Winter Steelhead of the Clackamas and Sandy Rivers: Spawning Ground Surveys 2006-2007

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Introduction

Located east of Portland, the Clackamas and Sandy rivers offer excellent recreation and sport fishery opportunities. Prized as a game fish, winter steelhead *Oncorhynchus mykiss* were historically abundant and widely distributed throughout the Clackamas and Sandy river basins. Anecdotal information suggests that the Sandy River once supported as many as 20,000 adult winter steelhead (Mattson 1959). Similarly, the Clackamas River sustained "significant" populations of winter steelhead in the early 1900's (Taylor 1999). Native stocks of winter steelhead have declined precipitously within the last century and were listed by the federal government as "Threatened" under the Endangered Species Act in 1998 (NOAA 2005). Management plans developed by the Oregon Department of Fish and Wildlife (ODFW) for the Clackamas and Sandy rivers emphasize protection and enhancement of native winter steelhead runs while continuing to support sport angling through hatchery steelhead production. Populations of winter steelhead in the Clackamas and Sandy Rivers are augmented by hatchery steelhead production to offset the loss of native fish production while still providing fishing opportunities. Adapting these management plans relies on comprehensive and accurate information on the population status of wild and hatchery winter steelhead stocks of both the Clackamas and Sandy rivers.

Traditionally, winter steelhead populations were tracked using a combination of angler punch cards and fish passage data from dams; Marmot Dam on the Sandy River and North Fork Dam on the Clackamas River. The effectiveness of using angler punch cards to monitor wild steelhead stocks decreased after angling regulations were implemented to reduce harvest impacts to wild fish (Jacobs et al 2002). Dam count information is useful for tracking population trends for the areas above the dam, but does not provide insight on the populations below. Furthermore, dam counts on the Sandy River will be discontinued with the removal of Marmot Dam in late 2007. Without these traditional approaches, a statistical method was initiated by ODFW Corvallis Research group using spawning ground surveys to develop population estimates for winter steelhead (Jacobs et al 2002).

In 2006 and 2007, we completed winter steelhead spawning ground surveys in the Clackamas and Sandy rivers. Utilizing spawning ground survey protocol developed by ODFW's Western Oregon Research and Monitoring Program, we used a probability based design to select survey locations (Firman and Jacobs 2001). Jacobs et al. (2002) developed and calibrated this steelhead monitoring plan from 1997 to 2002 and fully implemented the plan in 2003 to track coast-wide steelhead populations. A similar survey protocol has been successfully used for tracking Coho salmon abundance along the Oregon coast since 1990 (Jacobs and Nickelson

1998). The objectives of this project were to: (1) estimate adult winter steelhead abundance, (2) determine the ratio of hatchery to wild steelhead on spawning grounds, and (3) develop index sites for assessment of spawner distribution in the upper Sandy River basin after Marmot Dam removal.

Study Area

The Oregon portion of the Lower Columbia winter steelhead Evolutionarily Significant Unit (ESU) consists of nine populations in tributaries of the Columbia River from the Pacific Ocean to Fifteenmile Creek near The Dalles. Our study area encompasses two of the populations within the Lower Columbia ESU: the Sandy River and Clackamas River. The study area of the Clackamas River does not include the area above North Fork dam, where fish are sorted and enumerated as they pass through the dam facility (Figure 1).

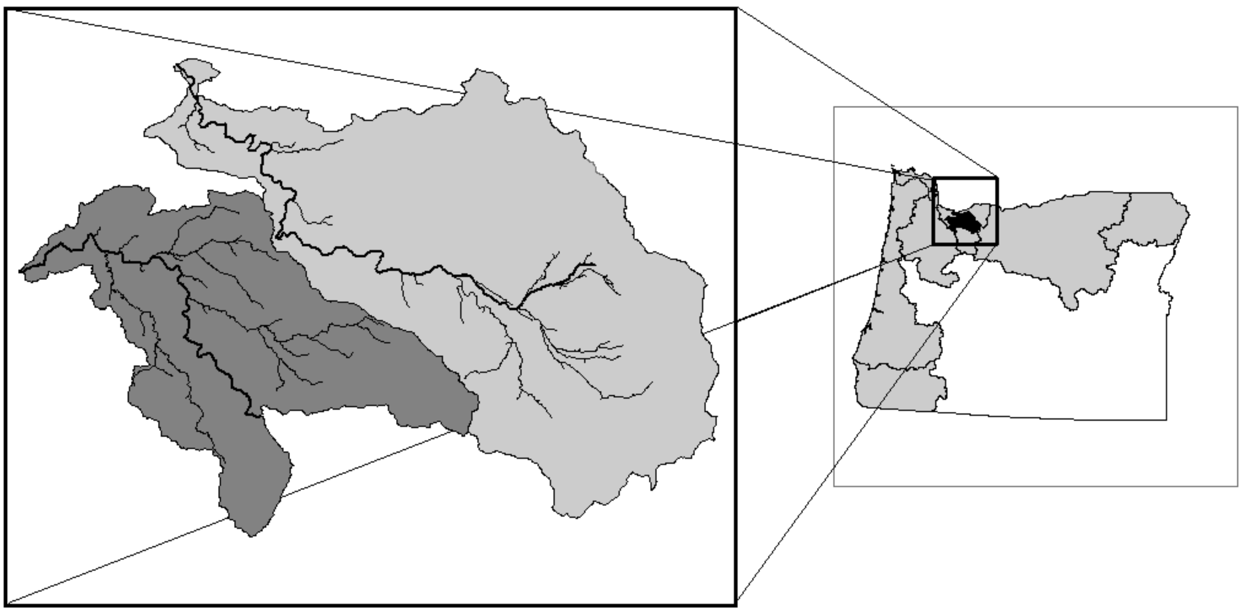


FIGURE 1. Clackamas and Sandy Rivers winter steelhead spawning habitat. Clackamas River shown in darker gray, the area above North Fork dam on the Clackamas River was not included in the sample frame. The inset map outlines the winter steelhead ESUs of Oregon.

Methods

Monitoring Design

We used the United States Environmental Protection Agency's Environmental Monitoring Assessment Program (EMAP) to select a spatially balanced, random sample of sites (Stevens 2002) with the goal of estimating spawning timing, distribution, and abundance of adult winter steelhead in the Sandy and Clackamas basins. The selection frame represents our best available knowledge of the total winter steelhead spawning habitat throughout the Clackamas and Sandy basins (Figure 1). This selection coverage does not include spawning habitat above the North Fork Dam on the Clackamas River.

The goal of our monitoring design was to estimate basin-wide winter steelhead population size within 35% variance. We set a goal of surveying 35 points per basin, or 30% of total available habitat, which balanced available funds to conduct surveys and objectives of producing reliable population estimates. Points randomly selected within the sample frame by the EMAP procedure were assigned survey reaches within the existing survey reach framework of Coho spawning surveys (Firman and Jacobs 2001). Selected sites that fell outside of the existing reach network were reviewed for habitat quality and site accessibility prior to the survey season. Typically, survey reaches were approximately one mile in length, but main stem reaches were often longer since they were surveyed by boat. In some cases, more than one point selected by EMAP fell within the same survey reach. Data analysis was based on the selected EMAP points and not survey reaches, so if two points were located in the same survey reach, the data collected from the survey would be counted twice in data analysis. See Jacobs and Nickelson (1998) for more information on specific site verification and set up procedures.

Spawner Surveys

We conducted winter steelhead spawning ground surveys with supplemental help from volunteers who assisted in surveying smaller tributaries. Volunteers were trained by ODFW employees in survey protocol, species identification, and redd identification. Volunteers were also trained in following standard volunteer procedures for safety and conduct as described in ODFW volunteer manuals**.** Sites were surveyed every 7 to 14 days from February through May. Surveyors identified and counted winter steelhead redds, and recorded live and dead fish observations, noting the presence or absence of adipose fins when possible. Surveyors marked individual redds with painted rocks and flagging on a nearby tree to ensure redds were not counted on subsequent visits. Redd identification and tracking methods are described in Susac and Jacobs (1998). Survey conditions such as weather, flow, and visibility of water were documented. Main stem and larger tributary (i.e. Eagle Creek and Salmon River) surveys were conducted using boats, either whitewater kayaks or 14' pontoon boat.

Data Analysis

Following data analysis methods developed by Stevens (2002) and Susac and Jacobs (1998), we derived winter steelhead population estimates by (1) counting sites that meet survey criteria within a specified population category; (2) determining response from sites; (3) calculating hatchery to wild fish ratio based on live fish observations; (4) calculating weight of surveys in relation to specified population category; (5) calculating adult fish abundance; and (6) determining 95% confidence intervals.

We first determined the number of sites from the total EMAP selected sites that were successfully surveyed and met protocol within selected populations or strata. We based our analysis on the four population areas: 1) Clackamas River basin below North Fork dam, 2) Sandy River basin above Marmot dam, 3) Sandy River basin area below Marmot dam, 4) and the combined Sandy River basin. We also developed estimates for main stem and tributary strata within these population areas. The process of counting sites was expressed using an indicator variable where we defined the variable S_{pt} to represent sites within population area p or strata t that were successfully surveyed. Then following the indicator variable expression (Stevens 2002) given as

$$\boldsymbol{I}(S_{pt}) = \begin{cases} 1, \text{ if } (S_{pt}) \text{ meets criteria within population } p \text{ and stratum } t; \\ 0, \text{ otherwise.} \end{cases}$$

The sum of the result is the total number of sites that meet the criteria for inclusion and are within a specified population and stratum.

Next, we determined response (*R*), which is the number of redds per mile observed at each site over the entire season within the population areas (S_{pt}). To estimate influences of naturally spawning hatchery fish we adjusted response to reflect observations of live hatchery and wild fish within surveys. All hatchery fish are marked with an adipose fin clip that distinguishes them from wild fish. To estimate response for wild fish, we multiplied the response for each site by the proportion of wild adult steelhead observed from the total fish positively identified as marked or un-marked. The following equation was used to adjust response from each site for hatchery fish (Hankin 1982): for population area (S_{pt}),

$$R_w = R * (w/w+h)$$

where, R_w = response from wild, R = response from site, w = wild fish observed within population area S_{pt} and, h = hatchery fish observed within population area S_{pt}.

To expand our observations to areas not surveyed, we weighed each site to represent a fraction of the overall spawning habitat in the population areas (S_{pt}). The response from each site was multiplied by this fraction, or weight, to determine redds abundance over the whole area. Weight was calculated using the formula

$$W = m / \sum \boldsymbol{I} (S_{pt})$$

where W = weight, m = total spawning habitat stream miles in population area S_{pt}. The total miles of winter steelhead spawning habitat within each population area was estimated using ArcMap (ESRI) at a 1:24,000 scale (Suring 2006a).

By combining these variables we calculated steelhead redd abundance for the entire population areas. For population area (S_{pt}),

$$X = \sum R * W$$

where, X = steelhead redd abundance, R = response for each site, and W = weight. Similarly, the response variable for wild fish (R_W) was used to determine redd abundance from wild steelhead. Furthermore, this redd abundance estimate was converted from redds to adults using the equation

$$N = 1.0379X + 42$$

where, N = number of adult spawners, and X = redd abundance. This conversion was derived from calibration studies along the Oregon coast by ODFW Western Oregon Research and Monitoring Program (Jacobs et al 2002).

Finally, we used R statistical program and software package "psurvery.analysis," which used a local variance estimator to calculate 95% confidence limits (R Statistical Package, available at http://epa.gov/nheerl/arm/analysispages/software.htm).

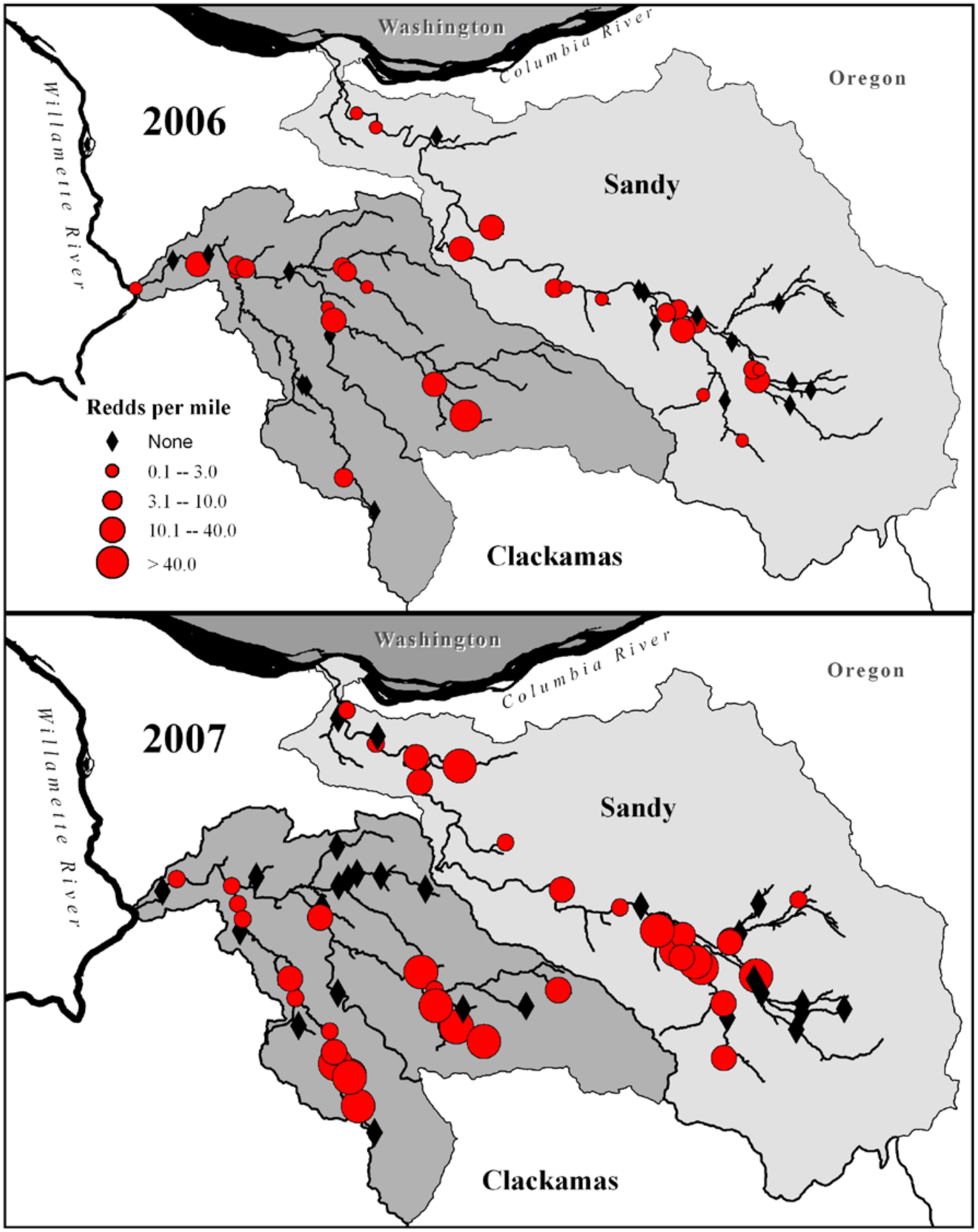
Results

In 2006, we selected a total of 61 EMAP points across the spawning habitat sample frame. Of those 61 points, 51 (84%) were successfully surveyed. In 2007, we refined our site selection and broadened our survey scope by selecting 70 points and successfully surveying 65 (93%) of the points (Table 1). Unsuccessful surveys were those points that could not be accessed due to lack of landowner consent, or road and weather conditions, or surveys that did not maintain a 14-day survey rotation.

TABLE 1. Summary of study surveys by basin and strata. (* = not statistically valid)

Basin stratum	Total Habitat miles	Number of surveys		Survey miles	
		2006	2007	2006	2007
Clackamas River	123.1	21	34	23.3	38.1
tributary	100.1	13	28	12.4	27.4
main stem	23.0	8	6	12.5	10.7
Sandy River	166.7	25	31	26.7	39.1
tributary	131.2	17	21	15.0	18.3
main stem	35.5	8	10	11.8	20.8
Upper Sandy River	118.6	19	23	20.1	25.5
tributary	111.3	13	18	13.7	15.9
main stem	7.3	4	5	6.4	9.7
Lower Sandy River	48.1	6	8	6.6	13.5
tributary	19.8	2*	3*	1.6	2.4
main stem	28.3	4	5	5.0	11.1
Total	289.8	46	65	50.0	77.2

FIGURE 2. Winter steelhead observations in the Clackamas and Sandy Rivers. Circle size is proportionate to number of redds counted at each site, diamonds indicate sites with no redds observed.



Estimates of wild steelhead abundance varied between the two sample years. For the Clackamas River we estimated 878 (95% confidence interval, 361-1393) winter steelhead in 2006 and 670 winter steelhead (95% confidence interval, 438-902) for 2007. For the Sandy River we estimated 839 (95% confidence interval, 479-1199) winter steelhead for 2006 and 1248 (95% confidence interval, 755-1741) (Table 2). The precision of abundance estimates for 2006 was 59% for the Clackamas River and 43% for the Sandy River. These numbers greatly improved in 2007 with 35% precision in the Clackamas and 39% in the Sandy. Precision of individual strata and populations ranged from 35% to 161%, since the sample size of these sub-samples is reduced (Table 2). In the lower Sandy River tributary strata there was less than four sites and result from abundance estimates are statistically invalid.

TABLE 2. Clackamas and Sandy river winter steelhead abundance estimates for 2006 and 2007 spawning seasons. Estimates are derived from counts in EMAP selected spawning surveys.

	Steelhead abundance					
Basin stratum	Estimate 2006	Estimate 2007	Lower confidence 2006	Lower confidence 2007	Upper confidence 2006	Upper confidence 2007
Clackamas River	878	670	361	438	1393	902
tributary	954	531	283	341	1624	721
main stem	126	102	52	28	202	176
Sandy River	839	1248	479	755	1199	1741
tributary	671	933	321	417	1020	1447
main stem	210	351	51	112	369	590
Upper Sandy River	519	1054	257	562	782	1545
tributary	557	831	251	339	862	1323
main stem	75	131	29	4	121	258
Lower Sandy River	341	260	109	97	573	423
tributary	234	173	0	0	612	408
main stem	172	148	9	72	335	223

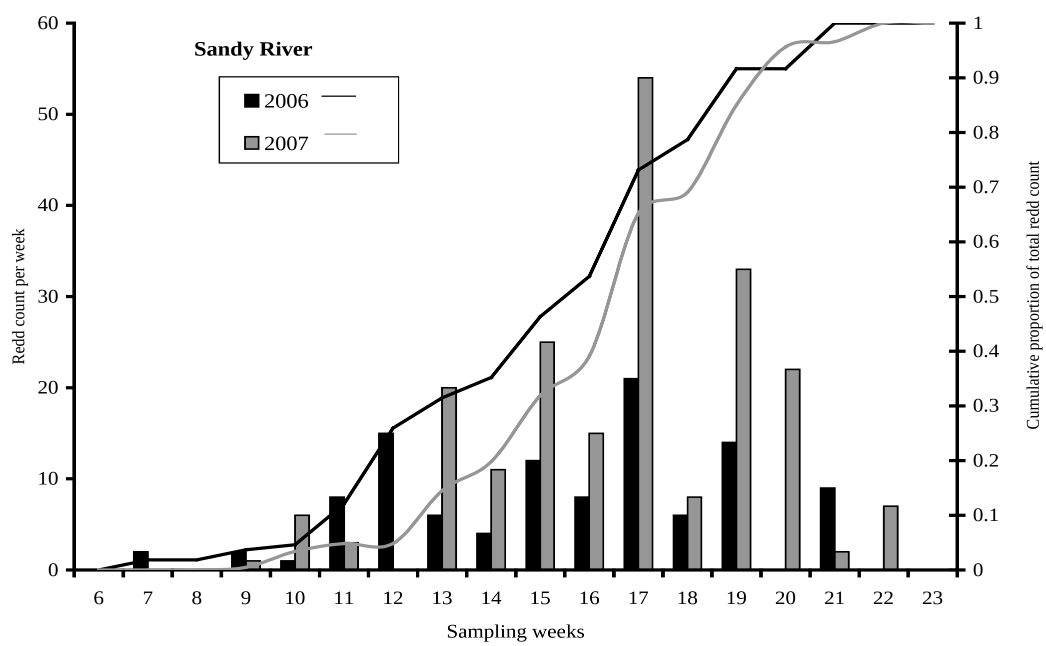
Marked hatchery fish were observed in the Clackamas River study area. Consequently, we discounted hatchery fish from the total abundance figure to estimate wild winter steelhead. In the 2006, we estimated 493 (95% confidence interval, 214-773) wild winter steelhead, and 2007 we estimated 513 (95% confidence interval, 264-683) wild winter steelhead in the lower Clackamas River (Table 2). No hatchery winter steelhead where positively identified in the Sandy River during surveys, therefore abundance estimates for the Sandy basin remain unchanged and represents only wild winter steelhead.

We identified the fin-clip status of 26% of the live fish observed in 2006 and 52% in 2007. Our observed wild:hatchery ratio was within 2% of the ratio recorded at Marmot Dam on the Sandy River for both sample years. Our observed ratio for the Clackamas River was within 4% of that observed at North Fork Dam both years (Table 3).

TABLE 3. The number of live and dead steelhead by adipose fin clip status. Fish with unknown fin clip status are not included in calculating total percent of wild fish observations.

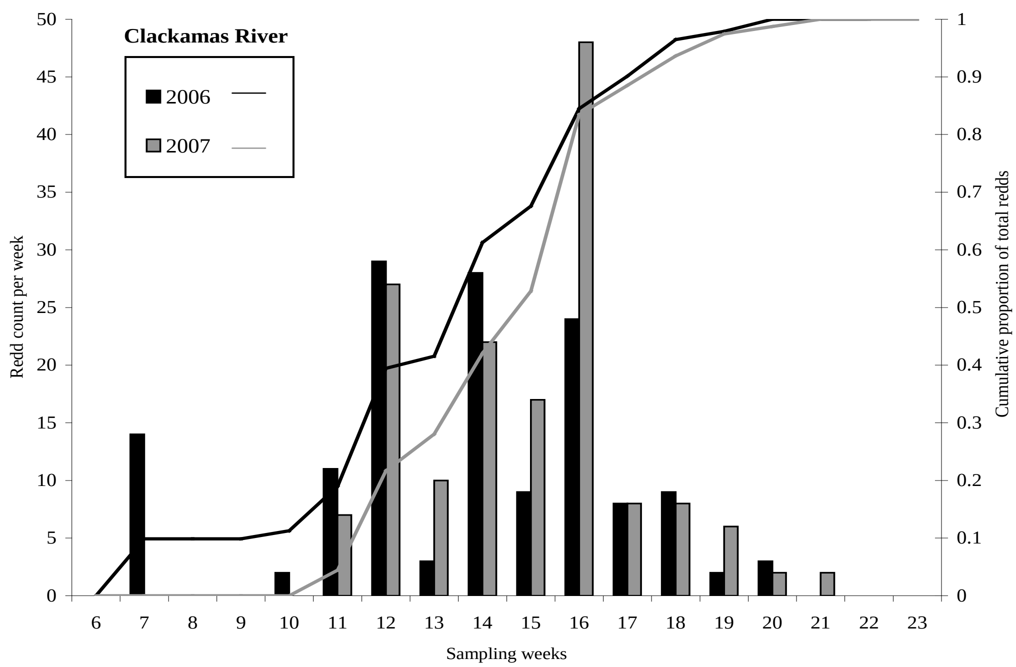
Basin stratum	% wild		Fish observed: Marked		Unmarked		Unknown	
	2006	2007	2006	2007	2006	2007	2006	2007
Clackamas River	54	75	11	5	13	15	61	19
tributary	52	73	11	4	12	11	46	14
main stem	100	80	0	1	1	4	15	5
Lower Sandy River	100	100	0	0	8	5	29	9
tributary	100	100	0	0	7	2	15	1
main stem	100	100	0	0	1	3	14	8
Upper Sandy River	100	100	0	0	5	9	18	4
tributary	100	100	0	0	1	9	7	2
main stem	100	100	0	0	4	0	11	2
Total	70%	92%	11	5	26	29	108	33

FIGURE 3. Observations of winter steelhead redds in the Clackamas River basin by calendar week. See Appendix A for specific dates of sampling weeks. See Appendix B and C for specific reach results.



Steelhead spawning activity was observed in the Clackamas River and Sandy River from the second week in February to the last week in May (Figures 1 and 2). Spawn timing in each population showed similar trends in both years of surveys. Each basin showed a spike in redd counts in week 7 of 2006 due to early run hatchery fish. Also, the 2007 peak redd count for both basins was in weeks 16-17 (Figures 3 and 4).

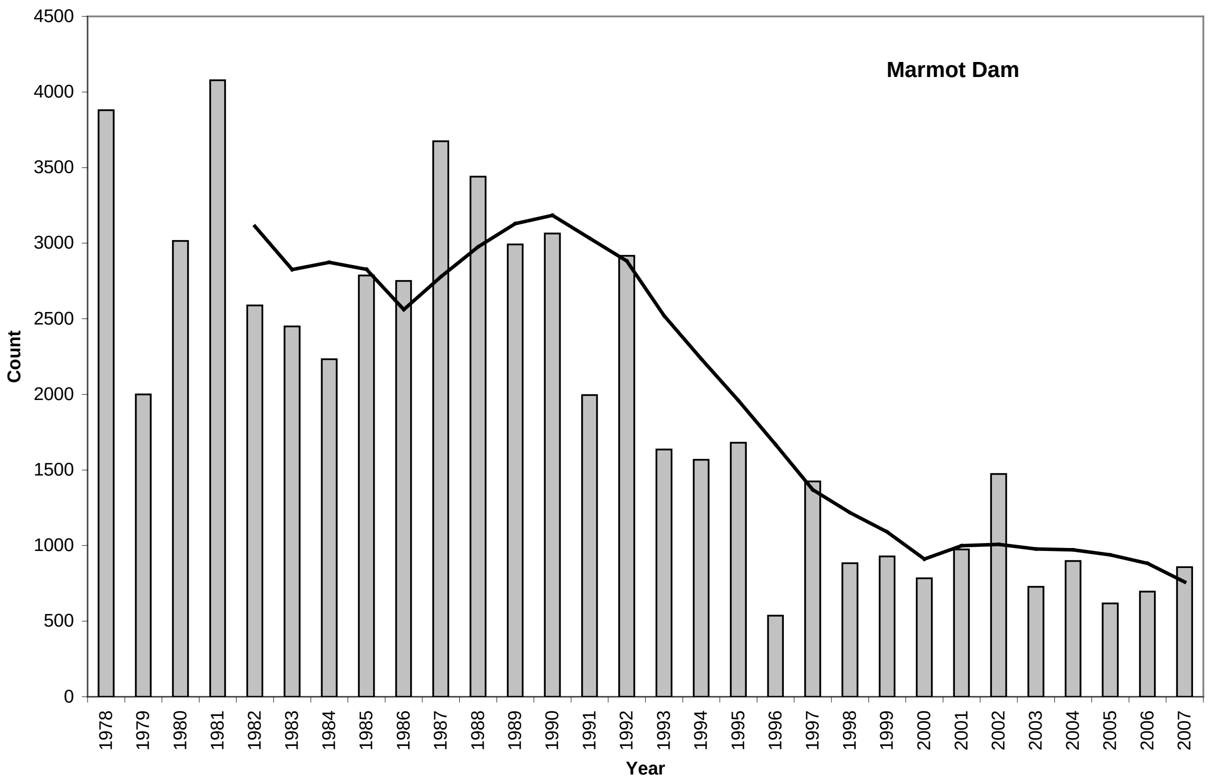
FIGURE 4. Observations of winter steelhead redds in the Sandy River basin by calendar week. See Appendix A, B, and C.



Discussion

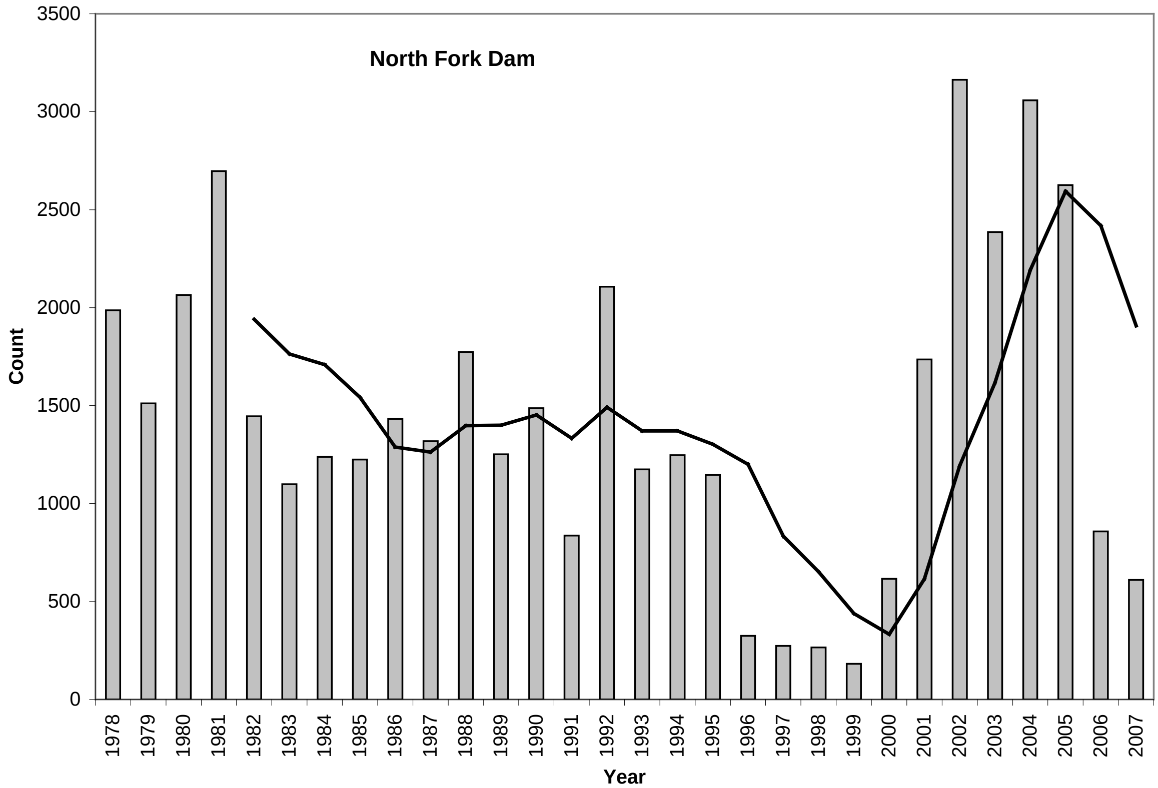
As the two largest sub-basins in the Oregon portion of the Lower Columbia ESU, the Clackamas and Sandy rivers contribute significantly to the ecological integrity of larger regional populations of winter steelhead. ODFW has developed population objectives to ensure that the Clackamas and Sandy rivers continue to produce winter steelhead at levels to support the biological functions of the ESU as well as recreational sport fisheries. The Sandy River Basin Plan of 2001 sets an objective of an annual escapement of 1,730 wild winter steelhead and to "[e]stablish an increasing trend in the population of Sandy River wild winter steelhead" (Muck and Flory 2001). Runs of Sandy River wild winter steelhead have not exceeded this objective since 1992, based on fish passage at Marmot dam, (Figure 5, available at www.portlandgeneral.com/community_and_env/hydropower_and_fish). Following this trend, our population estimates are approximately half of the objective set forth in the Sandy River Basin Plan (Muck and Flory 2001), but our 95% upper confidence limits nears this objective mark.

FIGURE 5. Yearly winter steelhead counts at Marmot Dam on the Sandy River with 5 year average trend lines. Counts represent combined hatchery and wild fish counted at traps.



Similarly, the Clackamas Subbasin Fish Management Plan places emphasis on escapement goals for wild winter steelhead in the Clackamas River, particularly in the upper Clackamas River above North Fork Dam. Murtagh et al believe that 13,000 adult steelhead are needed to fully seed the habitat above North Fork Dam, but state that "an escapement of 3,000 indigenous winter steelhead represents a reasonable interim goal to reverse the decline in escapement" (Murtagh, 1992). Figure 6 shows the trend in winter steelhead counted at North Fork Dam.

FIGURE 6. Yearly winter steelhead counts at North Fork Dam on the Clackamas River with 5-year average trend lines. Counts represent combined hatchery and wild fish counted at traps.



Sample Design

Comparing our estimate of winter steelhead escapement to actual fish counted at Marmot Dam provided us with an excellent opportunity to scrutinize our sampling design. The accuracy of our estimates for winter steelhead above Marmot Dam were within 25% of the actual number of fish counted at the Marmot Dam fish trap. Therefore, our estimates meet the criteria of our monitoring design to estimate population size within 30% (Susac and Jacobs 2001). The variance in our basin-wide estimates ranged from 35% to 57%, but this was expected given the variation in spatial density of response, large sample frame, survey conditions, and site accessibility problems. For example, winter steelhead spawning activity in the upper Sandy basin was locally distributed. Spawning activity was concentrated in reaches of high quality habitat, such as Still Creek and Sixes Creek. In 2006, 71% of total redds in the upper Sandy basin were observed at three sites.

Given the variation in response from sites; it is likely that the sample frame includes areas that may not be used by winter steelhead. For example, we did not encounter steelhead activity during surveys in the upper watershed, such as Camp Creek, Devils Canyon Creek, or upper Still Creek.   On the other hand, these areas represent areas of possible or historical steelhead habitat and the site selection process is designed to “ensure that the resulting sample has spatial properties reminiscent of the population” (Stevens 2002). In the case of the Sandy basin, winter steelhead spawning activity was concentrated in a few areas over the entire network of possible spawning habitat and using random spatial balanced site selection accurately characterizes this winter steelhead population. If sites were chosen based on level of response, the surveys would conversely tend to over-estimate the number of steelhead in the population. The sample frame used for site selection is based on five years of reconnaissance by ODFW Corvallis Research and represents the best available knowledge of current and historic winter steelhead distribution (Brown 2007). Other sources of error in our estimate may include under-counting redds in surveys, especially in main stem reaches where the surveys were conducted by boat. Also, we did not survey a number of sites due to low snow levels blocking access or problems with private landowners which decrease our sample size.

Unlike the Sandy River where we can compare our results to fish counts at a dam, the study area of the Clackamas River occurred completely below the North Fork Dam. McElhany et al (2007) suggests that since the area below North Fork Dam represents 40% of the available winter steelhead spawning habitat, and that a conversion from North Fork dam fish counts could provide a coarse estimation of winter steelhead abundance in the lower Clackamas River. McElhany et al's method is useful for historical comparisons but is simplistic and does not correspond to our estimate using randomized sampling. However, this provides a good example for the need for robust sampling efforts in order to avoid generalizations about fish population, especially those that are federally listed as threatened.

Overall, we noticed poor response from main stem reaches. At times redd delineation was difficult due to jet boats or boat anchors creating redd-like scars in pool tail outs. There was also copious amounts Pacific lamprey *Lampetra tridentata* spawning activity late in the season which further complicated winter steelhead redd identification.

Hatchery:Wild Ratios

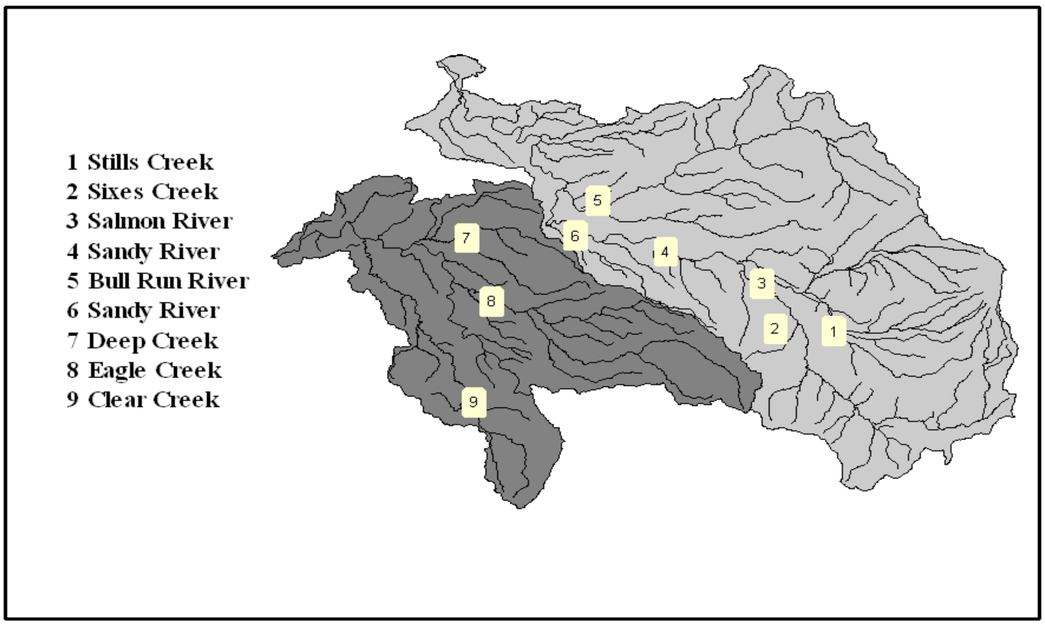
We relied on visual observations to determine fin clip status to obtain a wild winter steelhead abundance estimate. All hatchery-raised winter steelhead in the Clackamas and Sandy River basins have their adipose fin clipped. Visual observations of adipose fin clip presence or absence on live fish can be challenging in the field. Water clarity, depth, and flow all pose possible problems for identifying fin clip status of winter steelhead. Unlike Coho and Chinook salmon, which fin clip status can be determined from carcasses, steelhead do not always perish after spawning and carcasses are difficult to recover. Keeping these limitations in mind, it is possible to carefully and accurately identify a number of winter steelhead as hatchery or wild. During the 2006 winter steelhead spawning survey season we were successful in positively identifying the fin clip status of 34 % of the live fish observed during surveys. This coincides with Susac and Jacobs (2001) observations that 30 % of steelhead can be identified as hatchery or wild based on adipose fin clips. There were no winter steelhead in the Sandy basin identified as hatchery fish (i.e. with an adipose fin clip); while in the Clackamas basin 46% of the live fish were identified with fin clips. The difference in the observations of hatchery fish between basins is due to our focus on the lower Clackamas River below North Fork Dam where hatchery fish would most likely be observed, compared to the upper Sandy River basin where hatchery fish are excluded.

In the Clackamas basin, hatchery-origin naturally reproducing winter steelhead were common during our surveys, especially on Eagle Creek. The origin of native and hatchery steelhead can be accurately classified by scale analysis (Hankin 1982) or microsatellite DNA variation techniques (Beacham et al, 1999) but these methods are time consuming, expensive, and require handling of live fish or carcasses. Over two years, we only recovered three winter steelhead carcasses. Despite the involved nature of determining hatchery or wild origin beyond fin clip status, future studies using these methods could provide important insights on the levels of hatchery fish straying and the possible genetic influences of hatchery fish on native steelhead stocks.

Index Site Development

The EMAP-based study design is intended for long term monitoring of fish populations, and 2007 is only the third year of full implementation of the protocol in the Sandy and Clackamas Rivers. Although the need and aspirations for the long-term application of the EMAP procedures in monitoring winter steelhead are certain, the funding sources are not. Compared to other fish monitoring programs this project is relatively inexpensive, but requires the retention of field staff for at least six months per year. Given the uncertainty of future funding sources, a scaled back monitoring program using index sites could provide limited information about winter steelhead populations when funding for large EMAP style programs is lacking. Index site monitoring useful in tracking trends in fish populations but may not meet the requirement of the Willamette-Lower Columbia Technical Recover Team that monitoring "must meet reasonable standards of statistical rigor"(NOAA, 2005). Figure 7 provides a general overview of surveys that could be used for index monitoring in the future. The suggested sites are areas with spawning activity and easy access.

FIGURE 7. Suggested sites for spawning ground index surveys.



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Appendix A: Dates of sampling weeks for 2006.

Sampling Week	Dates			Sampling Week	Dates		
6	2/5/2006	--	2/11/2006	15	4/9/2006	--	4/15/2006
7	2/12/2006	--	2/18/2006	16	4/16/2006	--	4/22/2006
8	2/19/2006	--	2/25/2006	17	4/23/2006	--	4/29/2006
9	2/26/2006	--	3/4/2006	18	4/30/2006	--	5/6/2006
10	3/5/2006	--	3/11/2006	19	5/7/2006	--	5/13/2006
11	3/12/2006	--	3/18/2006	20	5/14/2006	--	5/20/2006
12	3/19/2006	--	3/25/2006	21	5/21/2006	--	5/27/2006
13	3/26/2006	--	4/1/2006	22	5/28/2006	--	6/3/2006
14	4/2/2006	--	4/8/2006				

Appendix B: Summary of 2006 winter steelhead spawning ground surveys in the Clackamas and Sandy Rivers. Survey reaches are listed in upstream order.

							Steelhead					Lamprey
							Live Fish Observations					
	Reach	Seg-ment	Downstream Reach Boundary	Upstream Reach Boundary	Times Surveyed	Survey Length (miles)	Total	Marked	Un marked	Un known	Redd/mi	Redd/mi
CLACKAMAS	Clackamas R	1	Mouth	Rock Cr	9	1.5	0	0	0	0	0.7	0.0
CLACKAMAS	Clackamas R	4	Mouth	Rock Cr	9	1.9	0	0	0	0	0.0	0.0
CLACKAMAS	Clackamas R	5	Mouth	Rock Cr	9	1.5	0	0	0	0	10.7	0.6
CLACKAMAS	Clackamas R	6	Mouth	Rock Cr	9	1.4	1	0	0	1	0.0	0.0
CLACKAMAS	Clear Cr	1	Mouth	Trib A	9	1.0	0	0	0	0	2.0	0.0
CLACKAMAS	Clear Cr	4	Mouth	Trib A	9	1.5	0	0	0	0	0.7	0.0
CLACKAMAS	Clear Cr	1	Little Clear Cr	Trib A2	9	1.1	0	0	0	0	0.0	0.0
CLACKAMAS	Clear Cr	1	Swagger Cr	Little Cedar Cr	8	0.9	3	0	3	0	4.4	0.0
CLACKAMAS	Little Clear Cr	1	Mouth	Headwaters	5	0.4	0	0	0	0	0.0	0.0
CLACKAMAS	Clackamas R	1	Clear Cr	Richardson Cr	9	1.2	2	0	1	1	5.8	0.0
CLACKAMAS	Tickle Cr	2	Mouth	Tickle Cr, S Fk	6	1.6	1	0	0	1	1.9	0.0
CLACKAMAS	Tickle Cr	2	Trib B	Trib C	7	0.6	0	0	0	0	0.0	0.0
CLACKAMAS	Deep Cr	1	Tickle Cr	Deep Cr, Trib B	10	1.5	2	0	1	1	6.7	0.0
CLACKAMAS	Deep Cr	2	Tickle Cr	Deep Cr, Trib B	10	1.1	0	0	0	0	2.7	1.3
CLACKAMAS	Deep Cr	2	Deep Cr, Trib B	Headwaters	7	1.0	0	0	0	0	0.0	1.1
CLACKAMAS	Clackamas R	1	Deep Cr	Goose Cr	9	1.2	1	0	0	1	0.0	0.0
CLACKAMAS	Clackamas R	1	Goose Cr	Eagle Cr	9	1.8	5	0	0	5	0.6	0.0
CLACKAMAS	Eagle Cr	1	Mouth	Currin Cr	9	1.3	13	0	3	10	13.1	15.0
CLACKAMAS	Eagle Cr	3	Eagle Cr, N Fk	Delph Cr	9	0.7	15	1	2	12	28.6	13.3
CLACKAMAS	Eagle Cr	4	Delph Cr	Eagle Cr, S Fk	9	0.7	35	10	2	23	84.3	0.0
CLACKAMAS	Clackamas R	1	Eagle Cr	Dubois Cr	9	2.0	7	0	0	7	0.0	5.0
SANDY	Sandy R	3	Beaver Cr	Big Cr	8	1.3	1	0	0	1	1.5	0.0
SANDY	Sandy R	5	Beaver Cr	Big Cr	8	2.9	9	0	0	9	0.3	2.8
SANDY	Buck Cr	1	Mouth	Headwaters	7	0.4	2	0	2	0	0.0	23.8
SANDY	Sandy R	1	Gordon Cr	Trout Cr	8	0.4	1	0	0	1	0.0	0.0
SANDY	Bull Run R	1	Little Sandy R	Bull Run Res 2	7	0.9	20	0	5	15	21.1	0.0
SANDY	Sandy R	2	Cedar Cr	Badger Cr	6	0.7	4	0	1	3	20.0	0.0
SANDY	Sandy R	5	Badger Cr	Whisky Cr	10	0.6	0	0	0	0	16.4	0.0
SANDY	Sandy R	1	Whisky Cr	Spring Trib A	10	1.4	3	0	0	3	0.7	0.0
SANDY	Wildcat Cr	1	Mouth	Headwaters	10	0.8	0	0	0	0	1.2	0.0

SANDY	Sandy R	1	Spring Trib B	Salmon R	10	0.9	1	0	0	1	0.0	0.0
	Boulder Cr	2	Mouth	Headwaters	10	0.9	0	0	0	0	0.0	0.0
	Salmon R	2	Boulder Cr	Sixes Cr	9	1.7	7	0	0	7	7.2	0.0
	Sixes Cr	1	Mouth	Headwaters	11	0.4	1	0	1	0	15.0	0.0
	Cheeney Cr	1	Little Cheney Cr	Headwaters	10	1.3	0	0	0	0	1.5	0.0
	Trib A, Salmon R	1	Mouth	Headwaters	10	0.1	0	0	0	0	0.0	0.0
	Salmon R	1	Salmon R, S Fk	Trib B, Salmon R	8	1.3	0	0	0	0	0.8	0.0
	Hackett Cr	2	Mouth	Headwaters	10	1.0	0	0	0	0	0.0	0.0
	Sandy R	1	Hackett Cr	Bear Cr	10	3.6	11	0	4	7	5.6	0.0
	Bear Cr	2	Mouth	Headwaters	10	0.7	0	0	0	0	0.0	0.0
	Still Cr	1	Mouth	Cool Cr	11	1.0	0	0	0	0	6.0	0.0
	Still Cr	2	Mouth	Cool Cr	11	0.9	0	0	0	0	14.4	0.0
	Still Cr	2	Cool Cr	Trib A, Still Cr	10	0.7	0	0	0	0	0.0	0.0
	Zigzag R	2	Still Cr	Camp Cr	12	0.7	0	0	0	0	1.4	0.0
	Camp Cr	1	Wind Cr	Headwaters	10	1.1	0	0	0	0	0.0	0.0
	Devil Canyon	1	Mouth	Headwaters	10	0.4	0	0	0	0	0.0	0.0

Appendix C: Summary of 2007 winter steelhead spawning surveys in the Clackamas and Sandy rivers.

							Steelhead					
							Live Fish Observations					Lamprey
	Reach	Seg- ment	Downstream Reach Boundary	Upstream Reach Boundary	Times Surveyed	Survey Length (miles)	Total	Marked	Un marked	Un known	Redd/mi	Redd/mi
CLACKAMAS	Clackamas R	4	Mouth	Rock Cr	7	1.9	0	0	0	0	0.0	71.6
	Clackamas R	5	Mouth	Rock Cr	7	1.5	1	0	0	1	2.0	94.7
	Clackamas R	1	Rock Cr	Clear Cr	7	1.5	2	0	0	2	0.7	52.0
	Clear Cr	3	Mouth	Trib A	6	1.5	0	0	0	0	2.0	36.7
	Clear Cr	2	Mouth	Trib A	6	1.5	0	0	0	0	2.0	42.7
	Clear Cr, Trib A	1	Mouth	Headwaters	5	0.5	0	0	0	0	0.0	0.0
	Clear Cr	2	Bargfeld Cr	Little Clear Cr	5	0.5	0	0	0	0	4.0	0.0
	Little Clear C	1	Mosier Cr	Headwaters	5	0.8	0	0	0	0	0.0	0.0
	Clear Cr	4	Little Clear Cr	Trib A2	5	0.9	0	0	0	0	1.1	14.4
	Clear Cr	5	Little Clear Cr	Trib A2	4	0.6	2	0	2	0	6.7	15.0
	Clear Cr	1	Little Clear Cr	Trib A2	6	1.2	0	0	0	0	1.7	3.3
	Clear Cr	1	Trib A2	Trib B	6	1.5	3	0	2	1	12.0	10.0
	Clear Cr	1	Trib B	Swagger Cr	6	0.7	1	0	0	1	18.6	41.4
	Clear Cr	1	Little Cedar Cr	Little Clear Cr	6	1.1	8	0	4	4	8.2	0.0
	Little Clear Cr	1	Mouth	Headwaters	5	0.6	0	0	0	0	0.0	0.0
	Richardson Cr	1	Mouth	Headwaters	5	1.4	0	0	0	0	0.0	0.0
	Deep C, N FK	3	Mouth	Doane C	6	1.3	4	1	0	3	0.0	0.0
	Deep Cr	2	Trib A	Tickle Cr	6	0.9	0	0	0	0	0.0	0.0
	Tickle Cr	2	Mouth	Tickle Cr, S FK	6	1.6	0	0	0	0	0.0	0.0
	Tickle Cr, S FK	1	Mouth	Winslow Cr	6	0.5	0	0	0	0	0.0	0.0
	Tickle Cr	1	Trib C	Headwaters	5	1.3	0	0	0	0	0.0	0.0
	Clackamas R	2	Deep Cr	Goose Cr	7	1.6	0	0	0	0	0.0	0.0
	Clackamas R	1	Goose Cr	Eagle Cr	7	1.8	1	0	1	0	6.1	13.3
	Eagle Cr, N FK	1	Mouth	Bear Cr	7	0.5	0	0	0	0	22.0	0.0
	Eagle Cr, N FK	1	Bear Cr	Suter Cr	6	0.8	0	0	0	0	2.5	0.0
	Suter Cr	2	Mouth	Headwaters	6	0.7	0	0	0	0	0.0	0.0
	Little Eagle Cr	3	Mouth	Headwaters	4	0.8	0	0	0	0	0.0	0.0
	Eagle Cr, N FK	2	Trout Cr	Headwaters	6	1.3	1	0	1	0	3.8	0.0
	Eagle Cr	3	Eagle C, N FK	Delph Cr	5	0.7	5	0	2	3	20.0	0.0

CLAC	Eagle Cr	5	Delph Cr	EagleCr, S FK	5	1.1	2	2	0	0	20.9	0.0
	Eagle Cr	3	Delph Cr	EagleCr, S FK	5	0.8	2	1	0	1	36.3	0.0
	Clackamas R	2	Eagle Cr	Dubois Cr	6	2.4	6	1	3	2	0.0	0.0
SANDY	Beaver Cr	3	Mouth	Kelly Cr	6	1.0	0	0	0	0	0.0	0.0
	Sandy R	5	Beaver Cr	Big Cr	6	2.9	10	3	5	2	2.4	0.0
	Sandy R	2	Beaver Cr	Big Cr	6	4.4	0	0	0	0	0.5	0.0
	Sandy R	3	Beaver Cr	Big Cr	6	1.3	0	0	0	1	0.0	0.0
	Sandy R	1	Big Cr	Buck Cr	6	2.0	2	0	0	2	3.5	0.0
	Gordon Cr	3	Mouth	Cat Cr	5	0.5	3	0	2	1	31.5	0.0
	Sandy R	2	Trout Cr	Bear Cr	6	0.4	8	0	3	5	20.0	0.0
	Bull Run R	2	Little Sandy R	Bull Run Res 2	4	0.9	0	0	0	0	1.1	0.0
	Sandy R	4	Badger Cr	Whiskey Cr	6	0.6	0	0	0	0	3.3	0.0
	Sandy R	1	Wildcat Cr	Spring Trib B	6	2.3	0	0	0	0	2.6	0.0
	Little Joe Cr (Trib B)	1	Mouth	Headwaters	6	0.9	0	0	0	0	0.0	0.0
	Salmon R	1	Boulder Cr	Sixes Cr	8	1.0	2	0	1	1	21.0	0.0
	Salmon R	2	Boulder Cr	Sixes Cr	8	1.7	2	0	2	0	34.7	0.0
	Sixes Cr	1	Mouth	Headwaters	7	0.4	0	0	0	0	10.0	0.0
	Salmon R	1	Sixes Cr	GC Trib, Salmon R	8	1.2	2	0	2	0	16.6	0.0
	Salmon R	1	Cheeney Cr	Trib A, Salmon R	8	0.9	1	0	0	1	3.2	0.0
	Salmon R	2	Cheeney Cr	Trib A, Salmon R	8	1.0	0	0	0	0	0.0	0.0
	Salmon R, S FK	1	Mouth	Mack Hall Cr	5	0.9	0	0	0	0	4.4	0.0
	Sandy R	1	Hackett Cr	Bear Cr	6	3.6	2	0	0	2	9.7	0.0
	Henry Cr	1	Mouth	Caldwell Cr	6	1.0	0	0	0	0	11.0	0.0
	Still Cr	2	Cool Cr	Trib A, Still Cr	5	0.7	0	0	0	0	0.0	0.0
	Zigzag R	3	Still Cr	Camp Cr	6	0.5	0	0	0	0	0.0	0.0
	Zigzag R	1	Still Cr	Camp Cr	7	0.6	0	0	0	0	0.0	0.0
	Wind Cr	1	Mouth	Headwaters	6	0.4	0	0	0	0	0.0	0.0
	Camp Cr	3	Wind Cr	Headwaters	5	1.0	0	0	0	0	0.0	0.0
	Zigzag R	1	Devil Canyon	Lady Cr	7	0.8	0	0	0	0	0.0	0.0
	Clear Cr	1	Mouth	Little Clear Cr	8	0.8	2	0	2	0	3.9	0.0
	Clear Cr	1	Clear Cr, Trib A	Headwaters	7	0.7	0	0	0	0	0.0	0.0
	Sandy R	1	Clear Cr, Trib A	Horseshoe Cr	5	0.8	0	0	0	0	0.0	0.0
	Clear Fk	1	Mouth	Headwaters	5	1.5	0	0	0	0	2.6	0.0
	Muddy Fk	1	Mouth	Headwaters	5	0.6	0	0	0	0	0.0	0.0