Winter Steelhead Spawning Ground Surveys
Salmonberry River (Nehalem Basin), Oregon

A STEP Project Report

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1. Introduction

In 1993 a STEP (Salmon Trout Enhancement Program) project was established to collect spawning data on Salmonberry River winter steelhead (Oncorhynchus mykiss). This was intended to supplement the peak spawning ground surveys that have been conducted on the three-mile “Enright” reach of the Salmonberry every year since 1973 (except 1978). The peak surveys were conducted by ODFW biologists through the mid to late 1990’s. Retired ODFW biologist Walt Weber has continued the peak surveys since then, with the assistance of the Rainland Flycasters organization.

ODFW identified additional reaches for regular surveying under the STEP project. These reaches are described in Appendix A. The effort has been led by Marty and Joyce Sherman, who have recruited volunteers from a number of organizations: Oregon Trout, Trout Unlimited, Clark-Skamania Flycasters, Native Fish Society, Americorps, and Sierra Club. The 1993 results were not kept, as the project team was just feeling its way around. In 1994 the team surveyed eight reaches, from early March through the end of May. Surveys have been done every year since.

The purposes of this report are to:

- summarize the data
- assess the effectiveness of the STEP surveys in providing reliable data
- identify any needed changes in the STEP project
- examine trends in steelhead redd counts

2. Spawning Distribution/Extent of Coverage

Reach descriptions and a watershed map are shown in Appendix A. The nine reaches described in Appendix A cover 12.9 linear miles.

In addition to regular surveys of defined reaches, we have conducted periodic ad-hoc surveys to determine the actual extent of spawning habitat utilized by winter steelhead in the Salmonberry. In total, there are approximately 24 miles used by steelhead for spawning in the main stem and the three largest tributaries.

There are two barrier falls where redds have been observed all the way to the falls, but not above. These are in the upper main stem at RM 14.5 (approx.), and in a second-order tributary of Wolf Creek about 1.7 miles above Wolf Creek’s confluence with the Salmonberry. There is a third falls in Pennoyer Creek about 100 m above its confluence with the Salmonberry. This falls is certainly a barrier to anadromous fish, although Pennoyer Creek is not a steelhead spawning tributary. We have documented only one redd in Pennoyer Creek below the falls. Although there are certainly other impassable falls throughout the headwaters, it appears that spawning is curtailed by low water volume and limited gravel downstream of those barriers.
The nine defined reaches comprise 54% of the total area available for spawning. Another 3.2 miles, or about 13% of the total area, is in the lower river and appears to be well-used. Much of the remaining 33% is less favorable spawning habitat.

More than 4,000 redds have been counted over the life of the project.

3. Methods

Standard protocol for the ODFW Enright peak surveys has been to conduct two surveys about two weeks apart during the peak spawning period of late April – early May. In some years only one survey was conducted. All visible redds are counted in each survey, whether counted previously or not. Adult fish are also counted. Peak fish counts and peak redd counts do not necessarily coincide.

In the STEP surveys, crews of at least two people are assigned to each reach. An experienced person is assigned as the lead. Reaches are surveyed walking upstream. Surveyors wear billed caps and polarized sunglasses. Waders are required for many survey reaches; other surveys are done from the railroad grade. Redds are marked by placing a marker in the depression. The marker can be a painted stone, or a stone with surveyor’s flagging tape tied securely around it. Marked redds are not counted on subsequent visits. Adult steelhead are counted. When possible, dead steelhead are sexed and measured, and scale samples are taken and sent to ODFW’s Tillamook office.

A redd is defined as a structure with a pit on the upstream end, and a downstream tail spill of excavated gravel. The observer evaluates adjacent roughness elements to rule out hydraulic scour/deposit action as a cause for the structure. No attempt is made to determine whether eggs have been deposited.

ODFW spawning survey forms are used to record counts, weather, water temperature, water clarity, and relative flow, using ODFW’s standard coding. The forms are returned to the ODFW Tillamook office at the end of every survey season.

Surveys are not performed in conditions when visibility code 3 (cannot see bottom of riffles or pools) would apply. We have found that the Wilson River gauge (USGS station 14301500, 6 miles east of Tillamook) is valuable in determining when to call off a scheduled survey. A height of 6 feet on the Wilson gauge generally means poor visibility and difficult wading on the Salmonberry.

In 1994 every visible redd was counted on each survey, whether counted previously or not. In 1995 the team was asked to begin marking redds and to count only unmarked redds on subsequent visits. That protocol has been followed since.

Initially, surveys were conducted weekly from early March to the end of May. In 1999 the team stopped surveying in March, and changed the survey interval to two weeks. Dropping the March surveys was based on a combination of factors: the difficulty of recruiting enough volunteers for such a long season; the likelihood of high water conditions in March; and frequent difficult access on logging roads due to snow. The two-week interval was suggested by ODFW. The team has not always been able to find and train the volunteers needed to maintain even that reduced level of surveying activity. In some years, some reaches were surveyed only once in a season, with inconsistent timing from year to year. The consequence is that data are not always directly comparable from one year to another, making trends more difficult to discern.
Table 1. Annual survey results for standard reaches.

<table>
<thead>
<tr>
<th>Mainstem Reaches</th>
<th>Tributary Reaches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enright</td>
</tr>
<tr>
<td></td>
<td>Surv. Redds</td>
</tr>
<tr>
<td>1994</td>
<td>6 78</td>
</tr>
<tr>
<td>1995</td>
<td>9 105</td>
</tr>
<tr>
<td>1996</td>
<td>5 4</td>
</tr>
<tr>
<td>1997</td>
<td>4 17</td>
</tr>
<tr>
<td>1998</td>
<td>5 29</td>
</tr>
<tr>
<td>1999</td>
<td>1 13</td>
</tr>
<tr>
<td>2000</td>
<td>1 19</td>
</tr>
<tr>
<td>2001</td>
<td>2 97</td>
</tr>
<tr>
<td>2002</td>
<td>3 34</td>
</tr>
<tr>
<td>2003</td>
<td>2 47</td>
</tr>
<tr>
<td>2004</td>
<td>4 42</td>
</tr>
<tr>
<td>2005</td>
<td>1 2</td>
</tr>
<tr>
<td>2006</td>
<td>1 11</td>
</tr>
<tr>
<td>2007</td>
<td>2 24</td>
</tr>
<tr>
<td>2008</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>43 485</td>
</tr>
</tbody>
</table>

In addition, there have been 79 ad-hoc surveys (391 redds recorded) of other reaches in an effort to get a more complete picture of spawning distribution (see Section 2).

4. Reliability of Data

4.1. General

A major concern with a volunteer effort is the accuracy of the redd counts: can volunteers count adult steelhead and identify steelhead redds reliably enough to provide useful data?

Adult steelhead counts are probably not reliable as population or trend indicators. Live count data may be of only limited use even when gathered by trained professional observers, given the secretive nature of the fish. In the Salmonberry, the railroad provides additional complications, as moving trains send fish into hiding, and observers walking on the railroad grade can have the same effect. Individual observers display tremendous differences in their ability to spot fish. Even the methodology employed is variable: some people glance quickly at the water and move on; others study likely spots for long periods; still others toss rocks into pools to see what flushes out. Among groups of volunteers, this behavior would not be easy to standardize or control.

Redds, at least, are stationary. Even so, Dunham et al. (2001) found significant variability among observers in identifying and counting redds of bull trout (Salvelinus confluentus). They tested observers who received a one hour presentation in the evening before counts were conducted, and an additional one to two hour session in the field where actual bull trout redds were examined. Observers often committed both errors of omission (failing to count redds when present) and false identification (a stream feature identified as a redd). The errors tended to cancel each other out. Muhlfeld et al. (2006) conducted a similar study, with the notable difference being that very experienced observers were used, with 10-26 years of experience in counting bull trout redds (mean 18 years), as opposed to the relative novices used in the Dunham study. Accordingly, redd detection probabilities were high (mean=83%), with little variation among observers.
In the absence of a similar study, an evaluation of error sources in redd counts in this project will necessarily be subjective. However, it is still worth going through the analysis to see if any one error type predominates that could bias results.

Although ultimately any error can be considered an observer error, for convenience I will look at error sources as belonging to one of three general categories: 1) characteristics of the observers themselves; 2) environmental variables; and 3) characteristics of the redds constructed by the target or sympatric species. Within each of those categories, an error can be one of omission or of false identification. These sources overlap: an observer with a tendency to look for a “high score” might be more likely to make a false identification error of a natural stream scour feature.

4.2. Observer Characteristics

As demonstrated by the bull trout studies (Dunham et al., 2001 and Muhlfeld et al., 2006), the most important factors in redd count accuracy are training and experience. At this point in the project (2009) we have several regular observers with more than 10 years of experience. Over the entire life of the project, of course, that is not true. In the early years we were assisted by volunteers from the Clark-Skamania Flyfishers, who had experience with steelhead spawning ground surveys on the Washougal River (WA). We are careful to assure that the crew leader for every reach has had experience in redd identification. Typically this comes through participation in several surveys, in which the person has demonstrated the ability to identify redds. Crew leaders over the life of the project have tended to be people who return year after year, and have accumulated considerable experience. Overall, experience has been the limiting factor in determining how many surveys get done, and how often. No matter how many volunteers we might have on a given day, the number of reaches surveyed is limited by the number of experienced leaders.

Beyond experience and training, volunteers possess a wide range of energy, enthusiasm, awareness, and willingness to learn. These attributes could all contribute to high variability in redd counts.

There is an undeniable feeling of satisfaction associated with observing a high level of spawning activity. For some people, there may be a tendency to associate high numbers with “success”. In such conditions, over-counting may occur. This is not to suggest that anyone would deliberately inflate counts, only that they might be more likely to call an ambiguous feature a redd.

Our volunteers tend to be drawn from conservation organizations, and have a sincere concern for population status. This concern may help temper any enthusiasm for “high scores”: there might be a natural reluctance to over-count. With such a mindset, a person might be more likely to omit counting an ambiguous feature, such as a very old or partially excavated redd.

Errors resulting from such differences in enthusiasm/mindset might cancel each other out. These errors would come into play only with ambiguous features; with experienced observers, the ambiguities should represent a small proportion of the total.

The STEP project’s method of marking redds may result in over-counting. Standard ODFW procedure includes placing a small colored stone in the pit of the redd. The STEP crews usually tie flagging tape tightly around a rock (ideally, sized and shaped somewhat like a large baked potato), and place it in or very close to the pit. Either method is vulnerable if further spawning activity takes place at the site. The small stone can be buried or swept out, and the flagging can be removed even if the rock remains. In such cases, a subsequent survey would count the red again.
ODFW protocol for cumulative red counts provides a further backup, in which a nearby tree is flagged. The flagging tape is marked with date, redd number, and redd location (distance and direction). This notation would make it easier to evaluate what has happened when markers are obscured.

4.3. Environmental Variables

Stream discharge and clarity can affect visibility of redds. We avoid surveying when riffle bottoms and tailouts are not visible (visibility code 3), and in high water conditions. Nevertheless, the conditions represented by visibility code 2 present different challenges than those represented by code 1. Of 294 surveys where the visibility code was recorded, 82% were coded as 1 (Table 2).

Table 2. Frequency distribution of visibility conditions.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>can clearly see bottom of pools and riffles</td>
<td>240</td>
<td>82%</td>
</tr>
<tr>
<td>2</td>
<td>can see bottom of riffles, and tailouts of pools</td>
<td>53</td>
<td>18%</td>
</tr>
<tr>
<td>3</td>
<td>cannot see bottom of riffles or pools</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>294</td>
<td>100%</td>
</tr>
</tbody>
</table>

Based on the high frequency of optimum water conditions, it is unlikely that redds would have been significantly undercounted due to poor visibility.

Weather conditions can also play a part in visibility. Bright sunshine can cause reflections off the water surface that obscure subsurface detail, even when polarized sunglasses are used. Patches of sunlight illuminating a dark stream bottom can be difficult to distinguish from freshly cleaned gravel. Such conditions would primarily affect surveys done from the railroad grade. Even in that case, the increased elevation of the railroad grade helps ameliorate the effect. In-stream surveys, such as the tributaries and upper main stem reaches, are less affected by light conditions because the surveyors can cross back and forth to find the best visibility conditions.

Normal hydraulic processes erode redd edges and smooth tailspill mounds. In low water, a redd might be visible for months. Periods of very high water during the spawning season can greatly accelerate the erosion process. This appears to be a rare occurrence during the primary spawning season on the Salmonberry (March-May). Figure 1 is a hydrograph of the Wilson River stage heights for March through May from 1994 through 2008 (averaged), with 1996 overlaid. The Wilson occupies the next drainage south of the Salmonberry; there is no gauge on the Salmonberry. The basin topography is similar, though the Wilson drainage is larger. During this period, the Wilson only reached flood stage (12 ft.) once, in April 1996. Salmonberry redd counts were very low in 1996: fewer than two redds/mile on the main stem reaches. However, these low counts are not entirely due to the April flood. The severe flooding and landslides in February 1996 caused turbid water conditions throughout the spawning period. In addition, railroad repair work was in process, which increased turbidity even in lower water conditions. As a result, 1996 data are unreliable, both for the ODFW Enright peak survey and the STEP project surveys.
When the Wilson is at six feet, we generally do not survey the Salmonberry, because visibility conditions tend to be poor (close to a code 3), and crossing the main stem becomes difficult. The river is not at an unusual or dangerous level at that point, however. It is close to the average condition in March. Redds may not be significantly affected at that level. Susac and Jacobs (1999) thought that in the absence of significant freshets, a period of two weeks between surveys would allow reliable counts of most of the observable redds during the second half of the spawning season (where the spawning season is defined as January through May).

Scour features associated with roughness elements can resemble redds. This is an area of ambiguity where the experience of the observer can play a considerable role. The observer is expected to examine associated roughness elements to rule out hydraulic scour and deposition effects.

4.4. Redd Characteristics

Redd visibility diminishes with age. This is due primarily to periphyton recovery and erosion of pit sides and tailspill due to normal hydraulic processes.

Where periphyton is present, a newly constructed redd is highly visible. The cleaned gravel contrasts sharply with the surrounding substrate. Over time, periphyton recolonizes the excavation, and the redd becomes progressively less noticeable. During the peak spawning period on the Salmonberry (April and May), periphyton is usually abundant. In 1996, 2008, and 2009, following unusually severe winter flood events, periphyton growth was inhibited. The stream bottom was uniformly light in color, making redds less noticeable. The condition in 2009 persisted from the December 2007 flood. This might be the result of fine sediment acting as a scouring agent. By late May 2009, periphyton growth was visible at stream edges but not in the main channel. This condition may have resulted in some under-counting of redds.
Susac and Jacobs (1999) evaluated steelhead redd longevity in Oregon coastal basins. Longevity varied by region, with redds on the North Coast exhibiting the greatest longevity, Umpqua basin the next greatest, and Mid Coast the least. They attributed this difference to timing of the spawning runs, with the Mid Coast peaking earlier (late February) and as a result having the most exposure to high flows. The North Coast streams peaked in the last week of April. After one week, virtually all redds were still visible. After two weeks, 7% of North Coast redds were still visible, vs. 32% in the Mid Coast. A two-week resurvey interval would be adequate on the Salmonberry, due to late peak run timing (late April/early May on the main stem; mid-May on the North Fork). Redd aging has probably contributed to some degree of undercounting of redds in the STEP project in some years, due to late survey beginning dates and long intervals between surveys on some reaches.

Spawning that occurs outside the spawning survey dates has also contributed to undercounting of total numbers of redds. This may have little practical effect on trend detection if, for example, spawning regularly occurs into mid June and surveys regularly end in late May. In that case, while total season redd counts would be low, the consistent end date would still allow trend analysis. The difficulty arises when the last survey in some years is in late April, or early to mid May. This has been a frequent occurrence in the STEP surveys, which have been using methodology appropriate for cumulative season counts, but have not always been staffed sufficiently to do all the necessary surveys.

During its life, a redd can take many different forms, ranging from a slight scuffing of the substrate as construction begins, up to a classic pit and tailspill form, possibly becoming a large complex structure where several pairs may have spawned, and eventually declining to undifferentiated stream bottom.

We do not count “test redds”. These are areas where a fish has begun to clean the gravel, but the basic redd form of pit and tailspill does not exist. There is no way to tell whether such areas have been abandoned or represent redds where construction has just begun.

Redds in intermediate stages (Fig. 2) can be difficult. There is considerable scuffing, a pit, and a small amount of tailspill, though the tailspill is thin, without pronounced mounding. It is very likely that egg deposition has not begun. This redd is more than a test, but is not a fully mature redds. The surveyor needs to decide whether to count this structure or not; specific in-field discussions with biologists should be part of training in order to help resolve intermediate forms such as these.

![Fig. 2. A redd in an intermediate stage.](image)
At high redd densities, where multiple adjacent and superimposed reds can be present, it is likely that reds are undercounted. This is probably more pronounced on reaches that are surveyed wholly or partly from the railroad grade, due to the distances involved. A surveyor on the railroad grade 30-40 m away from the site shown in Fig. 3 would probably come up with a different count than an observer standing next to it.

In some river systems, the presence of more than one species spawning at the same time can complicate redd counting. This does not appear to be a significant issue on the Salmonberry. Chinook (O. tshawytscha) spawn in the fall, and reds would be fully obscured by winter flows. Coho (O. kisutch), present only in small numbers in the Salmonberry, would spawn November-January. Late-spawning coho could conceivably overlap with early-spawning steelhead. Anadromous and resident forms of coastal cutthroat trout (O. clarki) are present. Although there could be temporal overlap in spawning, it is unlikely that the reds of steelhead and anadromous cutthroat would be confused, due to the size difference of the fish, the difference in habitat selection, and substrate size.

Due to wide temporal overlap, Pacific Lamprey (Lampetra tridentata) may be the species whose reds are most easily confused with steelhead reds (Susac and Jacobs, 1999). If lamprey routinely spawn in the Salmonberry, there is no question that steelhead redd counts would be compromised, as the team has received no specific training that might help differentiate lamprey reds from steelhead, as illustrated in Susac and Jacobs (1999). Fortunately, lamprey do not seem to be present in the Salmonberry, other than incidentally. None of our surveyors has ever reported seeing a lamprey, alive or dead. According to Kavanagh et al. (2006), lamprey reds were observed in 2005 at low densities (0 to 5.6 redds/mile) in the Salmonberry, but none were observed in 2003. Susac and Jacobs (1999) reported no lamprey or lamprey reds observed in 9 surveys of the Salmonberry in 1998. They did find lamprey reds in the North Fork Nehalem, but in no other tributaries of the Nehalem system. Walt Weber (personal communication) has never seen a lamprey in the Salmonberry. The weight of the evidence says that the likelihood of significant numbers of lamprey appearing in the Salmonberry is small; nevertheless, specific training should be provided.
4.5. Specific Data Comparisons

Both ODFW/Weber and the STEP team have independently surveyed the Enright reach in the same years. Although the counting methodologies are different, with ODFW/Weber employing peak count methods, and the STEP team employing cumulative count methods, it is still possible to compare results for reasonableness. Peak counts are done in late April/early May. Cumulative counts through late April or early May should be slightly higher than peak counts.

In seven years, cumulative counts were done through at least late April, allowing comparison with peak counts. Numbers are shown in Table 3. Clearly, the cumulative numbers tend to be much lower than the peak counts, with 1995 and 2001 (highlighted) being the only years where the numbers were similar.

The Enright reach has characteristics that might favor an experienced surveyor over a conservative volunteer surveyor, which could contribute to this level of discrepancy. The reach is below the North Fork. The North Fork approximately doubles the volume of the main stem where it enters. This makes the Enright reach much larger (in width and volume) than any of the other reaches. It is surveyed entirely from the railroad grade. Redd identification is harder at a distance, and the distance would favor the experienced surveyor. Gravel beds on the Enright reach are larger; this might increase the probability of redd clustering and superimposition, both of which would result in undercounting by a more conservative surveyor.

4.6. Conclusions-Error Sources

There appear to be two primary sources of errors: a) timing and frequency of surveys, and b) training and experience of the observers.

Timing and frequency of surveys have contributed to undercounting in some years. Late starts and long intervals between surveys have probably caused redds to be missed that might have been counted with earlier starts and shorter intervals. Early end dates would have caused redds to be missed that were constructed after the end of surveying. The result is that cumulative season-long redd counts are not comparable over all years. However, adjustments can be made for this (see section 5.2).

Training and experience may account for a large error number in total, although many of the errors would tend to cancel each other out. This is not possible to quantify without a study. With the exception of the Enright reach, there does not appear to be an obvious reason for bias in either direction.
On the Enright reach, significant undercounting by the STEP team occurs. This finding would not necessarily apply to other reaches, as the reach characteristics are different. Only one other reach is surveyed entirely from the railroad grade, and that one is much smaller in volume. The others are surveyed partially or completely in-stream. The ability to inspect features from just a few feet away and from all sides adds considerable confidence to the surveyor. However, since the discrepancy exists, it would be advisable for ODFW to take further steps to gain more confidence in the data. See Section 7, Recommendations.

5. Run Timing

5.1. Main Stem

Fig. 4 is a composite curve showing the accumulation of new redds in four main stem reaches. The run peaks around the first week of May. 75% of the season’s redds have been counted by that point. There is a false peak in early April, due to a relative scarcity of March surveys. Dave Stewart (personal communication) has surveyed the Salmonberry for several complete seasons since 2003. His team typically begins marking redds in late February and continues finding new redds into early June.

![Mainstem, All Years Combined](image)

Fig. 4. Cumulative main stem counts (n=1,041).

5.2. South Fork

Figure 5 shows redd accumulation on the South Fork for three years having complete data. Although the South Fork has been surveyed every year, most years were not surveyed often enough to provide a complete picture of run timing. The chart is based on 1995, 1997, and 1998. The peak is the last week of April. The run appears more compressed than the main stem run. The South Fork is a small tributary, so it would require a certain minimum flow. This would suggest a run that would peak closer to early April. However, there is a steep and narrow bedrock channel at RM 0.7. This channel is about 50 m long and only about 1-2 m across, and the entire flow goes through it. The hydraulics in this channel might prevent or severely hinder passage at higher flows. It is likely that spawning continues beyond mid-May. However, by that time we have typically been forced to assign scarce resources to the North Fork.
5.3. North Fork

The North Fork is unique in the Salmonberry system in having a formidable obstacle to migration. A waterfall a short distance above the mouth may be impassable at high flows, which is a reversal of the typical case. The pool below the falls may be too turbulent at high flows for the fish to get a good jump. Even with a perfect jump, a fish must swim up over the lip of the falls, and higher flows make that part more difficult as well. We typically observe large numbers of fish in the pool below the falls mid-to-late April, with many failed attempts at jumping. Then at some point, generally early in May, the fish begin getting over the falls in large numbers, and the pool empties rapidly. There may also be a temperature component involved in addition to the flow component.

Following the Feb. 1996 and Dec. 2007 floods, the pool below the falls filled with gravel and reduced the overall drop to the point where passage was not significantly impeded. Heavy winter flows in succeeding years pushed the gravel farther downstream, re-establishing the typical configuration.

Both North Fork survey reaches are above the falls.

Fig. 6 shows the redd accumulation on the North Fork. This is biased by the timing of the surveys. In late April we are typically still surveying the main stem and South Fork, and do not shift efforts to the North Fork until May. We also stop surveying at the end of May.

Dave Stewart (personal communication) surveyed the North Fork for three years, beginning in mid-February and continuing until mid-June. His team counted no redds before April 25. New redds were still being found in early and mid-June. This indicates that the curve in Fig. 6 is missing at least one week of redds in late April and two weeks in June.
6. Trend Analysis

6.1. Peak Counts-Enright Reach

The Enright reach peak counts in this analysis are based on ODFW numbers from the Streamnet database (http://www.streamnet.org), and data provided directly by Walt Weber. It is important to note that the Streamnet numbers are not correct for the period 1994 through 2003, as they are based on the STEP team’s cumulative counts. The ODFW Tillamook office apparently submitted the highest single count without accumulating the numbers. Weber’s counts should be used instead for that period.

The Enright data illustrate the difficulty of establishing trends and the need for very long term datasets. The most obvious feature of the data is the cyclical nature (Fig. 7).
Within the 36 year period, there have been three cycles. The first might have begun sometime in the 1960’s, peaked in 1975, and ended in 1982. The next began in 1983, peaked in 1987, and ended in 1993. The third cycle began in 1994, and peaked in 2003. It is not clear whether the end has occurred yet. The low 2008 count may be a false trough, as it is related to the December 2007 flood, which may have caused enough changes in the main stem to influence spawning behavior and site selection (as opposed to actual population levels). Redd counts were very low in 2008 throughout the watershed, except for the North Fork. There is also some indication that spawning might have shifted somewhat to the upper reaches of the watershed. In late May 2009, when placing temperature monitors in the area of Pennoyer Creek, I found six redds in the 1/3 mile stretch between Pennoyer Creek and an impassable falls on the main stem. This is a density of 18 redds/mile in marginal habitat (low water flow, at >14 miles above the mouth). The shape of the descending limb of the curve, with the abrupt change between 2007 and 2008, suggests that 2008 may not have been the true “trough” of the third cycle. It may take several more years before the actual picture emerges.

Trend analysis is difficult with long-term cycles such as this one. Time-series analysis techniques are needed. It is clear that short term datasets could be picked out of this larger dataset that would allow widely differing conclusions about trends.

As it stands, for the period 1973-2009, we can say that there is high variability in redds per mile, ranging from a minimum of 2 to a maximum of 62, with a mean of 24. There have been nine years with more than 30 redds/mile; six of those have occurred in the last ten years.

It may be useful to compare the three discrete periods, even while recognizing that two of them may be incomplete. Table 4 provides a summary. With full data, the first period would probably show a lower mean redds/mile figure than it does, since there are presumably some lower count years missing from the front end. With the data available, it is not possible to say whether period 3 is really any different from period 1.

<table>
<thead>
<tr>
<th>Period (Years)</th>
<th>Mean</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period 1 (1973-1982)</td>
<td>25.7</td>
<td>2.0</td>
<td>62.0</td>
</tr>
<tr>
<td>Period 2 (1983-1993)</td>
<td>17.7</td>
<td>3.0</td>
<td>38.7</td>
</tr>
<tr>
<td>Period 3 (1994-2009)</td>
<td>28.6</td>
<td>3.3</td>
<td>50.7</td>
</tr>
</tbody>
</table>

There do not seem to be cycles related to spawning success in prior years, i.e. a low return or a high return in any given year does not appear to be associated with a corresponding low or high return four years later. The strongest association is actually seen in the following year, as seen in the autocorrelation function (Figure 8, SPSS v 10), where the data lagged one year shows the only significant positive correlation.
This correlation with immediately prior years suggests the influence of cyclic environmental factors. A cycle that may be closely related is the Pacific Interdecadal Oscillation, which has been linked to shifts in salmon production (Mantua et al., 1997). Figure 9 is a plot of the May-Sep Pacific (inter)Decadal Oscillation (PDO) Index along with Salmonberry River redd counts. It would be highly unusual for data for a single river to correspond closely with the PDO index; nevertheless there is a suggestion that the Salmonberry redd counts (and by extension, adult returns) may operate in a cyclic pattern linked to the greater cycle of the PDO. Shorter cycles in redd density appear to exist within the longer-period cycles of the PDO.

![Autocorrelation Function](image)

Fig. 8. Autocorrelation Function.

![Graph of PDO Index and Salmonberry Redds/Mile](image)

Fig. 9. PDO Index May-Sep average by year, with Salmonberry redd counts.
Note that redd counts appear to decline following a shift in the mid-1970’s from a cool regime to a warm one, and then increase during a possible transition period back to a cool cycle. Values are Enright peak counts, and upper main stem/South Fork/North Fork combined cumulative counts ("Other"). PDO data are from Joint Institute for Study of the Atmosphere and Ocean (http://jisao.washington.edu/pdo/PDO.latest); downloaded 7/5/2009.

6.2. Cumulative Counts—Upper Main Stem and Tributaries

The STEP counts, started in 1994, coincide with the most recent cycle seen in the Enright peak count data. Hence, any attempt at determining trends must be tempered with the recognition that this is a very short time period.

In this analysis, three contiguous reaches, starting at the North Fork confluence and extending 3.7 miles upstream to Wolf Creek, are combined and reported as the “upper main stem”. These are upstream of the Enright reach. The South Fork and North Fork are considered separately. Finally, a combined view of those reaches is presented.

All results are expressed in terms of redds per mile, rather than total redd counts, as not every reach was surveyed the same number of times in all years. The only reach where redds per mile and total redds are the same is the South Fork, which is a one-mile reach.

The STEP cumulative counts cannot be used “as is” for trends, because they do not represent full counts in all years. As time passed, counts were done less frequently. Main stem counts late in the season were sometimes sacrificed as the efforts of a limited corps of volunteers shifted to the later-running North Fork run. Using the unmodified data, with more complete counts in earlier years, might suggest a declining trend where none exists.

In theory it might be possible to adjust the counts for missed redds due to late start dates and survey intervals longer than two weeks. The data provided by Susac and Jacobs (1999) suggest that a curve can be developed to adjust redd counts for aging. However, without more rigorous testing of the estimating curve, this would add even more uncertainty to the final numbers.

To compensate for incomplete data, I used cumulative counts through the most common ending date. For the main stem and South Fork, I used cumulative counts through week 18 (typically, the last week in April or the first week in May; the average date for week 18 is May 2). Where a count for week 18 did not exist, I used the cumulative count for the week closest to 18. In the event of a tie for closest week, I used the later one. The same logic was used for the North Fork, with the exception that week 22 (the last week in May) was used as the common date. The net result of this approach probably comes close to what “peak” counts would have provided. This approach also allows the use of 1994 STEP data, which was counted on a “peak” basis. Results are presented in Table 5.

The final effect of this compensation can be seen in Figure 10, which shows the combined results of upper main stem, South Fork and North Fork surveys, with unadjusted (cumulative season counts) and adjusted (through week 18/22) counts. Redd/mile figures from 1995 through 1999 were 11% higher for the unadjusted counts than for the adjusted counts. From 2000 through 2004, the unadjusted counts averaged 6% higher, and from then on they averaged 3% higher. The result, had the unadjusted counts been used, appears to be a steeper decline than might have actually existed. Simple linear regression lines are fitted in Figure 10. Linear regression is not necessarily the most appropriate method to use for this type of data; however, it works well to illustrate the effects of adjusted vs. unadjusted data.
Fig. 10. Linear regression lines used to illustrate the difference in apparent trend between full-season counts with variable end dates, versus truncating counts at week 18 (22 for North Fork).

Table 5. Cumulative counts through week 18 (mainstem and South Fork) or week 22 (North Fork).

<table>
<thead>
<tr>
<th>Year</th>
<th>Mainstem</th>
<th>South Fork</th>
<th>North Fork</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redds Miles</td>
<td>Redds/ Mile</td>
<td>Redds Miles</td>
<td>Redds/ Mile</td>
<td>Redds Miles</td>
</tr>
<tr>
<td>1994</td>
<td>32</td>
<td>3.7</td>
<td>8.6</td>
<td>14</td>
</tr>
<tr>
<td>1995</td>
<td>94</td>
<td>3.7</td>
<td>25.4</td>
<td>11</td>
</tr>
<tr>
<td>1996</td>
<td>145</td>
<td>3.7</td>
<td>39.2</td>
<td>16</td>
</tr>
<tr>
<td>1997</td>
<td>108</td>
<td>3.7</td>
<td>29.2</td>
<td>10</td>
</tr>
<tr>
<td>1998</td>
<td>7</td>
<td>1.3</td>
<td>5.4</td>
<td>10</td>
</tr>
<tr>
<td>1999</td>
<td>60</td>
<td>3.7</td>
<td>16.2</td>
<td>14</td>
</tr>
<tr>
<td>2000</td>
<td>110</td>
<td>3.7</td>
<td>29.7</td>
<td>39</td>
</tr>
<tr>
<td>2001</td>
<td>74</td>
<td>3.7</td>
<td>20.0</td>
<td>26</td>
</tr>
<tr>
<td>2002</td>
<td>93</td>
<td>3.7</td>
<td>25.1</td>
<td>48</td>
</tr>
<tr>
<td>2003</td>
<td>105</td>
<td>3.1</td>
<td>33.9</td>
<td>44</td>
</tr>
<tr>
<td>2004</td>
<td>41</td>
<td>3.7</td>
<td>11.1</td>
<td>4</td>
</tr>
<tr>
<td>2005</td>
<td>54</td>
<td>3.7</td>
<td>14.6</td>
<td>38</td>
</tr>
<tr>
<td>2006</td>
<td>44</td>
<td>3.7</td>
<td>11.9</td>
<td>15</td>
</tr>
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<td>2007</td>
<td>3</td>
<td>1.9</td>
<td>1.6</td>
<td>5</td>
</tr>
<tr>
<td>2008</td>
<td>4</td>
<td>1.0</td>
<td>4.0</td>
<td>92</td>
</tr>
<tr>
<td>2009</td>
<td>5</td>
<td>1.0</td>
<td>5.0</td>
<td>54</td>
</tr>
</tbody>
</table>
Fig. 11 Time period and reds/mile of the STEP surveys compared to the Enright peak surveys, showing the STEP surveys have been conducted only within the last of three (apparent) major cycles. The high STEP counts in 1995-1999, and again in 2008, are due primarily to the influence of the North Fork.

Figure 11 puts the time period of the STEP surveys in perspective, and illustrates the difficulty of assessing trend. Rieman and Myers (1997) examined the use of redd counts to detect trends in bull trout populations over time periods similar to those in this study (7 to 17 years). They concluded that lacking detailed knowledge of all factors involved, simple models are appropriate and possibly the most powerful. They used nonparametric rank correlation, testing only for a monotonic trend. I used the same technique to look for trends in the STEP data, using the SPSS v. 10.0 “Crosstabs” procedure.

None of the areas (upper main stem, North Fork, or South Fork) showed significant trends. All trends were declining (Kendall’s tau, Table 6, is negative), but none were significant at the 95% level (p>.05 in all cases, Table 6). The small sample size and extreme variability of the data preclude any definitive statement of trend. Rieman and Myers (1997) estimated the number of years necessary to detect trends in bull trout populations. For Rocky Mountain streams with trends (Kendall’s tau-b) and p-scores similar to the Salmonberry combined scores, they estimated 35 to 56 years of data would be needed to detect trends. Other streams, with less variable redd counts and/or steep successive declines, would have been credible with as few as 6 or 7 years of data.

Table 6. Results of nonparametric rank correlation testing.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Kendall’s tau-b</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainstem</td>
<td>-0.231</td>
<td>0.294</td>
</tr>
<tr>
<td>South Fork</td>
<td>-0.039</td>
<td>0.827</td>
</tr>
<tr>
<td>North Fork</td>
<td>-0.124</td>
<td>0.577</td>
</tr>
<tr>
<td>Combined</td>
<td>-0.2</td>
<td>0.406</td>
</tr>
</tbody>
</table>
Figures 12, 13, and 14 show reds per mile by year for each segment. The vertical axis has been adjusted to the same scale (0 to 100 reds/mile) for each segment, for easier comparison.

Fig. 12. Upper main stem, based on cumulative counts through Week 18.

Fig. 13. South Fork, based on cumulative counts through Week 18.
6.3. Conclusions-Trends

There is no clear trend in redd counts, either increasing or decreasing. The inference is that the population is stable, with high and low years. Given that the Salmonberry was categorized by Huntington et al. (1996) as the only river on Oregon’s North Coast with a healthy native stock of winter steelhead, a stable trend is good news.

The unknown factor is how the current condition of the habitat might affect future production. To the eye, the December 2007 flood caused considerable changes. Kavanagh and Jones (2009), in summarizing detailed stream surveys done in the summer of 2008, stated that “deleterious long-term impacts to the Salmonberry River fish populations and instream habitat may result from an increased deposition of fine materials from scoured banks, landslides and debris avalanches into the stream.”

A return to favorable ocean conditions might mask the effects of declining habitat quality, as postulated by Lawson (1993).

7. Recommendations

The cumulative run size and timing information gathered from the season-long redd marking effort is valuable. However, that effort needs to be sustained throughout the season; sporadic surveys do not work well with that method. ODFW has conducted season-long cumulative counts on the Salmonberry recently, gathering much more focused and detailed data than the STEP team. Since it seems unlikely that volunteer resources will be available for the level of effort required for cumulative counts, it would be better for the STEP team to change focus and shift to peak counts on key reaches. Much of the data that we have can be converted to approximate the values that peak counts would have produced, so data continuity would be maintained.

The Enright reach on the lower main stem is the most critical reach at this point. Since data exist back to 1973, it is most important to maintain continuity there. Walt Weber has indicated a desire to hand off...
the responsibility soon. Given the discrepancy in the Enright counts noted in this report, ODFW/Weber will need to determine whether the STEP team can take over the Enright peak surveys; this assessment can be accomplished by on-site evaluation/training of team members.

Recommendations:

Arrange for training and evaluation by ODFW biologists and/or Walt Weber. This is necessary to establish confidence in the counts. Training could also include methods of identifying lamprey redds, if deemed necessary.

Shift to peak counts – two counts per reach at appropriate dates approximately two weeks apart, to capture redd counts at the peak of the season.

Determine the appropriate reaches. My recommendations for the highest priority reaches are Enright (for very long-term continuity), South Fork (a “Salmon Anchor Habitat”, and lower North Fork. When there are enough volunteers, upper main stem reaches such as Kinney Creek to Wolf Creek can be added.

References Cited


Kavanagh, P., K. Jones, and C. Stein. 2006. Fish habitat assessment in the Oregon Department of Forestry lower Nehalem and Necanicum study area. Oregon Department of Fish and Wildlife Aquatic Inventories Project, Corvallis, OR.


US Army Corps of Engineers Dataquery for TLMO3 river gauging station. Website link

Appendix. Reach Descriptions

All reaches are surveyed in an upstream direction. Where surveys are done from the railroad grade, surveyors do not leave the tracks at the tunnels, meaning the river is not surveyed where it bends around the ridges containing the tunnels. Tributaries are surveyed in-stream and from the banks immediately adjacent.

(Main stem) Buick Canyon Creek to Belfort Creek, 1.8 miles. This is infrequently surveyed for steelhead, but is a standard reach for fall chinook surveys. This is surveyed from the railroad grade except for two stretches done from the river banks where the river bends well away from the grade (just above Buick Canyon Creek, and from Brix Creek to Belfort Creek).

(Main stem) Enright, 3.0 miles. Starts at railroad marker 811 below the cabins (site name is Enright), ends at confluence with North Fork (just upstream from railroad marker 808). This reach is surveyed entirely from the railroad grade.

(Main stem) North Fork-Belding Crossing, 1.8 miles. Starts at North Fork confluence, ends at Belding Crossing (where Beaver Slide Road crosses the Salmonberry and becomes Belding Road). This is surveyed entirely from the railroad grade except for the river crossing immediately above the North Fork (traditional access for this reach has been via the North Fork road).

(Main stem) Belding Crossing-Kinney Creek, 0.6 miles. Starts at Belding Crossing, ends at Kinney Creek. Surveyed entirely from the railroad grade.

(Main stem) Kinney Creek-Wolf Creek, 1.3 miles. Starts at Kinney Creek, ends at Wolf Creek. Surveyed from the railroad grade for first 0.5 miles, up to the lower end of “Wolf Creek Flats”, and in-stream thereafter.

(Main stem) Wolf Creek-Pennoyer Creek, 1.4 miles. Starts at Wolf Creek, ends at Pennoyer Creek. Generally surveyed only when there is an excess of volunteers and leaders. Survey is done entirely in-stream.

Lower North Fork, 1.2 miles. Starts at unnamed tributary on west side at parking area. See UTM coordinates for start point, as road conditions can change. Ends at second (unnamed) tributary on east side.

Upper North Fork, 0.8 miles. Starts near end of Van Vleet Spur road (now decommissioned). Ends at unnamed tributary on east side. See UTM coordinates.

South Fork, 1.0 miles. Starts at mouth, ends at Ripple Creek.
Table A1. Reach Coordinates.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Miles</th>
<th>Easting</th>
<th>Northing</th>
<th>Easting</th>
<th>Northing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buick Canon Cr.-Belfort Cr</td>
<td>1.8</td>
<td>450712</td>
<td>5065522</td>
<td>453048</td>
<td>5064565</td>
</tr>
<tr>
<td>Enright</td>
<td>3.0</td>
<td>455387</td>
<td>5063804</td>
<td>459255</td>
<td>5062772</td>
</tr>
<tr>
<td>North Fork-Belding Crossing</td>
<td>1.8</td>
<td>459255</td>
<td>5062772</td>
<td>461521</td>
<td>5061471</td>
</tr>
<tr>
<td>Belding Crossing-Kinney Cr.</td>
<td>0.6</td>
<td>461521</td>
<td>5061471</td>
<td>462357</td>
<td>5061471</td>
</tr>
<tr>
<td>Kinney Cr. - Wolf Cr.</td>
<td>1.3</td>
<td>462357</td>
<td>5061471</td>
<td>464253</td>
<td>5061753</td>
</tr>
<tr>
<td>Wolf Cr.-Pennoyer Cr.</td>
<td>1.4</td>
<td>464253</td>
<td>5061753</td>
<td>465806</td>
<td>5062896</td>
</tr>
<tr>
<td>Lower North Fork</td>
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<td>460517</td>
<td>5064068</td>
<td>462090</td>
<td>5064992</td>
</tr>
<tr>
<td>Upper North Fork</td>
<td>0.8</td>
<td>461896</td>
<td>5065943</td>
<td>462163</td>
<td>5067066</td>
</tr>
<tr>
<td>South Fork</td>
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<td>457418</td>
<td>5062405</td>
<td>456535</td>
<td>5061140</td>
</tr>
</tbody>
</table>

Figure A1. Salmonberry watershed map showing defined reaches (blue), with breaks for adjacent reaches indicated by single lines. Verified extent of winter steelhead spawning outside defined reaches is shown in red. Known barrier waterfalls impeding steelhead migration are shown by double lines.