Salmonberry River Temperature Monitoring 1994-2008

A STEP Project

Spawning Steelhead, Main Stem Salmonberry River

Abstract: This is an update of a previously published paper, adding data from summer 2008 and presenting data in different formats. Water temperature loggers were placed at 10 sites in the summers of 1994-1997, 2004, 2007, and 2008. Significant temperature increases were recorded in 1996 and 1997, following the 1996 flood. 2004-2007 levels were closer to 1994-95. 2008 levels were elevated again, following the flood and debris torrents of December 2007. The lowest mainstem site exceeded the EPA "Core Juvenile Rearing Standard" for long periods (23 to 50 days) every year from 1994-1997. No data exist for this site in 2004/2007. The site registered 34 days above the standard in 2008. Four other sites exceeded the EPA standard for 5-16 days in 1996/97. None of those sites exceeded the standard in 2004/2007, and one of them (mainstem below North Fork) registered 2 days in excess of the EPA core standard in 2008. In general, water temperatures in summer 2008 were lower than 1996/1997, but higher than any other years. This should not be interpreted to mean that the 2007 flood caused less watershed damage. It is more likely that relatively cool weather helped keep water temperatures down in 2008.

Prepared By Ian Fergusson

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1. Introduction

A previous paper, "Salmonberry River Temperature Monitoring 1994 -2007" provides the project background. PDF versions of that paper, and this one, can be requested from the author at ian.fergusson@comcast.net or from Joyce Sherman at rivergraphics@spiritone.com .

This paper presents data for all years, although the presentation format is different. Previously each site was displayed individually. In this paper the sites are aggregated into 1st/2nd order reaches, 3rd order reaches, and 4th order reaches, and the temperatures averaged by stream order. This allows for a clearer picture of overall watershed temperatures from year to year.

For purposes of reporting against the EPA/DEQ Core Juvenile Rearing Standard, temperatures are not averaged by stream order. Each site is evaluated separately; a violation at any site counts as a violation.

The Salmonberry River is known for its run of wild winter steelhead, regarded as one of the healthiest runs on the West Coast. The South Fork of the Salmonberry has been designated as salmon "Anchor Habitat". Relatively healthy watersheds like the Salmonberry are critical to long-term survival of salmonids, and ongoing monitoring is essential.

During the period we have been monitoring Salmonberry temperatures, two major weather events have reshaped the landscape. In February 1996 a severe rain-on-snow event occurred. Of the monitored sites, Wolf Creek and Kinney Creek suffered major debris flows that removed miles of riparian vegetation. By contrast, Pennoyer Creek, the North Fork, and the South Fork suffered relatively little damage. Other tributaries that are not monitored, notably Tunnel Creek and Bathtub Creek, also suffered major debris torrents. The main stem was channelized. The Port of Tillamook Bay Railroad was severely damaged; repairs required about $12 million.

In December of 2007 a severe rain event occurred. Most of the tributaries that were scoured by debris flows in 1996 were scoured again. In addition, the South Fork was damaged, as was the lowest mile of the North Fork. The main stem was much channelized, and deep pools were filled in. Although habitat surveys are needed to confirm the extent of damage, observers who have seen the results of both events agree that the 2007 flood was worse. The POTB Railroad was nearly demolished; repairs are estimated to approach $30 million.

2. Methodology

General methodology was described in the previous paper.

We suggested in the previous paper that the project team should have the ability to launch the data loggers and retrieve data, and retain control over the loggers rather than asking an overworked field office to scrape them together each year. The STEP Biologist in the Tillamook Office, Tracy Crews, responded admirably by purchasing 10 NexSens® temperature loggers, plus the software and USB reader, and delivering them to the project team for the 2008 season and beyond.

Previously ODFW provided Onset Hobo® temperature loggers. The Hobo® monitors have a resolution of .1° C. Accuracy is unknown, but is probably in the neighborhood of ±0.5° C. The NexSens® model 1921G loggers have a resolution of 0.5® C and are accurate to ±1° C. In a monitoring project of this sort, where the primary objective is to monitor against a standard that uses a seven day moving average of daily high temperature, the differences in resolution and accuracy will not make any difference in results.

In 2008 the project was awarded a STAC mini-grant, and we purchased 10 additional NexSens® model 1921G loggers. They arrived too late to be used in the summer of 2008, but will be deployed at additional sites beginning in 2009. See “3. Locations” for a discussion of probable new sites.

3. Locations

Four main stem sites and six tributary sites are monitored. Each one is assigned a stream order designation, and results are grouped by stream order.

“Stream Order” is a system of classifying streams according to a hierarchy of tributaries. Stream order is usually determined with the aid of USGS 1:24,000 topographic maps. The smallest tributaries are 1st order. (In the system we use, intermittent streams are ignored, so a stream with no permanent tributaries is 1st order; however, some scientists also consider intermittent streams when determining stream order.) Where two 1st order streams combine, the result is a 2nd order stream. No matter how many other 1st order streams enter after that point, the stream remains 2nd order until it is joined by another 2nd order stream, at which point it becomes 3rd order, and so on. In the Salmonberry, we find most steelhead spawning taking place in 3rd and 4th order reaches. There are no 5th order reaches. The sites monitored are:

1. Main stem above Pennoyer Cr., river mile (RM) 13.9, 2nd order. Steelhead redds have been observed in this stretch. There is a falls about 0.5 miles above this point, which presumably marks the upper limit of steelhead spawning.

2. Pennoyer Cr., RM 13.9, 1st order. This is a small tributary with a barrier falls a short distance above its mouth. Occasional steelhead redds have been observed below the falls. Resident cutthroat trout are found above the falls.

3. Wolf Cr., RM 12.4, 3rd order. This is the third largest tributary of the Salmonberry, behind the North and South Forks. Although Wolf Creek is not regularly surveyed, ad-hoc surveys have noted considerable steelhead spawning activity, with redds observed as far as 2 miles upstream from the mouth. Wolf Creek was scoured by a massive debris flow in 1996 that began near the top of a ridge separating Wolf and Kinney Creeks, and travelled more than 3 miles along the entire length of Wolf Creek. Debris flows of a similar magnitude, apparently with multiple origins, also occurred in December 2007.

4. Main stem below Wolf Cr., RM 11.7, 3rd order. The site is within the area known as “Wolf Creek Flats” and is part of a standard steelhead spawning survey. This stretch typically has high numbers of steelhead redds and marks the upper limit of Chinook spawning activity. This was significantly altered in both the 1996 and 2007 floods, primarily by the deposition of material from Wolf Creek.

5. Kinney Cr., RM 10.9, 2nd order. A small tributary, not regularly surveyed for spawners. On occasion steelhead redds have been observed in lower Kinney Cr. Much of Kinney Creek was scoured by debris flows in the 1996 floods, and again in 2007.

6. North Fork, RM 8.3, 3rd order. The North Fork has a very large spawning run of steelhead. The Salmonberry's signature fish are the ones that ascend the daunting North Fork falls in April and go on to spawn well up the North Fork. Spawning Chinook have been observed in the lower North Fork (below the falls). Resident cutthroat trout occur above the falls, and resident rainbow trout are found in the headwaters. Steelhead redds have been documented 5 miles above the falls. This tributary was relatively unaffected in 1996; in December 2007 the lowest mile appeared to have been damaged by repeated damming/flooding events. The falls, about 300 yards upstream from the main stem Salmonberry, was filled in with gravel and is little more than a speed bump at this time. Above RM 1 on the North Fork, damage is considerably less.

7. Main stem below North Fork, RM 8, 4th order. This is within the "Enright" spawning survey reach, which has been surveyed by ODFW since the 1960's. Steelhead and Chinook salmon spawn within this reach.

8. South Fork, RM 6.7, 3rd order. The South Fork has a spawning run of steelhead, as well as cutthroat trout. The South Fork was designated as salmon "Anchor Habitat" under a 2003 agreement involving ODFW, Oregon Department of Forestry, and Oregon Trout. The volunteer team regularly surveys the South Fork to document steelhead spawning activity. Steelhead redds have been documented not only in the main South Fork, but also in its main tributary, Ripple Creek, and in the upper South Fork up to 0.5 miles above Ripple Creek. The South Fork escaped damage in 1996 but was heavily affected in 2007.

9. Belfort Creek, RM 3.1, 2nd order. This is a small tributary, too small for steelhead spawning, but may support cutthroat trout or other fish species.

10. Main stem below Belfort Cr., RM 3, 4th order. Both steelhead and chinook spawn in this area.

Totals:

1st/2nd order-4 sites

3rd order-4 sites

4th order-2 sites

We do not have complete data for each site for each year. Over the course of the project, 4 monitors have been lost. Occasional battery failures occurred. Some data are missing for unknown reasons. All data from the 4 sites monitored in 1993 are unusable, as the launching process tagged the beginning dates as 1/1/1980. Since the begin date represents the date the device was turned on in the ODFW office (date unknown), and field notes relating to placement and retrieval dates were lost, there is no way to associate the 1993 temperatures with exact dates.

In 2004, 3 monitors recorded temperatures so high relative to other sites and other years that the data are suspect and were not included in the analysis. The likely explanation is that they were placed in areas where the water went substantially underground, and the monitors were exposed to air temperatures.

This inconsistency of data from year to year is one reason we wanted to increase the number of sites monitored. For example, in 2004 and 2007 we have no data on the lower 8 miles of the main stem. By aggregating the data using the stream order classification, and adding sites, we hope to minimize the effects of occasional missing data.

The following table summarizes data availability for each location by year.

Table 1. Monitor Locations

Location	1993	1994	1995	1996	1997	2004	2007	2008
Mainstem above Pennoyer	missing	data	data	data	data	suspect	data	data
MS below Wolf Cr	missing	data	data	data	data	missing	data	data
MS below North Fk	missing	data	data	data	data	missing	data	data
MS below Belfort	missing	data	data	data	data	missing	missing	data
Pennoyer Cr	missing	data	data	data	data	data	data	data
Wolf Cr	missing	data	data	data	data	data	missing	data
Kinney Cr	missing	data	data	missing	data	suspect	data	data
North Fork	missing	data	data	data	data	data	lost	data
South Fork	missing	data	data	data	lost	suspect	data	data
Belfort Cr	missing	data	data	missing	data	lost	data	data

"data"=useable data present

"missing"=no data due to battery failure, monitor not placed, or other reason

"lost"=monitor not found (4 occurrences)

"suspect"=data present but not believable due to probable stream dewatering

Proposed new sites:

This is still in the planning stage, but at this point it looks as if we will add two sites on the lower main stem: one below the South Fork, and one downstream from the current lowest site (Below Belfort Cr.). This will provide a total of four sites on the eight miles of the main stem below the North Fork, all 4th order. Since violations of the EPA/DEQ “Core Juvenile Rearing Standard” (see Sections 4 and 5) have occurred most often at the lowest main stem site, this will help determine the extent of the affected area.

A main stem site (3rd order) will be added just above the North Fork confluence. This will provide a total of 3 sites on the main stem in the six miles above the North Fork. This site, along with the North Fork site and the main stem site just below the North Fork, will also allow direct evaluation of the influence of the North Fork on overall main stem temperatures.

Some authorities recommend redundant sites as a way of helping to validate data. Another reason for redundancy is to provide backup at critical sites. The North Fork and South Fork would both be good candidates for redundant sites.

It is likely that we will assign two loggers to record air temperatures. One of the difficulties in evaluating temperature trends is separating out the effects of physical changes in the watershed from the effects of annual weather variations. For example, we recorded generally lower temperatures in 2008 than we did in 1996/1997. Was this because 2008 was a cooler summer than 1996 and 1997, or was it because the flood damage that would have affected temperatures was actually less in 2008? A subjective impression at this point is that the summer of 2008 was relatively cool, but it will take examination of data from neighboring weather stations to determine if that is the case. Having air temperature data from sites within the watershed will make it easier to answer these sorts of questions.

4. Objectives and Criteria

The primary reasons for gathering temperature data are to determine if summer water temperatures meet the requirements of anadromous fish, and whether any discernible temperature trends exist.

We use the EPA "Core Juvenile Rearing" standard (16° C), which is defined as the upper limit of acceptable temperatures for core juvenile salmonid rearing habitat (except for bull trout). The Oregon Department of Environmental Quality has adopted this standard as well. The pertinent wording in the Oregon Administrative Rules (340-041-0028) is "The seven-day-average maximum temperature of a stream identified as having core cold water habitat use…may not exceed 16.0 degrees Celsius (60.8 degrees Fahrenheit)." The Salmonberry is among the streams identified by Oregon DEQ as having core cold-water habitat. The designation applies to the entire length of the river.

The seven-day moving average of the daily maximum temperatures (abbreviated 7DADM) helps avoid the results being unduly affected by the maximum temperature of a single day. The 7DADM reflects an average of maximum temperatures that fish are exposed to over a week-long period. It is calculated on a daily basis. The 7DADM for any given day can be calculated on the basis of the last seven days, or it can be calculated at the midpoint (i.e., the average of the seven days beginning three days before and ending 3 days after the reporting date). In a personal email communication, Joel Salter, Oregon Water Programs Coordinator, stated that "DEQ has not been consistent in the past but the Temperature Water Quality Standard Implementation (DEQ 2008) directs us to report the average on the 7th day." All numbers relative to the EPA/DEQ standards in this paper are based on the average as of the 7th day.

5. Results Relative to EPA "Core Juvenile Rearing" Standard

Table 3 summarizes the number of days the Core Juvenile Rearing Standard was exceeded, and as an additional reference, also shows the number of days the Migration and Non-Core Rearing Standard (18° C) was exceeded.

The temperatures recorded in 2008 were not as extreme as those recorded in 1996 and 1997…fewer days in total exceeded the core standard, and fewer days exceed the less stringent non-core standard. The only violations in 2008 were in 4th order reaches.

Days Exceeding EPA Core Rearing Standard (16 C; 60.8 F)					
	Stream Type			Totals	
Year	1st/2nd Order	3rd Order	4th Order	Days	Site-Days
1994	0	0	29	29	29
1995	0	0	24	24	24
1996	0	13	53	53	87
1997	14	16	50	50	87
2004	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	34	34	36

Days Exceeding EPA Migration and Non-Core Rearing Standard (18 C; 64.4 F)					
	Stream Type			Totals	
Year	1st/2nd Order	3rd Order	4th Order	Days	Site-Days
1994	0	0	0	0	0
1995	0	0	0	0	0
1996	0	0	17	17	17
1997	0	0	15	15	15
2004	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	1	1	1

Counts shown under Stream Type and the first total are unique days: a calendar day counts as 1 day no matter how many sites exceed the standard on that day.

Site-Days: if X sites exceed the standard on a day, that day counts as X site-days

In 2004 and 2007, there were no data from lowest mainstem site, the main core standard violator in prior years.
In 2004, data from 3 sites were not useable because of stream dewatering at the sites.

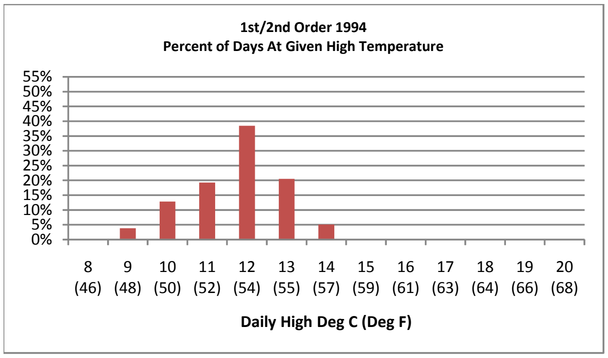
6. Summer Temperature Distribution

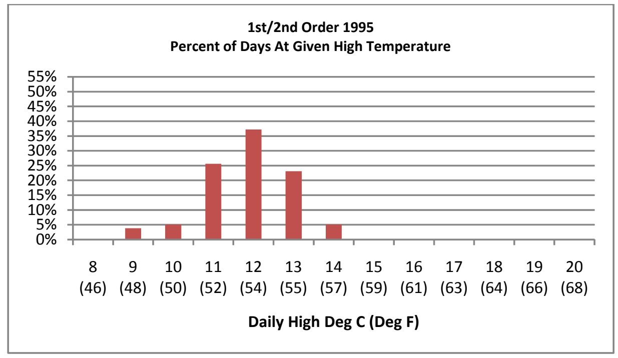
The following histograms show the percentage of days attaining a given high temperature (temperatures are rounded to nearest whole number) from June 15 through August 31 of each year. This time period was chosen to allow for varying placement/retrieval dates over the years and still provide consistent year to year comparison.

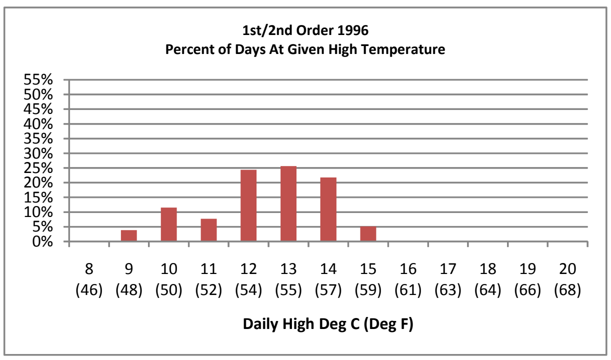
For easier comparison, all histograms have been adjusted so the horizontal and vertical axes match from chart to chart, and each stream order grouping is presented on one page.

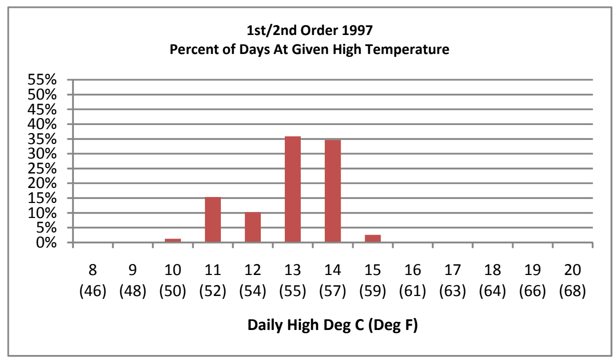
1994 and 1995 serve as the baseline years for comparison. At that time, the watershed was relatively intact. This was prior to the flood of February 1996, and although harvest of the trees regenerated after the “Tillamook Burn” had begun, it was not yet widespread.

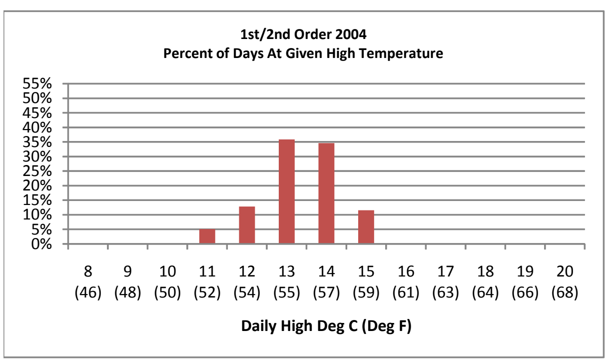
1st/2nd Order Reaches:

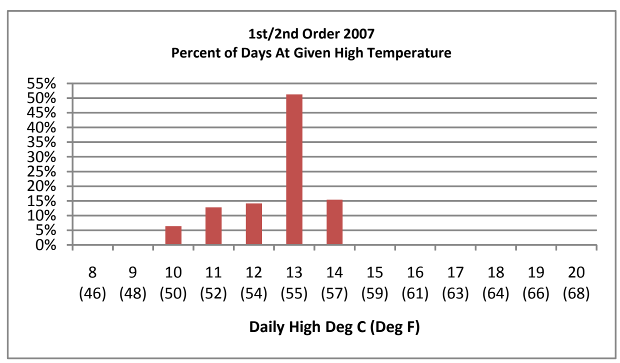


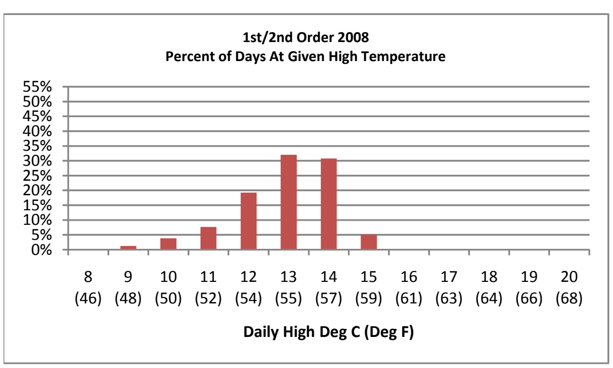




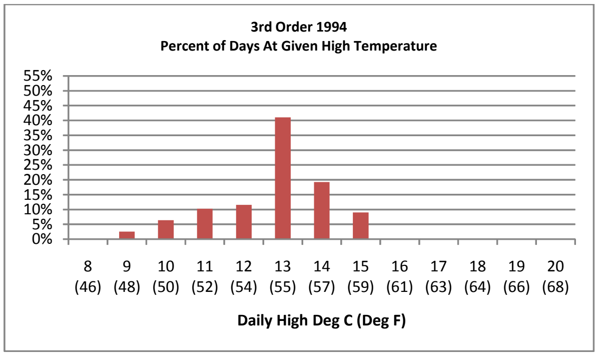


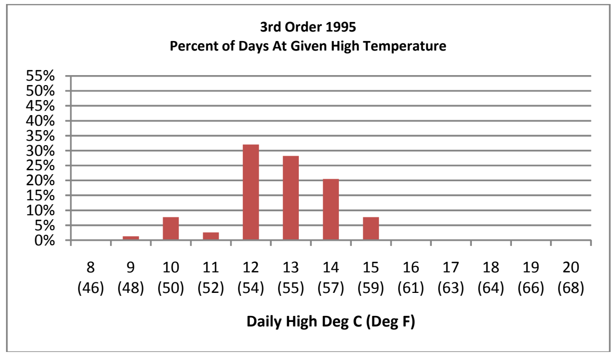


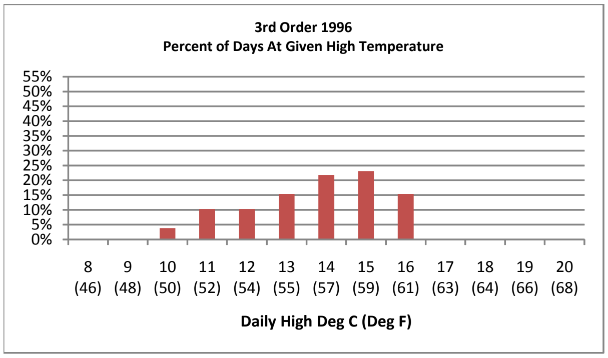


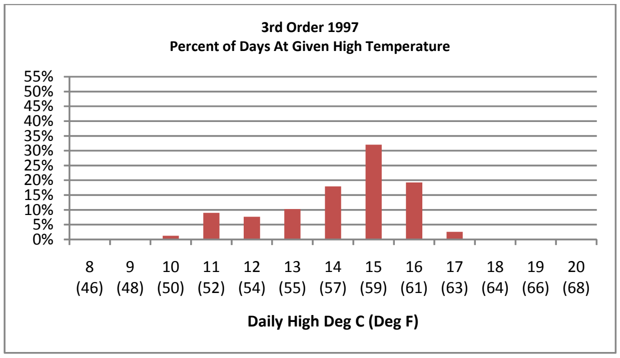


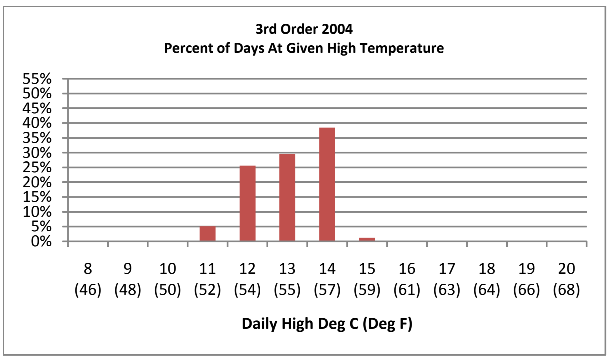
3rd Order Reaches:

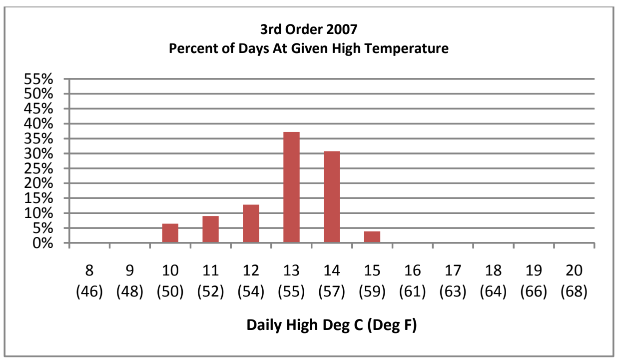


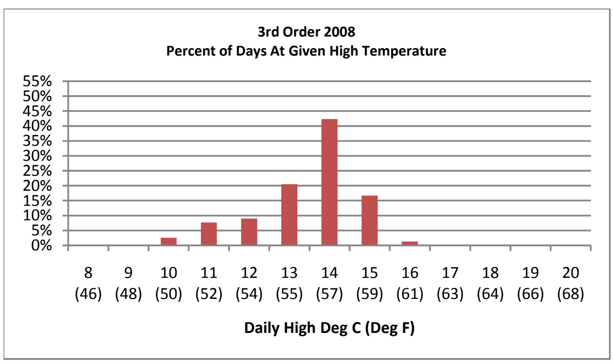




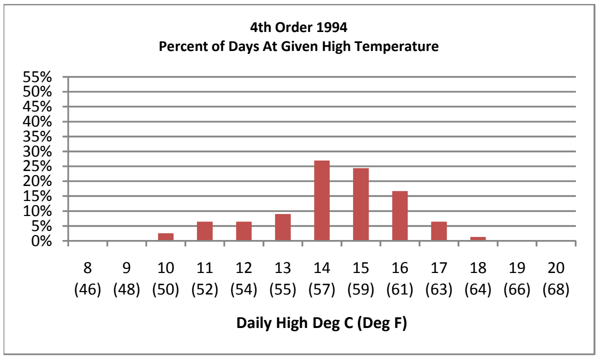


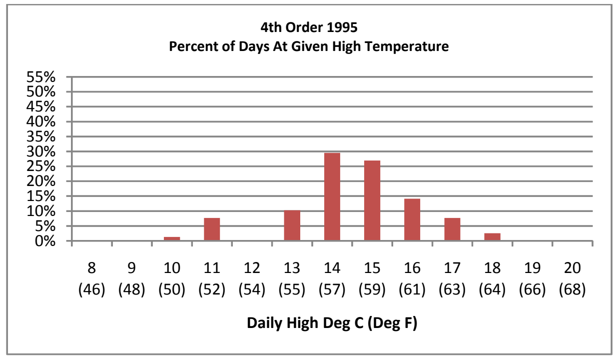


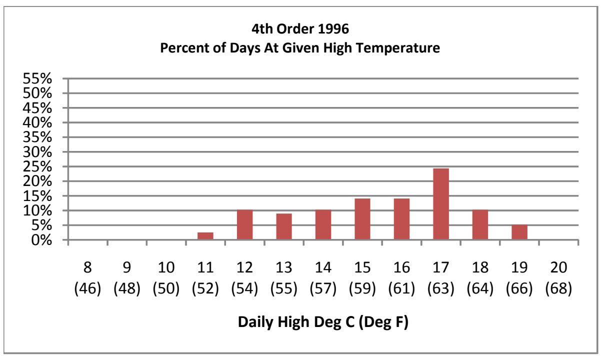


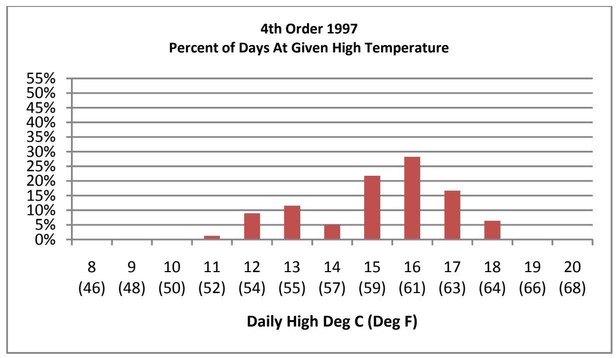


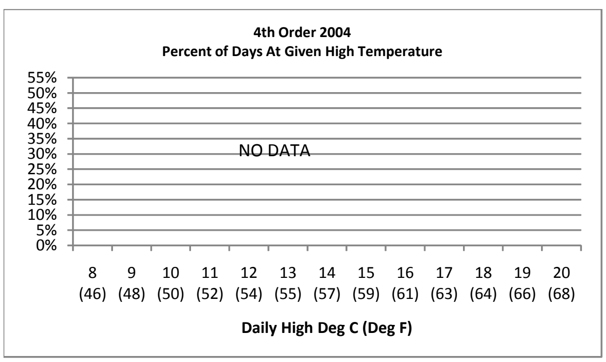
4th Order Reaches:

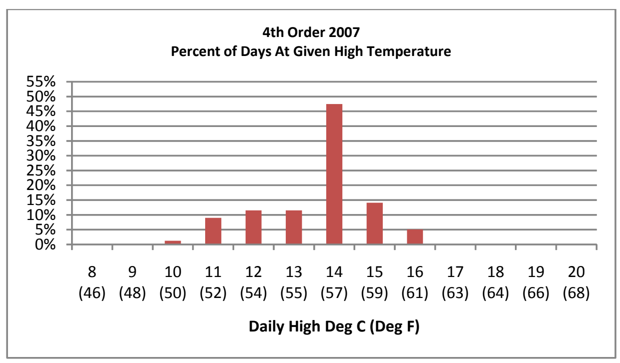


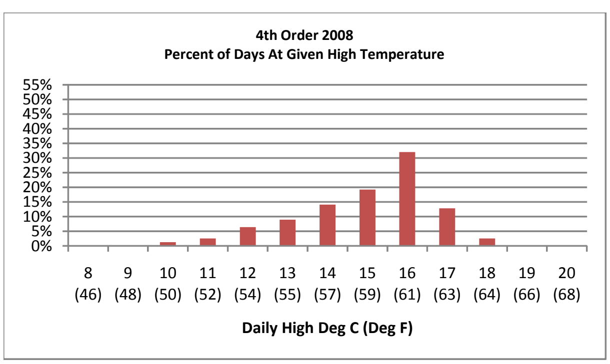












7. Temperature Trends

Examination of the histograms above suggests that temperatures are increasing, and that is probably due to removal of riparian vegetation by debris torrents in 1996 and 2007. This is evident for all stream orders when comparing 2008 (presumably a cool summer) with 1994 and 1995, prior to any significant disturbance. For all stream orders, the 2008 profile overall looks similar to 1996 and 1997, considerably warmer than 1994 and 1995. Without corresponding climatic data, it is difficult to make any conclusive statements about the extent of warming. A related project is underway to see if there is a statistically meaningful way to correlate our water temperature data with air temperature data from neighboring weather stations (probably Forest Grove, Vernonia, and Tillamook).

8. Ongoing Concerns

We are identifying additional sites for monitoring beginning in 2009, as discussed above.

One challenge in the coming years will be finding volunteers to keep the effort alive. Currently placement of the monitors requires 3 teams of at least 2 people (3 or 4 would be better), spread over the 14 miles of rugged terrain between Pennoyer Creek and the Salmonberry mouth. The effort takes a full day; at times it spills over to a second day. Retrieving the monitors at the end of the summer requires the same effort, and we take pains to ensure that at least one member of each team was present for the initial placement at the assigned sites as well. Even with that continuity and good photographic documentation, notes, and flagging of sites, it can be difficult to find the monitors again.

If railroad repair is undertaken and occurs during the summer, we will need to coordinate with the Port of Tillamook Bay to determine where monitors can be safely placed and retrieved and where they would be unlikely to be damaged by in-stream work.

Appendix 1 – Site Map