek in 2005; however, the average wetted width in the reach nearest the Columbia River confluence was 2.0 m (± 0.6 SD) on 25 April 2005. During the spawning period in 2006 and 2007, discharge measurements were as low as

1.7 cfs on 22 March 2006 and as high as 26.7 cfs on 10 May 2007 (Tables 3,4). During baseflow, discharge was 1.7 cfs on 9 August 2006 and 0.59 cfs on 2 September 2007 (Tables 3,4).

Rock Island Creek

The lower 0.5 km of Rock Island Creek was surveyed on 16 March 2005. Beaver dams and marshy meadow habitat appeared to limit the opportunity for adult steelhead to access the creek for spawning. Rock Island Creek was not surveyed again because the Foster Creek Conservation District (FCCD) had plans to survey it for spawning steelhead on several occasions during the spring of 2005 (T. Behne, personal communication). The FCCD has been surveying Rock Island Creek for the last several years and had not found adult steelhead (T. Behne, personal communication). However, snorkel surveys had revealed use by juvenile *O. mykiss*, as well as juvenile Chinook (*O. tshawytscha*) and coho salmon (*O. kisutch*) (R2 Resource Consultants 2004).

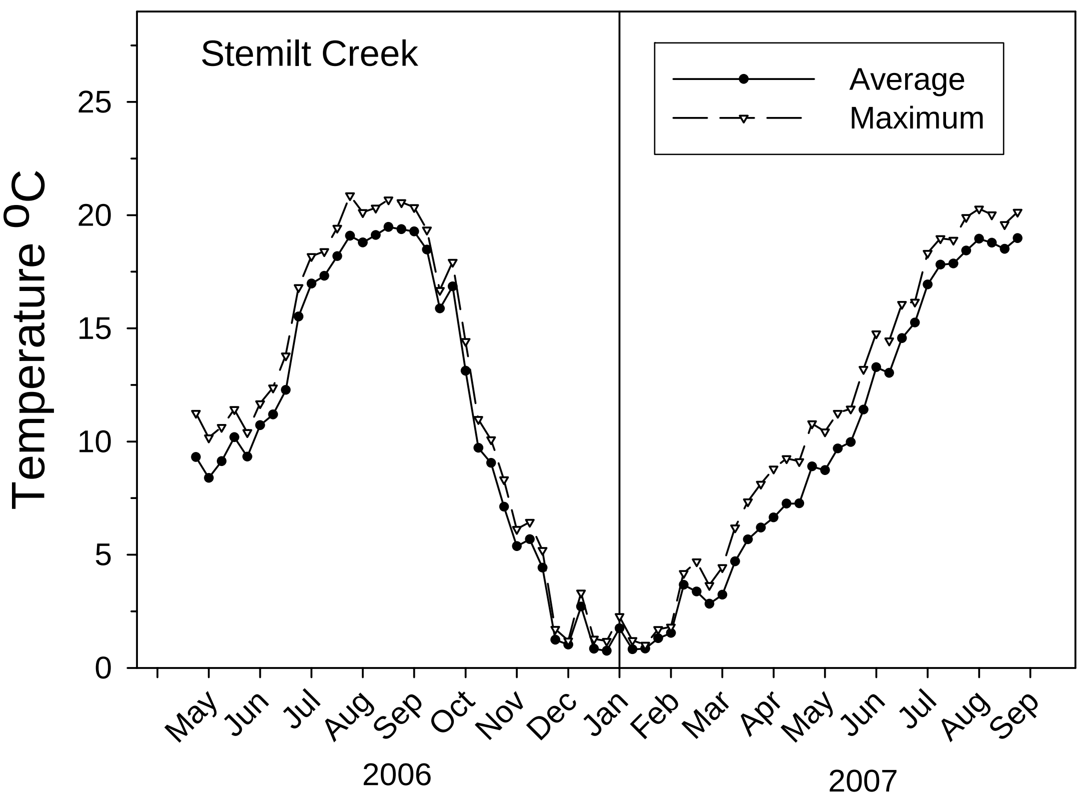

Figure 6. Mean weekly temperature and mean weekly maximum temperatures recorded at river kilometer 0.16 at one-hour intervals in Stemilt Creek, Chelan County Washington.

Colockum Creek

Redd Surveys.— In 2005, Colockum Creek was surveyed 9 times between 14 March and 16 May 2005 (Appendix A). The lower 1.5 km was surveyed on each site visit, along with a 0.5 km section below a beaver dam complex between km 3 and 4. Additional sections were covered on various dates, up through the lower 1 km of North Fork Colockum Creek. However, due to time constraints and the lack of available spawning gravels, these additional sections were not surveyed on a regular basis. No adult steelhead, carcasses or redds were observed in Colockum Creek. However, WSU personnel observed spawning *O. mykiss* during previous years near the research station at the confluence of the North and South Forks of Colockum Creek (T. Brandon, personal communication). A beaver dam complex at about rkm 4 appeared to be a natural barrier to upstream steelhead migration during 2005; however, several of the beaver dams did "blow out" during a high flow event in early May.

In 2006, Colockum Creek was surveyed eight times between 23 March and 16 May. On 12 April 2006, a steelhead (with an intact adipose fin) was observed in the lower reach of Colockum Creek, near the confluence with the Columbia River. No redds, carcasses, or live fish were observed on subsequent visits.

In 2007, Colockum Creek was surveyed five times between 5 April and 10 May, however, turbid conditions prohibited conducting a redd survey on 3 May. No adult *O. mykiss*, redds, or carcasses were observed in Colockum Creek in 2007.

Temperature.— During the spawning period, the mean weekly temperature in Colockum Creek increased from 5 to 10 °C. During summer baseflow, the mean weekly temperature was below 16 °C in both 2006 and 2007 (Figure 7). The MWMT during baseflow occurred the first week of July in 2006 (17.7 °C) and 2007 (16.2 °C). The MDMT was 18.5 °C on 6 July 2006 and 16.9 °C on 5 July 2007.

Discharge.— Discharge was not measured in 2005. The wetted width of Colockum Creek was 4.1 m (± 2.1 SD) on 25 April 2005. During the spawning period, discharge measurements in Colockum Creek ranged from 5.7 cfs on 16 March 2006 to 68 cfs on 16 May 2006 (Tables 3,4). In 2007, discharge was more consistent at 26 and 33 cfs in March and May, respectively. During baseflow, discharge was 0.92 cfs on 9 August 2006 and 0.30 cfs on 2 September 2007. On 2 September 2007 discharge at the upper Colockum Creek survey site (rkm 12) was 0.27 cfs.

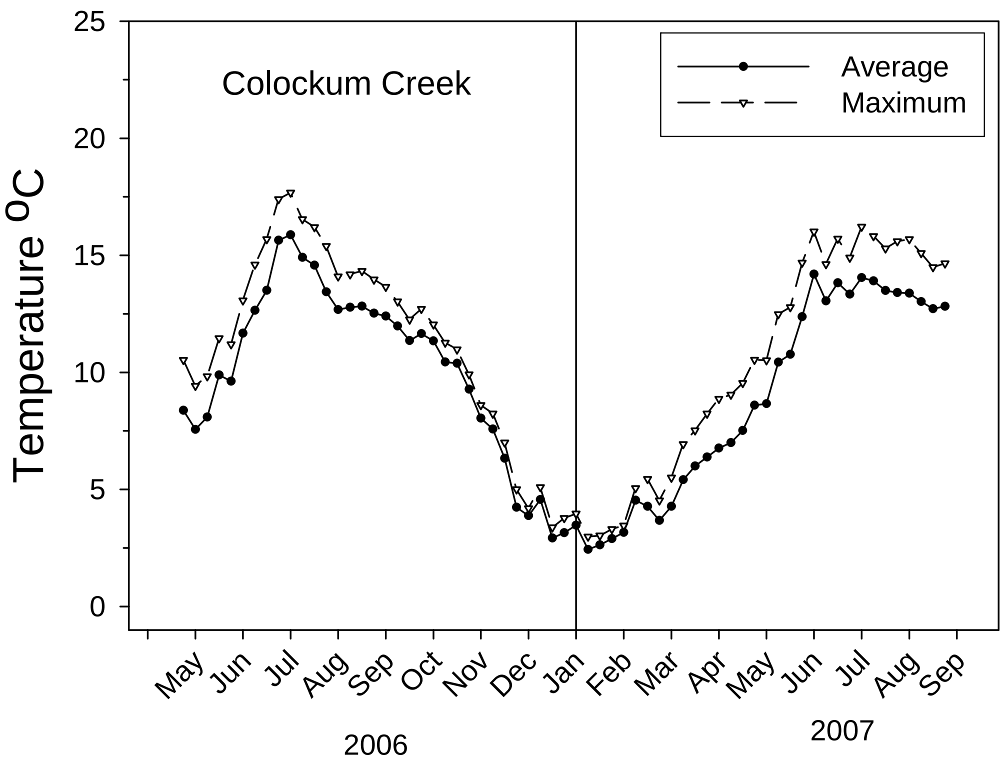

Figure 7. Mean weekly temperature and mean weekly maximum temperatures recorded at river kilometer 0.08 at one-hour intervals in Colockum Creek, Chelan County Washington.

Tarpiscan Creek

Redd Surveys.—Tarpiscan Creek was surveyed 8 times between 15 March and 9 May 2005. Each time the creek was surveyed from the mouth to approximately rkm 3.2 of both the North and South Forks Tarpiscan Creek, for a total survey distance of approximately 7.5 km. One carcass was recovered near the mouth of Tarpiscan Creek on 18 April 2005, however, no live adults or redds had been observed. The carcass was a female with an intact adipose fin, 75 cm total length, and a red left elastomer tag. This fish was from a Wenatchee River release at the Chiwawa River from a hatchery-by-hatchery parental cross.

In 2006, Tarpiscan Creek was surveyed 9 times between 27 March and 23 May. No redds, carcasses, or live adult fish were observed.

In 2007, Tarpiscan Creek was surveyed 5 times between 9 April and 10 May. No redds, carcasses, or live adult fish were observed. Multiple age classes of juvenile *O. mykiss* were observed in a pool 2 to 3 km up South Fork Tarpiscan Creek on 9 September 2007.

Temperature.—During the spawning period, the mean weekly temperature in Tarpiscan Creek increased from 5 to 10 °C. During summer baseflow, Tarpiscan Creek and the South Fork near its confluence with the North Fork went dry so we cannot report maximum temperatures because we cannot be certain exactly when water was present or absent on and around the probe as the stream was going dry. The temperature probe at rkm 6.3 was in a dry sidechannel so although water was present in a nearby channel we could not analyze or report it.

The North Fork Tarpiscan Creek had an average weekly temperature less than 18 °C throughout the late summer and early fall of 2006 (Figure 8). The MWMT was 20.0 °C during the fourth week of July and the MDMT was 21.0 °C on 27 July 2006. In 2007, the North Fork went dry near its confluence with the South Fork; however, water was present at our temperature probe site at rkm 4.7. The MWMT was 20.1 °C the second week in July with a MDMT of 21.2 on 11 July 2007.

Discharge.—Discharge was not measured in 2005. During the spawning periods in 2006 and 2007, discharge measurements ranged from 6 to 32 cfs in Tarpiscan Creek with similar flow contributions coming from the North and South Forks on all occasions, except 15 May 2006 when approximately two thirds of the flow came from the North Fork (Figures 3,4). There was no water in Tarpiscan Creek on 15 August 2006 or 9 September 2007. Likewise, there was little to no flow in each of the forks near their confluence. However, there was some flow within 0.5 km of the confluence of the North and South Forks on 9 September 2007, but either depth or velocity was generally too low to obtain a reliable discharge estimate.

Based on the temperature data, it appeared that Tarpiscan Creek near the Columbia River confluence went dry on or around 22 July 2006 and re-watered on 2 November 2006 (Figure 8). Likewise, it appeared that the South Fork of Tarpiscan Creek went dry on 24 July 2006 and re-watered by 16 September 2006. The lower portion of the South Fork appeared to dewater at a similar time in 2007. The North Fork did not completely dewater in 2006, though discharge was so low that measurements could not be taken. In 2007, the North Fork of Tarpiscan Creek did not dewater until the first week in September, as estimated by temperature data (Figure 8).

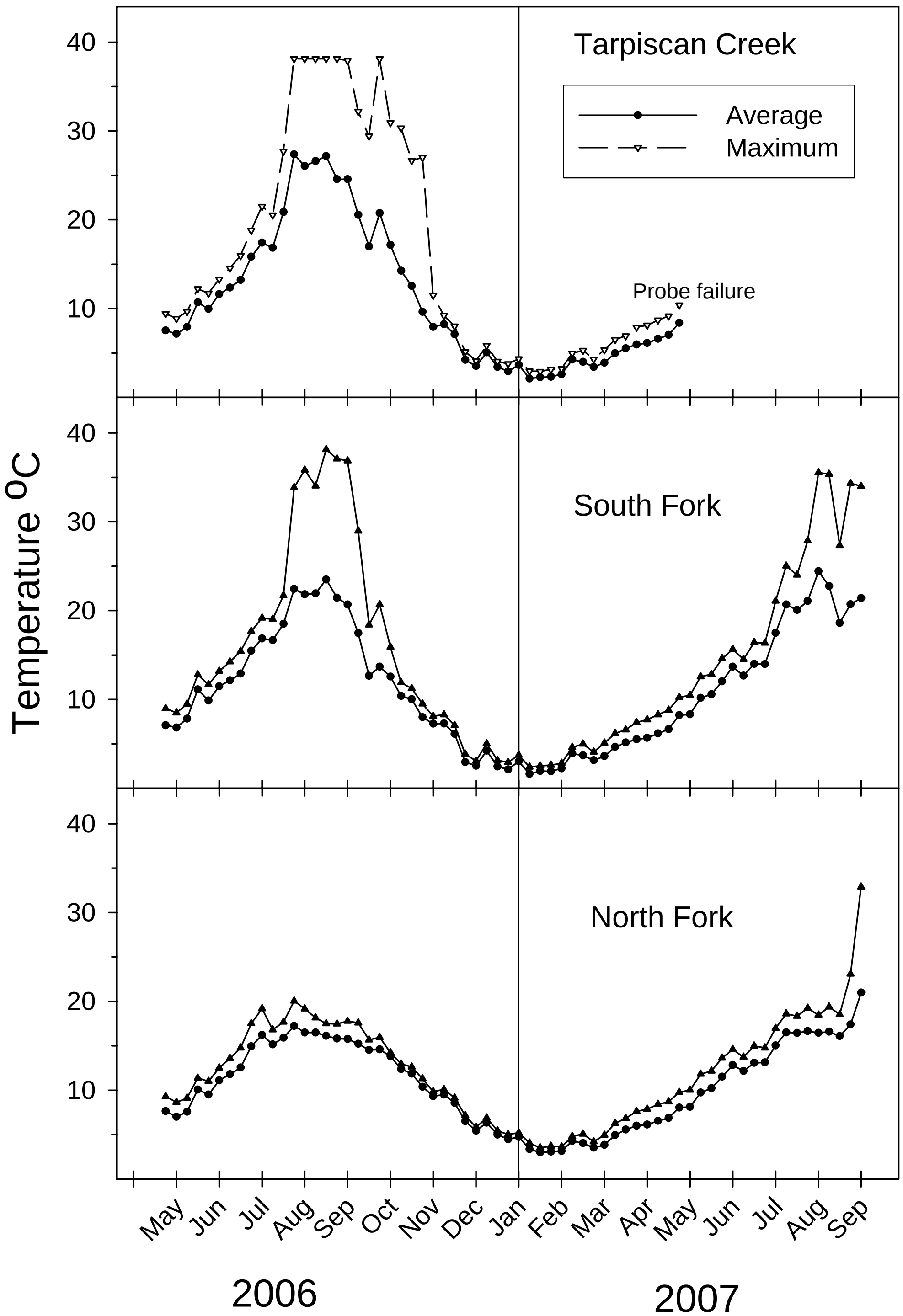

Figure 8. Mean weekly temperature and mean weekly maximum temperatures recorded at river kilometer 0.05 at one-hour intervals in Tarpiscan Creek and in the North (rkm 1.1) and South Forks (rkm 1.1) Tarpiscan Creek, Kittitas County Washington. Field observations confirmed that the stream was dry during late summer, corresponding to the periods with high maximum daily temperatures.

Trinidad Creek

Redd Surveys.—Trinidad Creek was surveyed 8 times between 16 March and 5 May 2005. On 16 March 2005, the creek was surveyed from the mouth to the Highway 28 culvert (rkm 2.25) that is a barrier to upstream migration; however, there is a series of large well-established beaver dams that would prevent upstream passage of adults starting just above the canyon section at rkm 1 (Figure 9). Therefore, on all subsequent visits the creek was only surveyed throughout the lower 1 km.

Eleven redds were documented in Trinidad Creek, most directly upstream of the bridge on Crescent Bar road. The first redds were documented on 31 March 2005, with 3 redds and at least 9 different steelhead observed on or around the redd sites. On 11 April 2005 a carcass was recovered with an intact adipose fin but a redd left elastomer tag (total length = 75 cm). This fish was from a Wenatchee River release at the Chiwawa River from a hatchery-by-hatchery parental cross. On 13 April 2005, four additional redds were constructed with 10 steelhead observed on or around the redds. Another carcass was recovered but the condition was too far degraded to determine if it had an adipose fin clip, elastomer tag, or to take a genetics sample. On 19 April 2005, two steelhead were observed well upstream of the bridge (100 and 300 m) past several beaver dams that had previously appeared to be the upstream end of the spawning area. No redds were located in the upstream area. Twenty-three steelhead were observed in the creek on 19 April 2005. On 26 April 2005, the final redd (#11) was completed and by 2 May 2005 no steelhead were observed in the creek and all redds were fading. Additionally, a large number (>100) of suckers (*Catostomus sp.*) were observed spawning in the same area as the steelhead redds.

Trinidad Creek was surveyed nine times between 22 March and 17 May 2006. No redds, carcasses, or live adult fish were observed.

Trinidad Creek was surveyed six times between 3 April and 8 May 2007. On 23 April 2007, three adult steelhead were observed in the lower 50 m of Trinidad Creek just downstream of the first beaver Dam. On 1 May 2007 one adult steelhead was observed in the same area. No redds or carcasses were observed on subsequent visits.

Temperature.—During the spawning period, the mean weekly temperature in Trinidad Creek increased from 11 to 15 °C (Figure 10). During summer baseflow, the mean weekly temperature stayed below 17 °C in all years. The MWMT occurred the first week in July during both 2006 (19.1 °C) and 2007 (18.3 °C). The MDWT was 19.8 °C on 5 and 6 July 2006 and 20.0 °C on 23 July 2007.

Discharge.—Discharge was not measured in 2005. During the spawning period, discharge measurements in Trinidad Creek ranged from 3.3 to 11.8 cfs. During baseflow, discharge measurements were 4.7 cfs on 16 August 2006 and 10.8 cfs on 9 September 2007. Trinidad Creek had the highest baseflow of any of the creeks included in this study during both years (Figures 3,4).

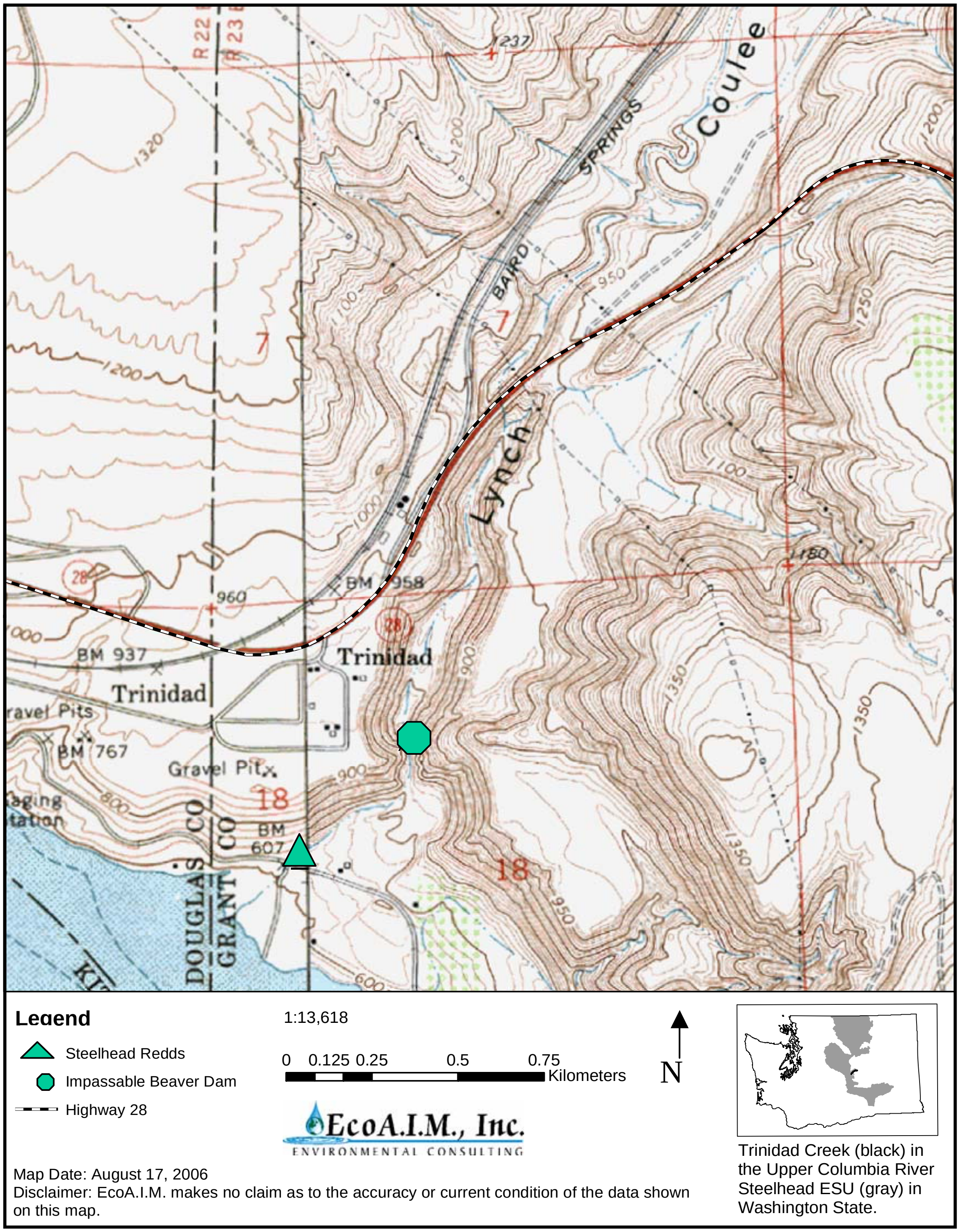

Figure 9. Map of Trinidad Creek, Grant County Washington, showing redd locations and the beginning of the series of impassable beaver dams in 2005.

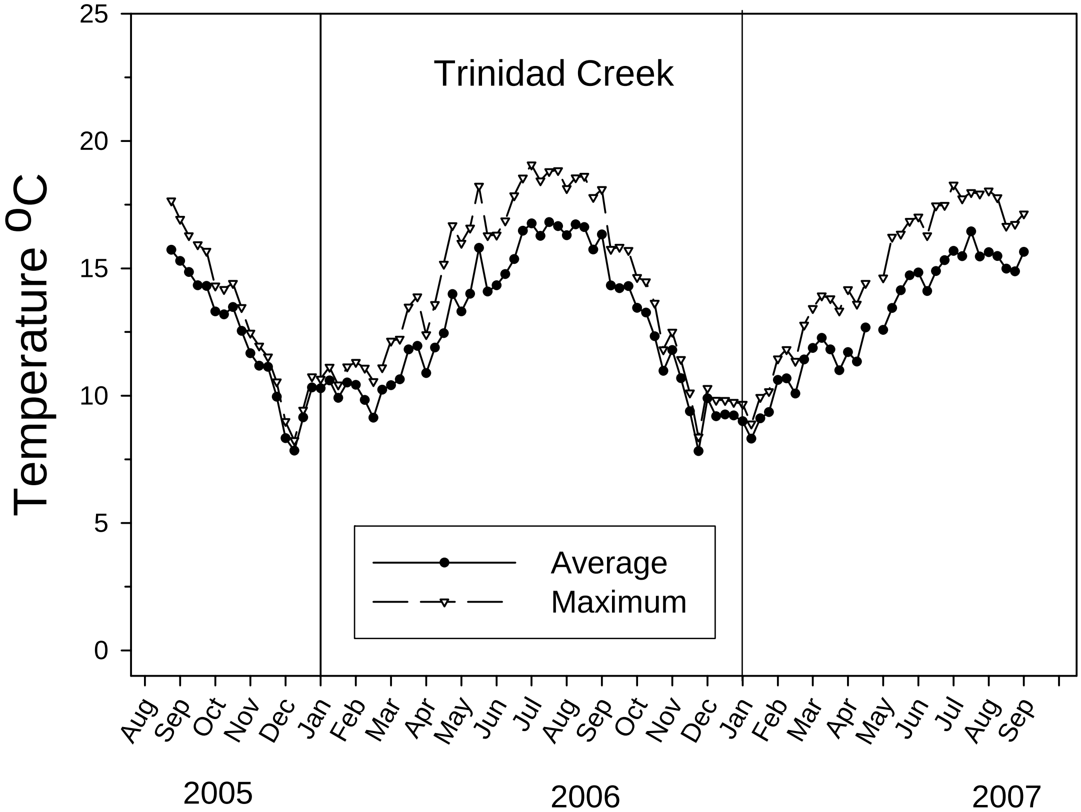

Figure 10. Mean weekly temperature and mean weekly maximum temperatures recorded at river kilometer 0.1 at one-hour intervals in Trinidad Creek (Lynch Coulee), Grant County, Washington.

Tekison Creek

Redd Surveys.— In 2005, Tekison Creek was visited in February and there was no flow throughout at least the lower 2 km of stream channel. The creek was not visited again until 19 April 2005, when again there was no flow at the mouth. No further site visits were conducted in 2005.

Tekison Creek was surveyed six times between 31 March and 2 May 2006 (Appendix A). Redd surveys covered the lower 5.2 km of Tekison Creek on each site visit. On 24 April 2006 a steelhead carcass was recovered in Tekison Creek. The carcass was suspected to be a male and was a hatchery fish based on a missing adipose fin. On 2 May 2006 an adipose present female was observed near the mouth of Tekison Creek. No redds or carcasses were observed on subsequent visits. In October 2006, juvenile Chinook were observed in a pool approximately 2 km up Tekison Creek when there was no flow at the mouth of Tekison Creek.

Tekison Creek was surveyed five times between 2 April and 7 May 2007. No redds, carcasses, or live adult fish were observed.

Temperature.—During the spawning period, the mean weekly temperature in Tekison Creek increased from 6 to 15 °C (Figure 11). During summer baseflow, Tekison Creek went dry, so we cannot report maximum temperatures because we cannot be certain exactly when water was present or absent on and around the probe as the stream was going dry.

Discharge.—Tekison Creek was dry in February and in April of 2005. In 2006 and 2007 discharge measurement were between 4-20 cfs during the spawning period (Tables 3,4). Tekison Creek went dry in all years. Based on temperature data, it appeared that Tekison Creek de-watered the second or third week in June 2006. Lower Tekison Creek was still dry in late October of 2006 but had relatively good flow by January 2007 (based on anecdotal observations). Tekison Creek was dry (near its mouth and at rkm 5.2) when checked on 5 September 2007 and, based on temperature data, may have dewatered as early as 28 May 2007 (Figure 11).

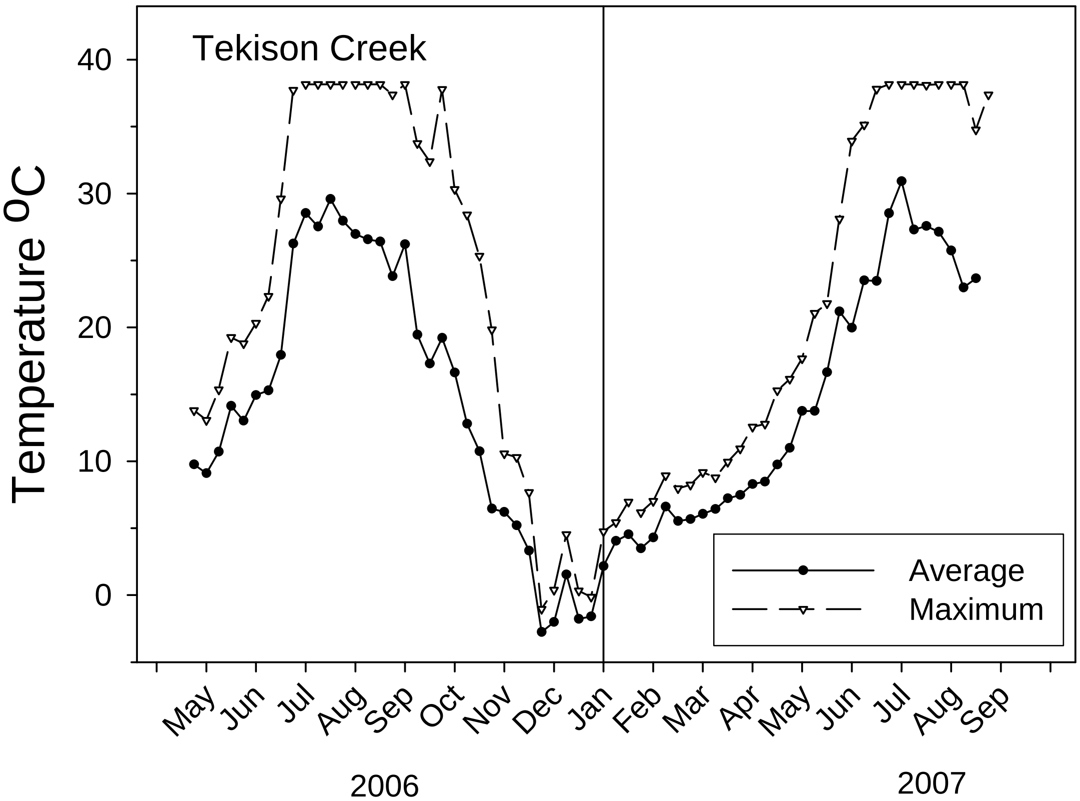

Figure 11. Mean weekly temperature and mean weekly maximum temperatures recorded at river kilometer 0.26 at one-hour intervals in Tekison Creek, Kittitas County Washington.

Quilomene Creek

Redd Surveys.— In April 2004, WDFW personnel documented two redds and three live steelhead in addition to two trout on a redd in Quilomene Creek. Although not part of this study, the survey data had not been published elsewhere so we thought it was important to include it in this report (Figure 12).

In 2005, Quilomene Creek was surveyed seven times in between 18 March and 12 May. Quilomene Creek was surveyed for approximately 6 km upstream of the confluence with the Columbia on each site visit. Three steelhead were observed at or near the mouth on two occasions (6 and 14 April 2005) and one was observed digging in lower Quilomene; however, subsequent visits revealed that no redd was developed.

The lower 2.25 km of Quilomene Creek was surveyed 6 times between 4 April and 8 May 2006. On 17 April 2006 a male with an intact adipose fin was observed approximately 1 km up Quilomene Creek. On 8 May 2006 a steelhead was observed in Quilomene Creek but gender and adipose fin clip could not be assessed. Field notes indicated that vegetation had overgrown much of the creek and stretches could not be surveyed.

The lower 3.25 km of Quilomene Creek was surveyed five times between 11 April and 8 May 2007. No redds, carcasses, or live adult fish were observed.

Temperature.—During the spawning period, the mean weekly temperature in Quilomene Creek increased from 5 to 11 °C (Figure 13). During summer baseflow the mean weekly temperature was below 20 °C during 2006 and 2007 at both sites (upstream and downstream of the Brushy Creek confluence (Figure 13). At the site downstream of the Brushy Creek confluence the MWMT was 28.1 °C the fourth week in August 2005 with a MDMT of 29.7 °C on 28 August 2005. Its not clear if that site went dry in 2005 or if some water was present and it was just not flowing. In 2006, the MWMT was 23.3 °C the first week in July with a MDMT of 25.4 °C on 5 July 2006. In 2007, the probe was lost at the downstream site so baseflow temperatures could not be reported. At the site 200 m upstream of the Brushy Creek confluence, the MWMT was 18.3 °C the fourth week in July with a MDMT of 19.4 °C on 24 and 25 July 2006. In 2007 the MWMT was 19.6 °C the second week in July with a MDMT of 20.8 °C on 11 July 2007.

Discharge.—Discharge was not measured in 2005. During the spawning period, discharge measurements of Quilomene Creek were 10.6 cfs on 31 March 2006 and 2.5 cfs on 22 May 2006 (Table 3). In 2007, discharge measurements were 19.9 cfs on 3 April 2007 to 1.7 cfs on 15 May 2007 (Table 4). During baseflow in 2006, water was present but shallow depths and low velocity prevented a measurement of discharge in Quilomene Creek. The discharge measurement on 29 August 2007 was 0.09 cfs. At rkm 6.1 the discharge of Quilomene Creek was 0.14 cfs

Quilomene Creek (4-9-04)

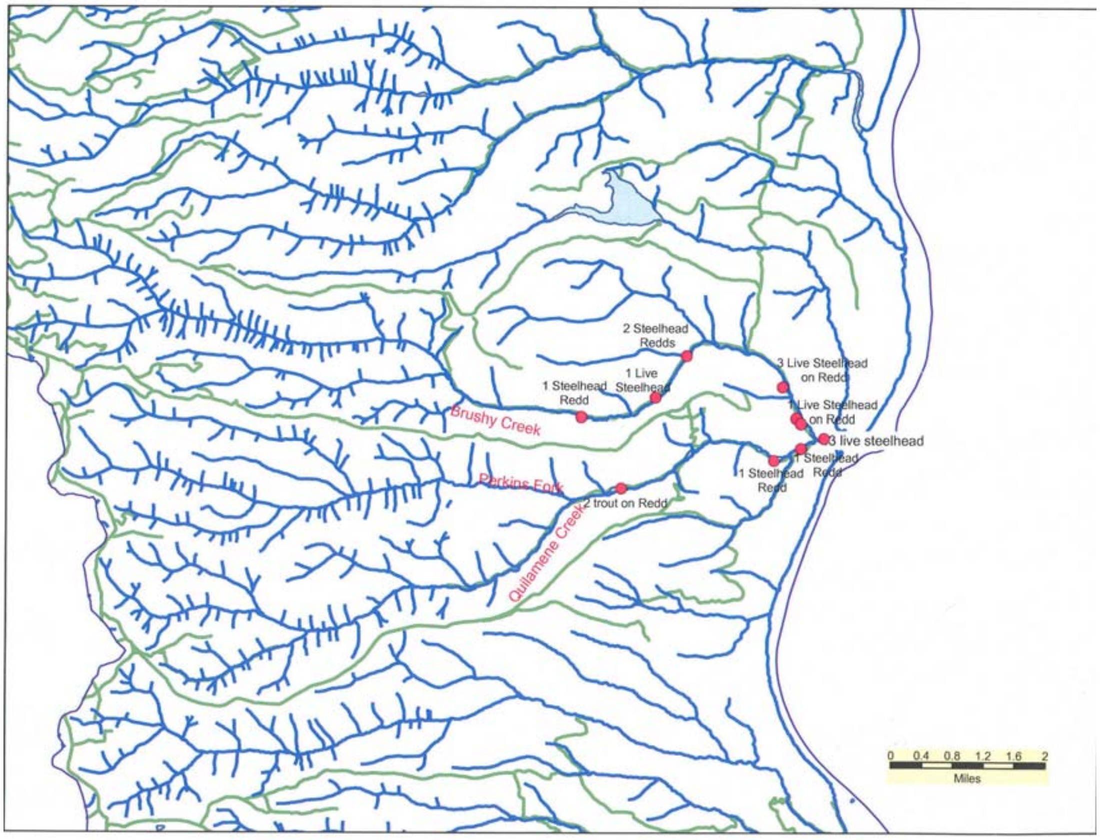

Figure 12. Map of Quilomene and Brushy Creeks, Washington, showing the locations of steelhead redds, surveyed by WDFW in 2004. Data and map courtesy of Alex Uber, Olympia, Washington.

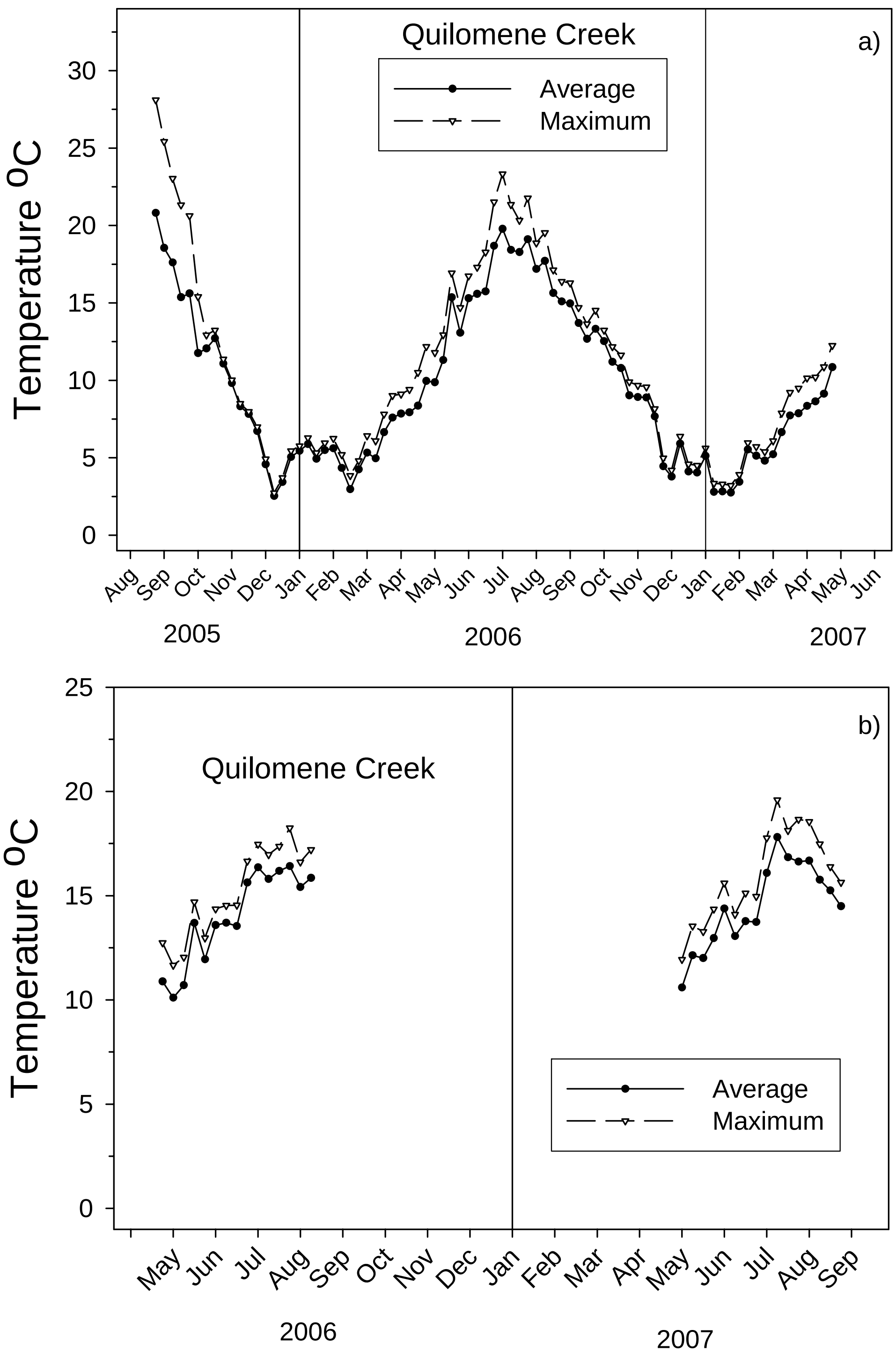

Figure 13. Mean weekly temperature and mean weekly maximum temperatures recorded in Quilomene Creek, Kittitas County, Washington. One site (a) was downstream of the Brushy Creek confluence at rkm 0.06 and the probe was lost sometime after the May 2007 upload. The other site (b) was 200 m above the Brushy Creek confluence and that probe had a data logging failure between 16 August 2006 and 1 May 2007.

Brushy Creek

Redd Surveys.— In April 2004, WDFW personnel documented five redds and five live steelhead in Brushy Creek (Figure 12). Although not part of this study, the survey data had not been published elsewhere so we thought it was important to include it in this report.

In 2005, Brushy Creek was surveyed seven times in between 18 March and 12 May. Brushy Creek was surveyed for approximately 6 km upstream of the confluence with the Columbia on each site visit. No redds, carcasses, or live adult fish were observed.

The lower 2.25 km of Brushy Creek was surveyed 6 times between 4 April and 8 May 2006. No redds, carcasses, or live adult fish were observed.

The lower 3.25 km of Brushy Creek was surveyed five times between 11 April and 8 May 2007. No redds, carcasses, or live adult fish were observed.

Temperature.— During the spawning period, the mean weekly temperature in Brushy Creek increased from 5 to 12 °C (Figure 14). During summer baseflow, Brushy Creek went dry, so we cannot report maximum temperatures. However, water was present in Brushy Creek at rkm 5.6 when monitored in 2007. The MWMT was 17.6 °C the second week in July with a MDMT of 18.3 °C on 23 July 2007.

Discharge.— Discharge was not measured in 2005. During the spawning period, discharge measurements of Brushy Creek ranged from 11.2 cfs on 31 March 2006 to 3.1 cfs on 22 May 2006 (Table 3). In 2007, discharge measurements were 36.2 cfs on 3 April 2007 and 1.2 cfs on 15 May 2007 (Table 4). Based on temperature data, it appeared that Brushy Creek completely de-watered by the fourth week in July 2006 and the second week in July 2007 (Figure 14). However, water was observed in Brushy Creek within approximately 0.5 km of its confluence on 29 August 2007. There was measurable flow (approximately 0.5 cfs) at the upper temperature probe site (rkm 5.6); however, no flow measurements were taken. Juvenile salmonids that appeared to be Chinook parr were also observed in a pool at rkm 5.6.

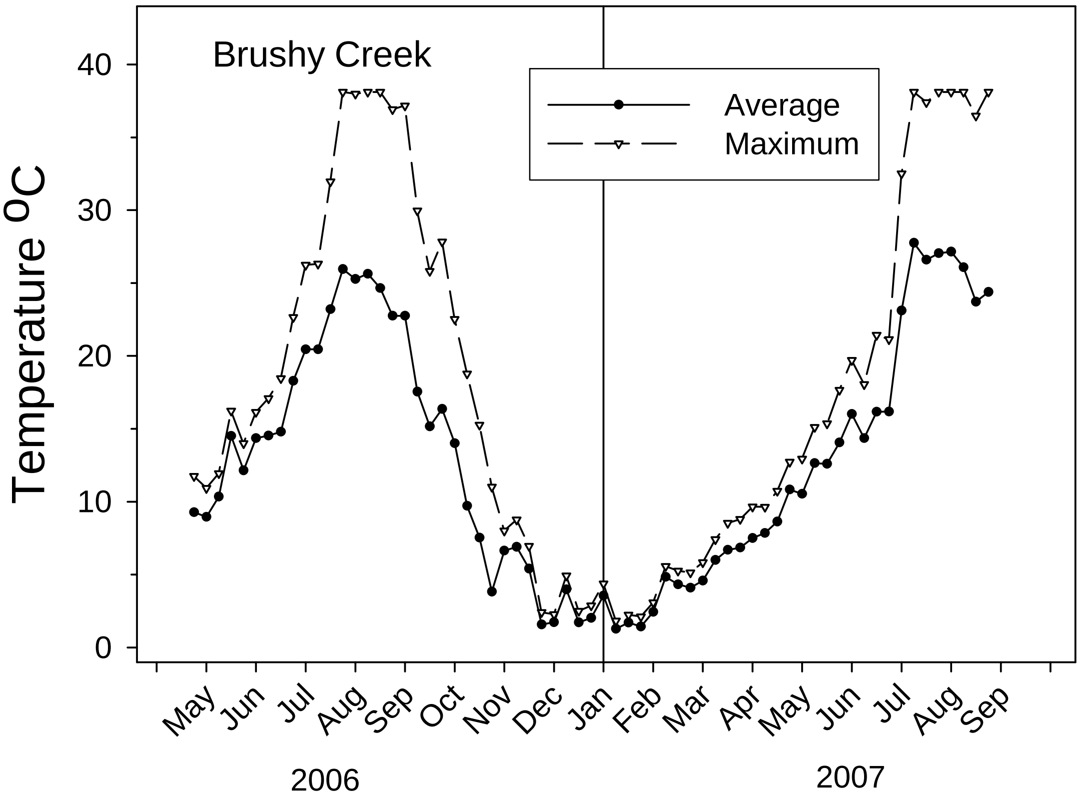

Figure 14. Mean weekly temperature and mean weekly maximum temperatures recorded at river kilometer 0.2 at one-hour intervals in Brushy Creek (a tributary to Quilomene Creek), Kittitas County, Washington.

Skookumchuck Creek

Redd Surveys.— Though not part of this study, WDFW Habitat Program personnel observed steelhead redds in Skookumchuck Creek in 2004, although numbers and locations were not documented (M. Teske, personal communication).

Skookumchuck Creek was surveyed four times between 18 March and 12 May 2005 (Appendix A). No redds, carcasses, or live adult fish were observed.

Skookumchuck Creek was surveyed five times between 31 March and 25 May 2006. Three live adult steelhead were observed in Skookumchuck Creek on 13 April 2006. The first was an adipose fin clipped (hatchery) female approximately 300 m from the confluence with the Columbia River. Two additional steelhead that appeared to be a male-female pair was observed at approximately rkm 1.0. On 21 April 2006, a pair of steelhead was seen in the lower 1.5 km of Skookumchuck Creek. On 5 May 2006, a pair of steelhead were observed between rkm 1.5 to 3.0. On 25 May 2006, a single steelhead was observed at approximately rkm 3.25. No redds were observed in Skookumchuck Creek during 2006; however, the density of the riparian vegetation was high and much of the stream was inaccessible.

Skookumchuck Creek was surveyed five times between 2 April and 7 May 2007. No redds, carcasses, or live adult fish were observed.

Temperature.—A temperature probe was initially deployed in April of 2006; however, that probe failed to upload its data and a replacement probe could not be re-deployed until May 2007. Temperature measurements with a handheld thermometer indicated that the temperature in Skookumchuck Creek was 10-11 °C between 16 March and 20 April 2005 and increased from 7 to 14 °C between 31 March and 25 May 2006. During baseflow 2007, the mean daily temperature did not exceed 17 °C (Figure 15). In 2007, the MWMT was 18.4 °C the second week in July. The MDMT occurred on 11 July 2007 and was 19.0 °C. The upstream temperature logger (rkm 5.8) revealed warmer water temperatures with a MWMT of 24.9 °C the first week in July and a MDMT of 26.8 °C on 5 July 2007.

Discharge.—Discharge was not measured in 2005. During the spawning period, discharge measurements of Skookumchuck Creek were 2.7 cfs on 31 March 2006 and 1.1 cfs on 22 May 2006 (Table 3). In 2007, discharge measurements were 1.9 cfs on 2 April 2007 and 0.8 cfs on 14 May 2007 (Table 4). During baseflow, discharge was measured at 1.0 cfs on 16 August 2006 and 0.31 on 2 September 2007. At rkm 5.8, discharge was only 0.05 cfs on 2 September 2007 and the creek was observed to go dry in several places between rkm 3 and 5.8

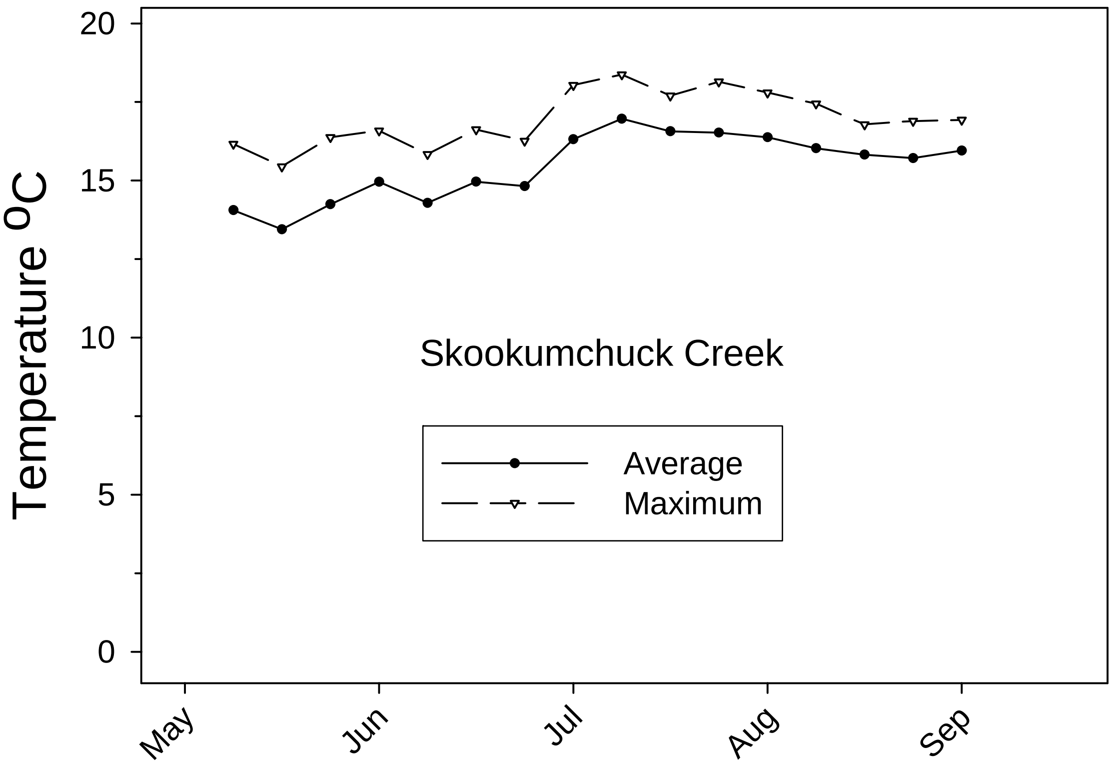

Figure 15. Mean weekly temperature and mean weekly maximum temperatures recorded at river kilometer 0.05 at one-hour intervals in Skookumchuck Creek, Kittitas County, Washington in 2007.

Whiskey Dick Creek

Redd Surveys.—Whiskey Dick Creek was evaluated on 18 and 23 March 2005. Low flows and beaver activity in a wet meadow appeared to restrict access by adult steelhead. The creek was approximately 0.5 m wide at the confluence with the Columbia and within 50 m there was a beaver dam with no pool below it. Above the beaver dam it was mostly a wet meadow and where the channel did reform (100 m upstream) there was a 100 m stretch that was choked with watercress and less than 10 cm deep. Due to these physical limitations, Whiskey Dick Creek was not surveyed for redds on subsequent dates. Although not part of this study, two hatchery steelhead (adipose absent) were observed near the mouth of Whiskey Dick Creek below the beaver dams on 22 April 2004 (Alex Uber, personal communication).

Temperature.—A temperature logger was installed above the wet meadow/beaver complex (rkm 0.37) on 25 April 2006. Whiskey Dick Creek remained relatively cool throughout the summer rearing period with a MWMT of 17.3 °C the last week in July 2007 and 16.8 °C the second week in July 2007 (Figure 16).

Discharge.—Discharge in Whiskey Dick Creek was between 0.7 and 2.5 cfs on the days it was measured during the spring of 2006 and 2007 (Tables 3,4). Discharge measurements during base flow were very low in both years, with low flow and macrophytes preventing measurements in 2006 and only 0.05 cfs in 2007.

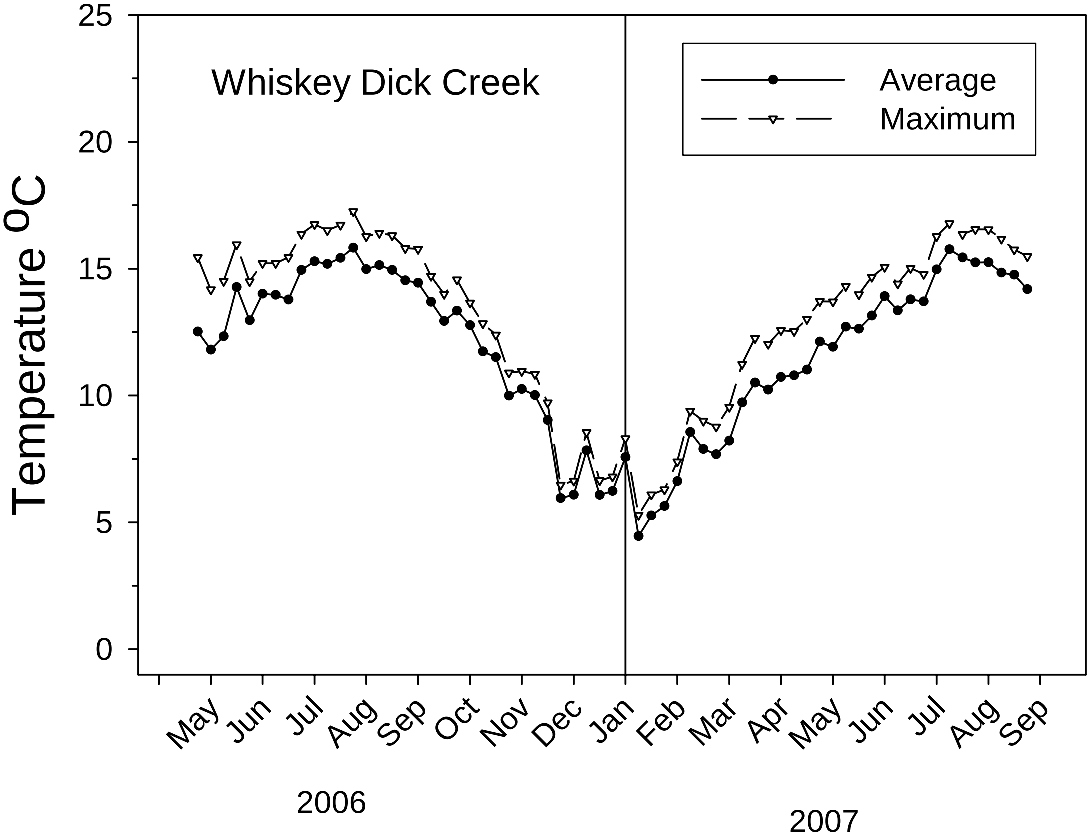

Figure 16. Mean weekly temperature and mean weekly maximum temperatures recorded at river kilometer 0.37 at one-hour intervals in Whiskey Dick Creek, Kittitas County Washington.

Johnson Creek

Redd Surveys.— Johnson Creek was surveyed six times between 16 March and 3 May 2005. On 16 March 2005, Johnson Creek was only 0.5 m wide and 2.5 cm deep within 200 m of the confluence with the Columbia. One adipose clipped steelhead was observed in the cove on 16 March 2005. On 28 April 2005, another adipose clipped steelhead was observed approximately 50 m upstream of the confluence with the Columbia. This fish was in very bad condition, but no redd was located and the carcass was not recovered on the subsequent trip.

Johnson Creek was surveyed three times between 6 April and 26 April 2006. No redds, carcasses, or live adult fish were observed.

Johnson Creek was not surveyed in 2007 based on funding limitations and because the creek went dry within 300 m of the Columbia River Confluence in 2005 and 2006 with little to no spawning potential in that stretch.

Temperature.—No temperature loggers were deployed in Johnson Creek. Manual temperatures were taken with a thermometer during site visits in 2005 and 2006. In 2005, temperature increased from 11 °C in late March to 14 °C in early May. Similarly, the temperature in Johnson Creek in April of 2006 was 11-13 °C.

Discharge.—Discharge was not measured in 2005 or 2007. Discharge was measured at 0.5 cfs on 6 April 2006 (Table 3). Visual observations indicated that Johnson Creek went dry within 300 m of the Columbia River confluence in 2005 and 2006.

Sand Hollow

Sand Hollow was not surveyed by WDFW as part of this study. The Bureau of Reclamation has been conducting steelhead surveys in Sand Hollow wasteway over the last several years (W. Larrick, personal communication). Therefore, we did not want to duplicate efforts. Spawning steelhead were observed in Sand Hollow during USBR surveys between 2002 and 2004 (USBR 2005).

Discussion

This study represents the first known attempt to formally survey this group of streams for spawning anadromous salmonids. A limited number of redds, carcasses, and adult steelhead were observed in these streams with no consistent productive reaches being discovered. Low flow conditions appeared to interact with geomorphic conditions, beaver activity, barriers and reservoir elevation to restrict access to some creeks (Rock Island, Tekison, Whiskey Dick, Johnson, Trinidad, Colockum, Swakane).

Even with limited spawning use, juvenile salmonids are known to rear in all of these Creeks (Pfeifer et al. 2001; R2 Resource Consultants 2004; WDFW unpublished data). Additional anecdotal information exists regarding the presence of juvenile salmonids, apparently including Chinook, in Brushy Creek and Tekison Creek (Alex Uber, personal communication). The temperature and flow data collected in this study shows that there is perennial rearing habitat available in virtually all of the creeks. Even those that go dry in stretches had isolated pools that were supporting juvenile salmonids. Late summer temperature ranges were generally above the optimum for Chinook (12-16 °C)(reviewed by Richter and Kolmes 2005), with MWMT generally well below lethal levels (> 22 °C) in the streams or stream reaches that did not go dry. Temperatures observed in this study were well within the preferred range for steelhead egg incubation as reviewed by Richter and Kolmes (2005). Mean Weekly Maximum Temperatures did exceed the optimal for growth of juvenile steelhead (15-19 °C, as reviewed by Richter and Kolmes 2005) in some creeks. However, in creeks that did not go dry, temperatures did not exceed levels that would inhibit all growth or cause direct mortality (Richter and Kolmes 2005).

The discharge measurements recorded in this study were not measured often enough to serve as a comprehensive evaluation of seasonal flow patterns. It was beyond the scope of this study to establish a gauge-discharge relationship and monitor discharge on a more consistent basis. Rather, our intention was to begin to document how much flow was present near the beginning and ending of the steelhead-spawning period and during baseflow. Obviously, the timing of snowmelt and spring rains influenced the magnitudes of the measurements during the spawning period. Likewise, the summer baseflow measurements were dependent on variables including irrigation and annual precipitation patterns. Stemilt and Squilchuck Creek drainages have storage reservoirs and their summer discharge is probably tied closely to return flow from the irrigation system.

Although there were water withdrawals in many of the creeks, none of them seemed to be a substantial influence on the quantity of water present during baseflow. Excluding Stemilt and Squilchuck Creeks, Colockum Creek appeared to have the highest number of local water users, however, in 2007 there was a similar amount of discharge near the mouth of Colockum Creek as there was at rkm 12.

Our data indicated that some creeks had relatively flashy spring runoff patterns and tended to go dry near their mouths such as Brushy, Tekison, and Tarpiscan Creeks. Other creeks (Swakane, Skookumchuck, Whiskey Dick) had relatively low flows in the spring but retained some flow during late summer. Trinidad Creek was the exception with moderate but consistent flows. Trinidad Creek appeared to be strongly influenced by groundwater recharge based on the patterns observed in the temperature and discharge data.

Presumably, some of the juveniles rearing in the creeks are from upstream production areas such as the Wenatchee, Entiat, Methow, or Okanogan Rivers. Therefore, the creeks would act as rearing areas for fry or parr that did not remain in their natal production area due to high water events, competition for limited space, or genetic predisposition for migratory rearing.

With a better understanding of current and potential fish use in these small tributaries the Upper Columbia resource management agencies / technical teams can make informed decisions regarding the most appropriate way to incorporate these streams into the larger scheme of monitoring, habitat protection, and habitat restoration. The NWFSC, in conjunction with the Upper Columbia Regional Technical Team, implemented the Intensively Monitored Watershed Project in the Wenatchee Basin. This project was designed to add to the spatial and temporal intensity of ongoing sampling using a probabilistic sampling design that added statistical robustness (Hillman 2006). However, this project did not include small tributaries outside the Wenatchee Subbasin, even though steelhead in these tributaries were considered part of the Wenatchee population by the ICTRT (ICTRT 2007). Data gaps for current distribution and habitat suitability were the primary justification for not including the UMM tributaries in the sampling universe for the IMW project (M. Ward, personal communication). Data from multiple years of surveys in these creeks is now available and should help determine how to incorporate these streams within the sampling design for the Wenatchee steelhead population. Specifically, the Upper Columbia managers and researchers can determine whether or not to establish one or more index reaches in these creeks and if / how much of these streams to include in the probabilistic sampling design for evaluating the abundance and spatial structure of the Wenatchee summer steelhead population.

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Appendix A. Redd survey Dates

Table A 1. Redd survey dates for 2005.

Date 2005	Swakane[1]	Squilchuck	Stemilt	Colockum	Tarpiscan	NF-Tarpiscan	SF-Tarpiscan	Trinidad	Tekison[2]	Quilomene	Brushy	Skookumchuck	Whiskey Dick	Johnson
14-Mar		x						x						
15-Mar					x	x	x							
16-Mar														x
18-Mar										x	x	x	x	
21-Mar		x						x						
22-Mar					x	x	x							
23-Mar										x	x		x	
24-Mar														x
28-Mar		x						x						
29-Mar					x	x	x							
30-Mar										x	x			
31-Mar														x
4-Apr		x						x						
5-Apr					x	x	x			x	x			
7-Apr														x
11-Apr		x						x						
12-Apr					x	x	x							
14-Apr										x	x	x		
18-Apr		x			x	x	x	x						
19-Apr														
20-Apr										x	x	x		
25-Apr		x						x						
26-Apr					x	x	x							
28-Apr														x
3-May														x
9-May		x			x	x	x							
12-May										x	x	x		
16-May		x												

[1] Swakane Creek was not surveyed for redds due to extremely low flows preventing access.

[2] Tekison Creek was checked in February and April and had no flow so it was not surveyed for redds.

Table A 2. Redd survey dates for 2006.

Date 2006	Swakane	Squilchuck	Stemilt	Colockum	Tarpiscan	NF-Tarpiscan	SF-Tarpiscan	Trinidad	Tekison	Quilomene	Brushy	Skookumchuck	Whiskey Dick	Johnson
22-Mar								x						
23-Mar				x										
27-Mar					x	x	x							
29-Mar								x						
30-Mar		x	x	x										
31-Mar									x			x	x	
03-Apr					x	x	x							
04-Apr									x	x	x			
05-Apr		x	x	x										
06-Apr	x							x						x
10-Apr									x	x	x			
11-Apr					x	x	x							
12-Apr		x	x	x										
13-Apr								x				x		
17-Apr									x	x	x			
18-Apr					x	x	x							
19-Apr		x	x	x										x
20-Apr								x						
21-Apr												x		
24-Apr									x	x	x		x	
25-Apr					x	x	x							
26-Apr	x	x	x					x						x
27-Apr			x											
02-May									x	x	x			
03-May		x	x											
04-May				x	x	x	x							
05-May								x				x		
08-May										x	x			
09-May					x	x	x							
10-May	x	x	x	x										
11-May								x						
15-May					x									
16-May		x	x	x										
17-May								x						
18-May					x									
22-May													x	
23-May						x	x							
25-May												x		

Table A 3. Redd survey dates for 2007.

Date 2007	Swakane	Squilchuck	Stemilt	Colockum	Tarpiscan	NF-Tarpiscan	SF-Tarpiscan	Trinidad	Tekison	Quilomene	Brushy	Skookumchuck	Whiskey Dick[1]	Johnson[2]
30-Mar		x												
02-Apr									x			x		
03-Apr								x						
05-Apr		x	x	x										
09-Apr								x	x					
10-Apr					x	x	x							
11-Apr										x	x	x		
12-Apr		x	x	x										
16-Apr									x	x				
17-Apr										x	x			
18-Apr					x	x	x							
19-Apr		x	x	x				x						
23-Apr		x	x					x						
24-Apr					x									
26-Apr						x	x							
27-Apr												x		
30-Apr									x			x		
01-May								x		x	x			
02-May					x	x	x							
03-May		x	x[3]	x[3]										
07-May									x			x		
08-May								x		x	x			
09-May					x	x	x							
10-May		x	x	x										

[1] Whiskey Dick Creek was not surveyed in 2007 based on inadequate access through a wet meadow / beaver dam complex at the confluence with the Columbia River.

[2] Johnson Creek was not surveyed in 2007 based on funding limitations and because the Creek went dry within 300 m of the Columbia River confluence in 2005 and 2006 with little to no spawning potential in the lower 300 m.

[3] The Creek was visited that day, but high flows and turbid water prevented spawning ground surveys.