Work Completed for Compliance with the 2008 Willamette Project Biological Opinion, USACE funding: 2013 hatchery baseline monitoring

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Section 1: Introduction

The National Marine Fisheries Service (NMFS) listed spring Chinook salmon *Oncorhynchus tshawytscha* and winter steelhead *O. mykiss* in the upper Willamette River Evolutionarily Significant Unit (ESU) as threatened under the Endangered Species Act (ESA; NMFS 1999a; NMFS 1999b). As a result, any actions taken or funded by a federal agency in the ESU must be evaluated to assess whether they are likely to jeopardize threatened and endangered species, or result in the destruction or impairment of critical habitat. Several hatcheries produce and release hatchery salmonids in the upper Willamette Basin (Figure 1), which may impact wild populations of listed species. All hatcheries are operated by the Oregon Department of Fish and Wildlife (ODFW) and are funded (50–100%) by the U.S. Army Corps of Engineers (USACE).

Potential risks of artificial propagation programs have been widely debated (e.g. Kostow and Zhou 2006; Levin and Williams 2002). Risks include disease transfer, competition for food and spawning sites, increased predation, increased incidental mortality from harvest, loss of genetic variability, genetic drift, and domestication (Steward and Bjornn 1990; Hard et al. 1992; Cuenco et al. 1993; Busack and Currens 1995, and Waples 1999). Hatcheries can also bolster spawner abundance—a critical consideration for those populations on the verge of extirpation—by providing a genetic reserve, and by providing marine-derived nutrients to streams (Steward and Bjornn 1990; Cuenco et al. 1993). Recent work, however, has shown that some hatchery fish tend to have lower reproductive success than wild fish even when broodstocks are largely comprised of wild fish (Araki et al. 2007) and productivity parameters are depressed when large numbers of hatchery salmonids mix with wild fish (Chilcote et al. 2012). However, reproductive success studies focused specifically on spring Chinook salmon yielded conflicting results with some suggesting lower reproductive success for hatchery Chinook salmon (Williamson et al. 2010) and others showing little difference between hatchery- and natural-origin fish (Hess et al. 2012).

The objective of this project is to conduct baseline monitoring of returning adult fish and to evaluate the potential effects of hatchery programs on naturally spawning populations of spring Chinook salmon and winter steelhead in the upper Willamette River Basin. Restoration of spring

Chinook salmon under the ESA and the implementation of ODFW's Native Fish Conservation Policy require monitoring the number of hatchery and wild fish that comprise the spawning populations in the Willamette Basin. The Willamette Project Biological Opinion identified the need to reduce hatchery fish spawning in the wild to "the lowest extent possible (0–10%)" (NOAA 2008).

In the Willamette Basin upstream of Willamette Falls (Figure 1), there are four distinct spring Chinook salmon hatchery programs (North Santiam [Stock 21], South Santiam [Stock 24], McKenzie [Stock 23], and Middle Fork Willamette [Stock 22]) that are managed for integrated harvest augmentation as part of the Willamette Valley Hatchery Mitigation Program. These hatchery stocks, as well as all naturally spawned spring Chinook salmon in the Upper Willamette Basin, are included in the Upper Willamette River Evolutionary Significant Unit (ESU).

The Upper Willamette Summer Steelhead Hatchery Program is managed to provide fish for sport fisheries and to replace loss of fisheries caused by habitat and passage loss/degradation in the Willamette and other lower Columbia basins. The hatchery program currently includes annual smolt releases into the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette rivers. Lack of access to historical habitat and degradation of remaining habitat below the dams, especially in the North and South Santiam (the "core" populations) are the key limiting factors shared between winter steelhead and spring Chinook salmon. In addition, summer steelhead are not native to the Willamette Basin upstream of Willamette Falls and a third, unique, limiting factor is the potential for competition, predation and genetic introgression from out-of-ESU hatchery fish interacting with and spawning in the wild with the native winter-run(Johnson et al. 2013). Summer steelhead were first introduced to the South Santiam River as mitigation for lost winter steelhead production in areas inundated by Foster and Green Peter reservoirs. The scope of work actually directed towards risks posed by summer steelhead is much smaller than that directed towards issues faced by spring Chinook salmon. The Willamette Project Biological Opinion (BiOP; NMFS 2008) required the USACE to collect information to describe the nature and extent of these potential effects but beyond relatively small-scale studies often integrated into much larger studies involving spring Chinook salmon, more focused work on steelhead will only follow commitment of significantly more effort and funds.

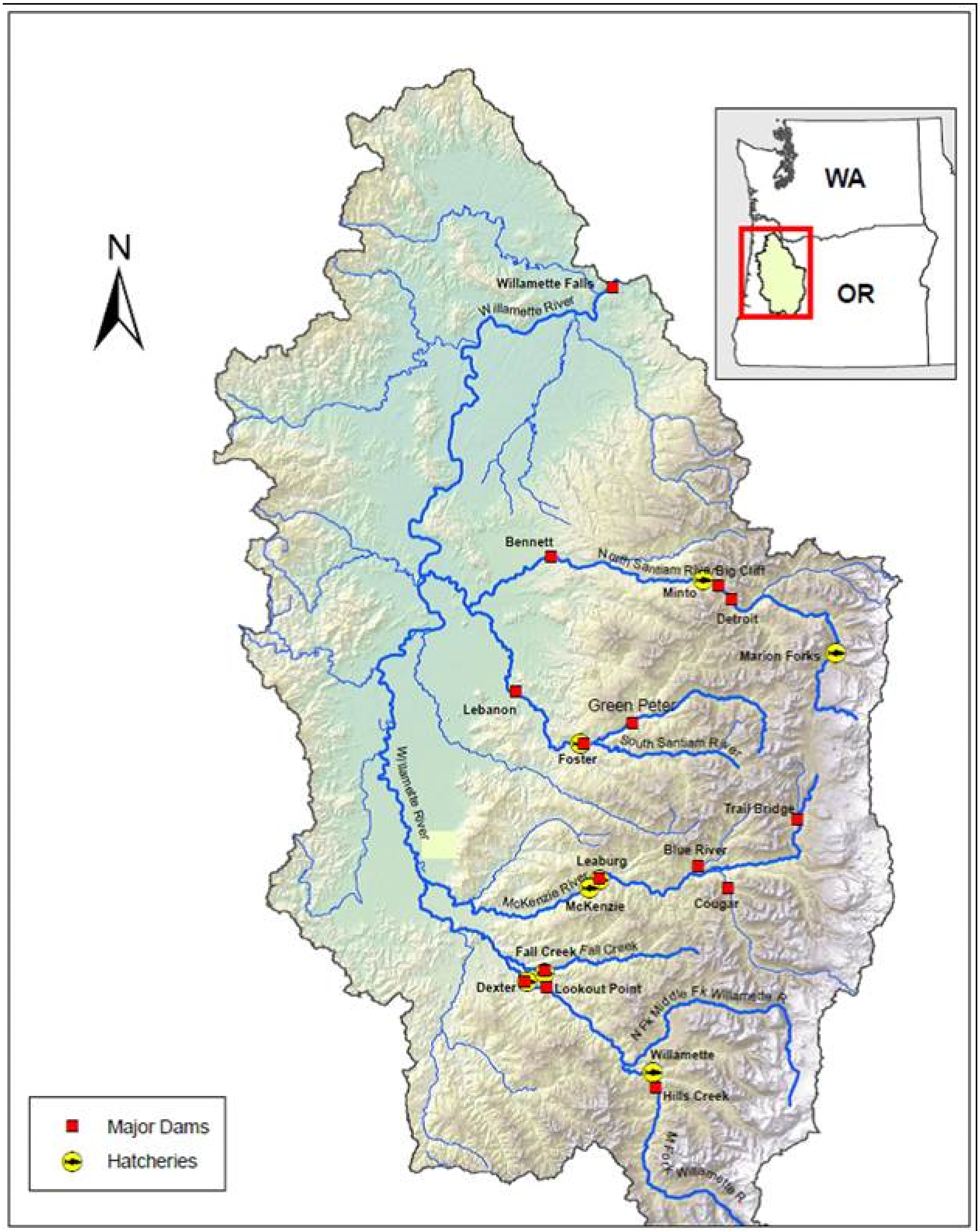

Figure 1. The Willamette Basin with major dams, hatcheries, and fish collection facilities.

This report fulfills a requirement under Task Order W9127N-12-2-0004-1009 covering activities of May 2013–June 2014, that were implemented by ODFW on behalf of the Corps to assist with meeting requirements of the reasonable and prudent alternatives (RPAs) and measures prescribed in the Willamette Project Biological Opinion (BiOp) of July 2008 (NOAA 2008). The Corps provided funding to continue ongoing monitoring activities and initiate long-term planning. The conceptual relationship between spring Chinook salmon prioritized objectives, RPAs, and 2013 work tasks is depicted in Figure 2. In future work, the intent is to expand the conceptual framework provided in Figure 2 and develop specific numerical goals in terms of, for example, adult returns desired per subbasin. A detailed list of tasks associated with the work is provided in Appendix 1.

The ultimate goal of ODFW's Hatchery Research, Monitoring and Evaluation (HRME) program is to inform decisions on operation of the USACE Willamette Valley Hatchery Mitigation Program so that mitigation goals are met while minimizing negative impacts on naturally-produced, listed species and promoting their conservation and recovery. Progress towards that goal will follow achievement of three overarching objectives:

1. Develop and maintain hatchery broodstocks to meet harvest goals and assist with implementation of the Upper Willamette Conservation and Recovery Plan for Chinook Salmon and Steelhead (National Marine Fisheries Service [NMFS] and ODFW 2011), while complying with the existing genetic guidelines (Hatchery Genetic Management Plans);

2. Rear and release high quality hatchery fish to minimize impacts on naturally produced fish and promote conservation and recovery of listed species;

3. Manage adult returns to minimize impacts on naturally produced populations and to aid in recovery goals.

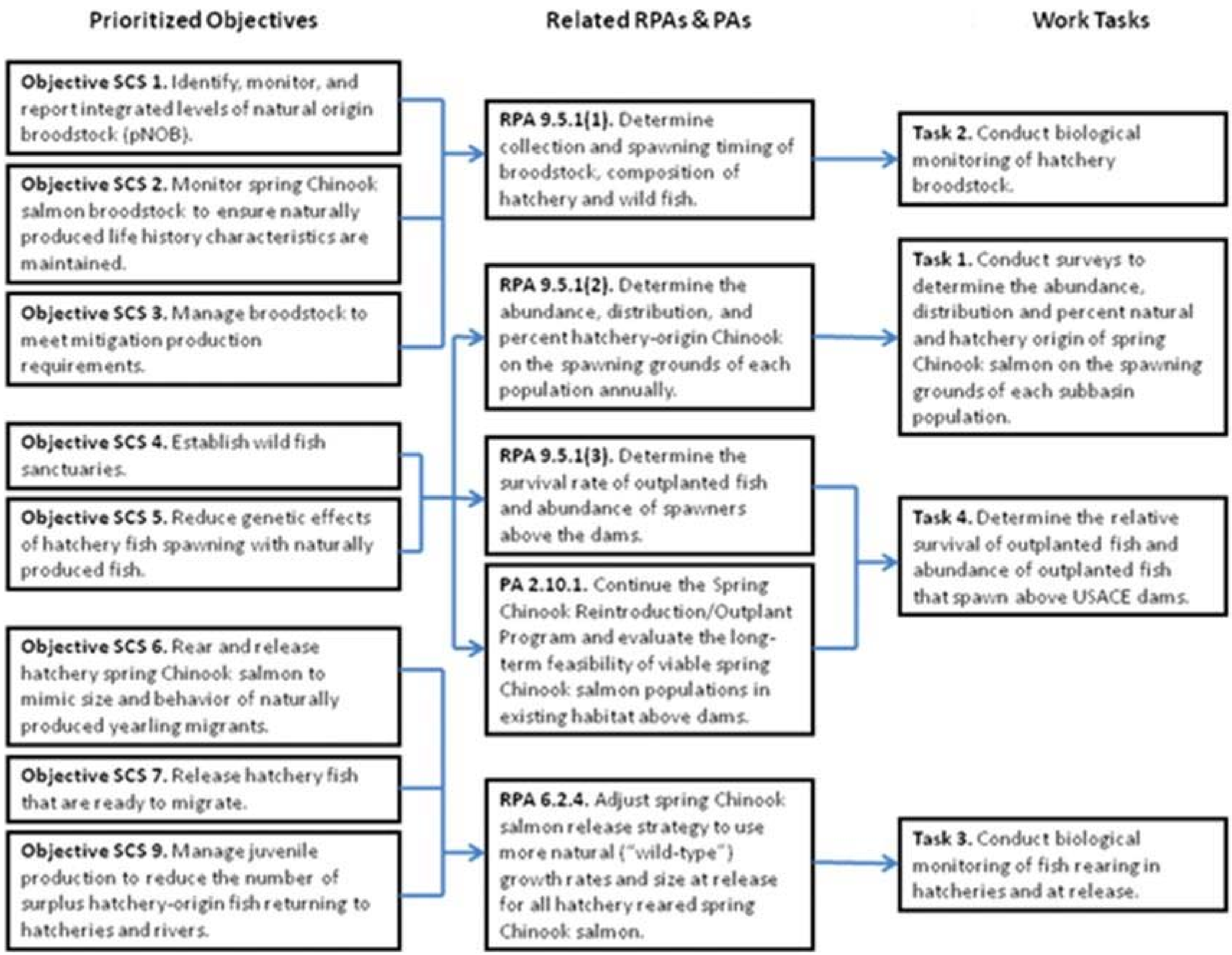

Figure 2. Relationship between Prioritized Objectives, Reasonable and Prudent Alternatives (RPAs), Proposed Actions (PAs), and Work Tasks conducted for spring Chinook salmon hatchery programs in the Upper Willamette Basin.

Section 1.1 Tasks

Task 1. Conduct surveys to determine the abundance, distribution and origin (hatchery or naturally-produced) of spring Chinook salmon on the spawning grounds of each subbasin population. (Objectives addressed: SCS 4 and SCS 5)

The purpose of this task is to describe the abundance, distribution, and composition (i.e., hatchery vs. natural origin fish) of adult spring Chinook salmon returning to spawn in Upper Willamette Basin tributaries. This task aims to describe, at varying spatial scales (Appendix 2), the population of adult returns with respect to: run size and timing, numbers of natural and hatchery origin fish collected for broodstock and outplanting, peak spawning dates, redd distribution and density, estimated natural spawner abundance, the proportion of hatchery origin fish on spawning grounds (pHOS), pre-spawning mortality (PSM) on spawning grounds, the age structure of the natural spawning population, hatchery stray rates, and harvest rates. To accomplish this, we employed a variety of data collection methods, such as monitoring the number of adipose fin clipped and unclipped adults arriving at dams and fish collection facilities, tracking the fate and disposition of fish entering traps and transported to hatcheries, conducting redd and carcass surveys on spawning grounds, sampling carcasses that were spawned at hatcheries, and compiling fish recapture data from the Regional Mark Information System (RMIS). Ultimately, the intent is to determine if mitigation goals have been met for harvest, broodstock, and conservation (reintroduction/outplanting). Establishing useful numeric goals for abundance and disposition of returning hatchery adults, goals that are agreed upon by the managers and Action Agencies, is an important ongoing process.

The spawning ground surveys conducted as part of Task 1 are aimed at characterizing the naturally spawning population in accessible stream reaches downstream of USACE dams. Similar spawning ground surveys were conducted above these dams as well but are included under Task 4 as described below. This separation has been made to specifically monitor and evaluate outplanting efforts in stream reaches blocked by dams and the potential of these reaches to serve for reintroduction purposes and as sanctuaries for wild fish populations. Comparisons of estimated spawning population parameters (e.g., peak redd counts, redd densities, pHOS, and PSM) between spawning areas downstream and upstream of USACE dams are a useful tool for identifying reaches with relatively greater habitat potential and for evaluating hatchery management practices. Such comparisons are also addressed under Task 4.

Task 2. Conduct biological monitoring of hatchery broodstock. (Objectives addressed: SCS 1, SCS 2, and SCS 3)

The purpose of this task is to obtain estimates of origin (hatchery, wild, strays), body size, age structure, run timing, and spawn timing of hatchery broodstock. The intent is to ensure that broodstock collected and spawned in each hatchery program adequately meet mitigation, conservation, and recovery goals, and comply with existing guidelines being developed in the Hatchery Genetic Management Plans (HGMP).

Task 3. Conduct biological monitoring of fish rearing in hatcheries and at release. (Objectives addressed: SCS 6, SCS 7, and SCS 9)

This task involves monitoring fish performance both in-hatchery (survival, growth) and post-release (migratory performance; SARS) and includes monitoring of timing and number of juveniles released by species and stock for each hatchery.

Task 4. Estimate the relative survival of outplanted fish and abundance of outplanted fish that spawn above USACE dams. (Objectives addressed: SCS 4 and SCS 5)

The purpose of this task is to monitor and evaluate outplanting efforts in each of the four major Upper Willamette River subbasins. As mentioned above, the components of this task include: conducting spawning ground surveys in reaches where fish have been outplanted; collecting data on spawning population parameters (e.g., peak redd counts, redd densities, pHOS, and PSM); and analysis of spawning population parameters at varying spatial scales (Appendix 2). In addition, genetic sampling of outplanted fish is conducted in support of ongoing parentage studies at several projects.

Section 1.2 Spring Chinook Salmon Production Program Goals

Section 1.2.1: Broodstock Collection and pNOB Goals

The intent of broodstock collection protocols at the UWR hatcheries is to sequester enough broodstock to ensure sufficient returning adults to support all mitigation requirements (e.g. harvestable fish, broodstock for the next generation, fish for outplanting, etc.) while also ensuring that the fish taken for broodstock are phenotypically similar to naturally-produced fish (e.g. run timing, spawn timing, age structure, etc.).

In 2013, adult collection began in May 2013 and occurred into October 2013 at all facilities. Collection protocols varied by hatchery program. In the North Santiam subbasin, broodstock were collected at the newly constructed Minto Fish Collection Facility. In the South Santiam subbasin collection occurred at a trap in Foster Dam and fish were transported by truck to the nearby hatchery. In the McKenzie subbasin fish volunteered to the ladder on site at the hatchery. In the Middle Fork Willamette subbasin fish were captured at the Dexter Dam trap and transported by truck to the Willamette Hatchery further upstream. Adults at capture are generally anesthetized with CO_2 or Aqui-S to facilitate handling.

Spawning protocols were relatively uniform across hatcheries whereby adults were crowded, anesthetized with MS-222, Aqui-S or CO_2, and checked for ripeness. Unripe fish were returned to holding areas and ripe fish were killed and bled. Eggs were removed from females into spawning buckets and fertilized using a 1:1 sex ratio.

Incorporation of natural origin fish into the broodstock may ultimately be set at 5% or more per ongoing discussions and development of the HGMPs, but in 2013 the HGMPs had not yet been approved.

Section 1.2.2: Outplanting and pHOS Protocols and Goals

Outplanting protocols varied widely throughout the subbasins. When the outplant goal is focused upon disposition of excess hatchery-origin fish (as in the North Santiam and Middle Fork Willamette subbasins), outplanting generally begins relatively early in the run when it becomes apparent that the run size will be adequate to provide sufficient broodstock, and ends late. Exceptions exist at the McKenzie Hatchery and Dexter Trap when ongoing research projects require outplants at specific times either to test a particular practice (Dexter trap: early outplants) or to achieve specific escapement goals (McKenzie Hatchery: genetic pedigree study). When outplanting is focused upon the disposition of unclipped fish (South Santiam River and the

Cougar Dam trap in the South Fork McKenzie River) then outplanting begins and ends with the capture of the first and last unclipped adult fish.

In the North Santiam River outplanted fish (adipose clipped only) were captured at Minto and trucked to the Breitenbush and North Santiam arms of Detroit Reservoir. On the South Santiam River only unclipped fish captured at the Foster Dam trap were outplanted at locations ranging from near the head of reservoir to multiple locations further upstream. On the McKenzie River outplants from the McKenzie Hatchery were exclusively adipose clipped fish taken to the South Fork McKenzie River to complement mostly unclipped fish transported from the Cougar Dam adult trap in support of a research project evaluating productivity of hatchery- and natural-origin spawners (Banks et al. 2013). Outplanting in the Middle Fork Willamette subbasin is a complex procedure and includes several locations. Adult fish from Dexter Dam trap are outplanted into the Middle Fork Willamette above Hills Creek Dam to support recovery efforts for bull trout, and into Little Fall Creek, a tributary entering the Middle Fork Willamette River below Dexter Dam. Adults from both the Dexter trap and Willamette Hatchery are also outplanted in the North Fork Middle Fork Willamette River above Lookout Point Reservoir in various locations to support ongoing research into causes of prespawning mortality (Schreck et al. 2013; Mann et al. 2012). Finally, unclipped adults captured at the Fall Creek Dam trap are outplanted above Fall Creek Reservoir to continue recovery efforts there.

Section 1.2.3: Marking and Tagging of Hatchery Chinook Salmon

Adult hatchery fish are identified using a combination of marks that were applied to the juveniles prior to release. All hatchery-origin Chinook salmon receive adipose fin clips and a secondary thermal otolith mark. In addition, a portion of the juvenile hatchery Chinook salmon are released with coded-wire tags (CWTs) to help evaluate the performance of individual hatchery stocks and release groups. A summary of marks applied in 2013 appears in Appendix 4. Specific information on CWT releases from RMIS is available online at http://www.rmpc.org/. On average, 687,000 CWT spring Chinook salmon are released into the basin annually (2000 – 2010; Shaun Clements, ODFW, pers. comm.) with more than 100,000 tagged fish typically released from each hatchery.

Section 2: Methods

Section 2.1 Estimating Spawner Parameters: Distribution, Abundance, and Proportion of Hatchery- and Natural-Origin Chinook Salmon

Section 2.1.1: Monitoring Adult Returns

The majority of the spring Chinook salmon adults that pass Willamette Falls enter the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette subbasins to spawn. In 2013, returns specific to each subbasin were monitored through spawning surveys and at fish ladders or collection facilities in each of these four subbasins. Depending on management objectives for each of the subbasin hatchery programs, fish captured at collection facilities were retained for broodstock, outplanted above USACE dams, recycled downstream for additional angling opportunities, sold to offset costs of fish transport, donated to tribes, or used for stream enrichment.

2.1.1.1 Spawner Surveys: We surveyed four major eastside tributaries (North Santiam, South Santiam, McKenzie, and Middle Fork Willamette rivers) in the Willamette Basin upstream of Willamette Falls (Figure 1) in 2013 by boat and on foot to count spring Chinook salmon carcasses and redds following established protocols (Boydstun and McDonald 2005; Schroeder et al. 2007; Gallagher et al. 2007; Kenaston et al. 2009; Cannon et al. 2010). We counted redds from late August through October to encompass the peak times of spawning based on data from surveys conducted in past years. Detailed maps of the subbasins are provided in the Results section and descriptions of the reaches are provided in Appendix 3.

For boat surveys we used rafts with elevated viewing towers on large river sections. On some river sections the raft stayed on one side of the river (with the other bank covered on subsequent surveys) over the entire length of the section to count redds, whereas on other sections the raft crossed the river to count redds on both sides. Similar techniques were used on medium-sized rivers except that we used small rafts with viewing platforms lacking elevated towers. In tributary reaches that were inaccessible to walking surveys we used inflatable kayaks. All boat surveys were conducted in a downstream direction except that a small number of reaches required paddling or rowing upstream a short distance (<100 m) when the only boat launch site was below a reach break that could not be safely passed.

For walking surveys, a stream was classified as "medium" if the surveyor had to cross the stream to observe areas on the other side, or "small" if the surveyor could observe both sides of the stream without crossing (Schroeder et al. 2005). Observers counted redds and attempted to record global positioning system (GPS) coordinates for each redd in a river section. If a GPS signal could not be obtained for a redd the redd was still counted. All walking surveys were conducted in a downstream direction except in a few instances when a surveyor completed a section and had the opportunity to assist a partner in a reach by surveying upstream.

***2.1.1.2 Carcass Sampling**:* During spawning surveys all carcasses that could be recovered by hand or with long-handled gaffs were examined for adipose fin clips to determine the proportion of hatchery fish on spawning grounds. We measured carcasses (cm fork length [FL]), determined sex, and estimated the proportion of remaining eggs in female fish to document pre-spawning mortality (details in section 2.1.2.5, below). Carcasses in water too deep to permit recovery or too degraded to permit inspection were recorded as unprocessable. We collected otoliths from processable carcasses without fin-clips to differentiate unclipped hatchery fish from naturally-produced fish using results from otolith analyses performed by the Washington Department of Fish and Wildlife Otolith Laboratory (*see Proportion of Hatchery Spawners*, below). We used hand-held detectors manufactured by Northwest Marine Technology, Inc. (Tumwater, WA) to determine if carcasses with adipose fin clips had CWTs, and in the McKenzie to determine if unclipped carcasses had a CWT. Fish with CWTs and without fin clips might simply be mis-clipped fish, fish with regenerated adipose fins or fish from "double-index release groups" (intentionally released without a fin clip for fishery management purposes). We collected the snouts of tagged fish and put them in plastic bags with individually numbered labels. Tags were removed and identified at the ODFW Clackamas Fish Identification Laboratory to establish the origin of tagged fish.

***2.1.1.3 Monitoring Fish Passage at Bennett and Leaburg Dams**:* We used underwater video cameras to monitor net upstream movement of salmon, steelhead and other fish species through ladders at the Bennett dams on the North Santiam River and the Leaburg Dam on the McKenzie

River (Figure 1). The video equipment uses software (FishTick, SalmonSoft, Inc., Portland, OR) that automatically scans and records fish movement and creates video files from these images. The captured video images were reviewed and species, presence or absence of an adipose fin clip, direction of movement (upstream or downstream) were noted so that the net upstream movement of spring Chinook salmon by presumed hatchery or wild origin could be estimated. Other fish species were also enumerated. Counts of clipped and unclipped Chinook salmon were later adjusted using otolith data to get estimates of actual hatchery- and natural-origin fish above the counting stations. We attempted to operate the video systems continuously throughout the migration season. On the rare occasions when a video system failed we estimated the number of fish that may have passed during these outages based on simple linear extrapolation of fish counts recorded during the time when the video equipment was operating normally, generally on the same day.

2.1.1.3.1 Video Monitoring at Bennett Dams: Passage of spring Chinook salmon (and other species) occurred at both Upper and Lower Bennett dams. The video monitoring system at upper Bennett Dam operated continuously and from April 25 through December 10, 2013 at Lower Bennett Dam.

2.1.1.3.2 Video Monitoring at Leaburg Dam: Passage of spring Chinook salmon through the two fishways at Leaburg Dam was continuously monitored with video recording equipment. We recorded fish passage at both the left-bank and right-bank fish ladders.

Section 2.1.2: Data Analysis

2.1.2.1 Peak Redd Counts and Peak Redd Densities*:* The peak redd count is the maximum number of redds observed in each survey section over the course of the survey season and represents an estimate of the total number of redds constructed by Chinook salmon in each section. When redd counts differed between initial surveys and resurveys conducted to evaluate variability in redd counts (described below), the resurvey counts were used to replace the initial counts. Peak redd densities were calculated by dividing the peak redd count by the length (km) of each section. Importantly, survey conditions in 2013 were not optimal. A series of severe rain events occurred during the time of peak spawning and the most important surveys, those counting the peak number of redds, could not be conducted in all river reaches.

***2.1.2.2 Spawn Timing**:* We compared spawn timing of naturally-spawning fish and broodstock spawned in the hatcheries. The intent of the work was to determine if the spawn timing in the hatchery differed from the average spawn timing in the river in recent years. We estimated peak spawning of naturally spawning fish by fitting a sigmoid curve to the cumulative redd counts over time for multiple years, 2008 through 2013, in the North Santiam, South Santiam and McKenzie rivers. We used the redd count data for only 2008, 2011, and 2012 in the Middle Fork Willamette because not enough redds were counted in that subbasin in 2009 and 2010. The date associated with the inflection point on the fitted sigmoid curve was assumed to represent the average date of the maximum rate of redd construction in each subbasin; that is, average peak spawn timing. We then compared the average spawn timing in the rivers to the spawn timing in the hatcheries in 2013. Average spawn timing in the hatcheries was calculated as the weighted mean date of spawning, weighted by the number of broodstock spawned on each spawn date.

***2.1.2.3 Spawner Abundance Estimates**:* We used the peak count expansion method (more detail below) to estimate total spawner abundance. We made three assumptions: 1) that the peak redd count in any reach of interest adequately reflected the relative abundance of fish that spawned in that reach; 2) each redd was constructed by one female; and 3) each female spawned with 1.5 males (Gallagher et al. 2007; Boydstun and McDonald 2005).

A spawner abundance estimate (A) derived from the peak count expansion method was calculated by the following equations:

$A = F_{spawn} + M_{spawn}$, where

F_{spawn} = number of spawning females = $Redd_{peak}/Redd_{female}$;

($Redd_{peak}$ = peak redd count, and $Redd_{female}$ = number of redds/spawning female = 1), and

M_{spawn} = number of spawning males = $F_{spawn} \times 1.5$.

We then parsed the total spawner abundance estimate into hatchery and wild spawning cohorts by using the pHOS estimates derived from carcass sampling with adjustments based upon otolith analyses. Clearly there is a large effect that this string of assumptions has on the accuracy of the estimates of spawner abundance, and there are no estimates of precision associated with redd count expansions. The values for spawner abundance and redd count expansion should therefore be used with caution.

2.1.2.4 Proportion of Hatchery Spawners*:* We combined counts of clipped and unclipped fish wherever they were encountered (at video counting stations, during spawner surveys, and during monitoring of adult fish entering hatchery traps) with validation of hatchery or wild origin from otolith data to derive the proportion of hatchery spawners (pHOS) at various spatial scales. The spatial scales included basin-wide, by subbasin, above and below dams, and, in some cases, by river reach. To differentiate between hatchery and wild fish and to implement a selective fishery, all hatchery spring Chinook salmon in the Willamette basin, beginning with the 1997 brood year, have been marked with adipose fin clips, CWTs, or both. Also, thermal marks were (and are) induced in the otoliths of all hatchery Chinook salmon released in the basin to provide an additional mark for identifying unclipped hatchery fish. Some juvenile Chinook salmon are inadvertently released without a fin clip at a rate that varies by hatchery and by brood year (Schroeder et al. 2005). However, the percentage of unclipped fish in hatchery releases has decreased in recent years with the implementation of automated fin-clipping systems. Other factors that contribute to the return of unclipped hatchery fish include the release of unclipped hatchery fish with CWTs (double-index), and natural regeneration of partially clipped adipose fins.

We estimated the proportion of natural-origin (wild) and hatchery-origin fish in 2013 by adjusting counts of clipped and unclipped carcasses after examining otoliths collected from the unclipped carcasses recovered on the spawning grounds. We collected samples from adult spring Chinook salmon carcasses without fin clips on spawning grounds (North and South Santiam, McKenzie, and Middle Fork Willamette rivers) and, in 2013, at Willamette Hatchery where a small number of unclipped Chinook salmon were incorporated into brood. Otoliths were collected and placed into individually numbered vials. The samples were subsequently sent to the otolith laboratory operated by Washington Department of Fish and Wildlife for analysis of thermal marks. The reach-specific proportion of hatchery origin spawners (pHOS) was derived from the counts of fin-clipped fish (AD), unclipped thermally-marked fish (UTM) and total count of fish examined (TOT) using the equation pHOS = [AD + UTM]/TOT).

The reach-specific pHOS estimates were then applied to the reach-specific spawner abundance estimates and the products summed to yield subbasin-wide pHOS estimates weighted by spawner abundance (reach-specific redd counts). For example, monitoring results in in the McKenzie River 2012 were typical of most years. Survey conditions were excellent throughout the survey season, many redds were counted and many carcasses were recovered. Carcasses were relatively easy to collect below Leaburg Dam. We counted 268 redds and collected 411 carcasses which equates to 1.5 carcasses/redd (411/268 = 1.5). In what are at present the two important natural spawning reaches above Leaburg Dam, Leaburg Dam to Cougar Dam and the mainstem and tributaries above the confluence with the South Fork McKenzie River, we estimated carcasses recovered/redd constructed at 0.3 and 0.2, respectively: it is much harder to recover carcasses in the upper river reaches. Our reach-specific pHOS estimates showed that pHOS in the lowest reach (83%; below Leaburg Dam) was much higher than in the two upper reaches (28% and 8%, respectively); hatchery fish are not evenly distributed throughout the basin. Therefore, the true basinwide pHOS estimate was derived by weighting the reach-specific pHOS estimates by the reach-specific indices of spawner abundance, in this case by:

pHOS = [(0.830*268)+(0.281*251)+(0.080*415)] / (268+251+415) = 0.349

The alterative grossly oversimplified method to estimate pHOS would be to simply divide the number of hatchery-origin carcasses by the total number of carcasses recovered (368/577 = 0.638), which results in an overestimate of pHOS in 2012 in the McKenzie.

We also used the otoliths to adjust estimates of the proportion of natural-origin brood (pNOB) in the Middle Fork Willamette Hatchery using the counts of non-thermally-marked unclipped broodstock ($WILD_B$), and the total number of broodstock (TOT_B) using the equation

$pNOB = WILD_B/TOT_B$.

2.1.2.5 Pre-spawning Mortality*:* We surveyed major tributaries of the Willamette basin, both above and below project dams, by boat and on foot in 2013 to estimate pre-spawning mortality

(PSM) based on the proportion of unspawned female salmon carcasses observed. Female carcasses with intact or relatively intact skeins (i.e. greater than 50% eggs remaining) were considered unspawned. The 50% threshold is arbitrary but in practical terms virtually all female carcasses had either essentially no eggs remaining or completely intact skeins. For the purpose of discussion in this document we arbitrarily categorize PSM as “low”, “medium”, and “high” when estimates were $< 20\%$, 20% to 50%, and $>50\%$, respectively. The surveys were conducted in a manner identical to the spawner surveys (described above) but began in the summer prior to spawning to permit observation of any early mortality that occurred as salmon reached spawning tributaries. Female carcasses were also checked for spawning success during the regular spawning surveys and redd counts through early October so that pre-spawning mortality could be assessed over the entire run. For every female salmon carcass that could be recovered during the pre-spawning and spawning surveys the gut cavity was cut open to visually judge the relative abundance of eggs. We then calculated PSM by dividing the number of unspawned female carcasses by the total number of female carcasses where spawning status was observed.

We conducted additional PSM monitoring in the South Santiam River for outplants above Foster Dam because only unclipped (presumably natural-origin) fish are outplanted in that subbasin. All outplanted fish were tagged with a numbered Floy tag. For each tagged fish fork length (cm), outplant date, and outplant site (Caulkins Marina, Riverbend Park, or Gordon Road) was recorded. During PSM and spawning surveys we recorded spawner status of all recovered female carcasses. We used multiple logistic regression to test for associations between spawner status and fish size, outplant date and outplant site. The multiple regression included data from surveys conducted in 2009 through 2013.

***2.1.2.6 Straying of Hatchery Fish**:* In the Willamette basin a “stray” is defined as any hatchery fish that does not return to its hatchery of origin and either spawns naturally or is encountered at another hatchery. In addition to estimating pHOS (described above) in each subbasin we estimated the contribution to pHOS of strays from outside the subbasin into which the juveniles were originally released.

We used handheld tag detectors to check for CWTs in carcasses recovered during surveys. The decimal codes of CWTs were read at ODFW's Clackamas Fish Identification Laboratory to identify the hatchery stock and release site. We estimated the extent and origin of stray hatchery fish by expanding the number of recovered fish with a specific tag code to the percentage of fish in that release group that were tagged. For example, if one CWT from a McKenzie release was recovered in the South Santiam River when 10% of the McKenzie fish received CWTs, we assumed an additional nine McKenzie fish from that release strayed into the South Santiam River.

Section 2.2: Reintroduction Efforts

We intercepted salmon for outplanting (and broodstock collection, fish sales, fish donation, and stream enrichment) at adult fish traps at the left (south) bank ladder of the Leaburg Dam, Dexter Dam, Foster Dam and the Upper and Lower Bennett dams. Biological data (fork length, sex, scales, presence of tags or fin clips) and specimens (otoliths [from lethally sampled fish], DNA) were collected. The count of adult fish outplanted above project dams was used as the initial basis for adult abundance above dams, modified by estimates of abundance and distribution based on spawner surveys (described below).

We collected biological data from all Chinook salmon that were outplanted. Data collected from spawned fish included fork length, sex, and presence or absence of an adipose fin clip. We collected tissue samples (small portion of a fin stored in 100% ethanol) from outplanted fish, and recorded sex along with presence or absence of a fin clip.

Section 2.3: Broodstock Sampling

2.3.1 Collection, Spawn Timing, Composition, and Disposition of Broodstock: Traps are operated for each of the Willamette spring Chinook salmon hatcheries to collect broodstock. Chinook salmon are also trapped at Leaburg Dam and Leaburg Hatchery and then transported to McKenzie River Hatchery. Disposition of collected salmon is recorded at each hatchery by presence or absence of an adipose fin clip. At each hatchery on each spawning date samplers record number of fish spawned by sex, length of broodstock, and obtain samples from fish as required (scales, otoliths, DNA, CWTs).

Section 2.4: Within-Hatchery Monitoring

2.4.1 Adult Monitoring*:* The bulk of within-hatchery monitoring involved tracking the fate and disposition of adult fish at each hatchery. The data were acquired by a combination of (1) direct sampling by HRME staff at each hatchery during outplanting and spawning activities, (2) queries of the data provided by the hatchery managers to the Hatchery Management Information System (HMIS), and (3) interviews with the hatchery managers to verify portions of the data that were provided to HMIS.

2.4.2 Juvenile Monitoring: We obtained summaries of the number of fish released, rearing locations, release locations and size at release in 2013 for both summer-run steelhead and Chinook salmon by querying HMIS for those data (Appendix 4). We also queried RMIS to obtain information on Chinook salmon liberation dates and release locations for CWT fish from Willamette hatcheries (Appendix 4). Steelhead have not been released with CWTs since the 1980s.

Other juvenile monitoring involved compiling hatchery records for size distributions and tag retention data for fish just prior to release.

Section 3: Results

Section 3.1: Abundance, Distribution, Spawn Timing and Composition of Naturally Spawning Adult Spring Chinook Salmon

Section 3.1.1 Adult Returns**:**

In 2013 the total count of spring Chinook salmon ascending Willamette Falls was 29,561 (27,897 adults and 1,664 jacks). Of the adults, 20,861 (74.8%) were adipose-clipped and 7,036 (25.2%) were unmarked. Of the jacks, 1,348 (81.0%) were adipose-clipped and 316 (19.0%) were unmarked. Run timing at Willamette Falls is shown in Figure 3. By convention, Chinook salmon counted after 15 August are considered fall Chinook salmon

In 2013, spring Chinook salmon adults and jacks were collected at Upper Willamette Basin facilities beginning in late May or early June at all facilities, and concluding in early September through early October at the North Santiam, South Santiam, McKenzie, and Dexter facilities. We attempted to account for the historical numbers of hatchery-origin fish that passed Willamette Falls from 2000 through 2012 by summing the estimates of the various fates of the fish (Appendix 5). Some data, such as the harvest estimates in 2013, are not available so the summary includes only data through 2012. It is almost always the case that more fish are estimated to have passed Willamette Falls than can be accounted for by hatchery recoveries, harvest, prespawning mortality, and natural spawner escapement. In recent years, the fate of about ten to twenty percent of the estimated numbers of adult Chinook salmon over Willamette Falls is unknown.

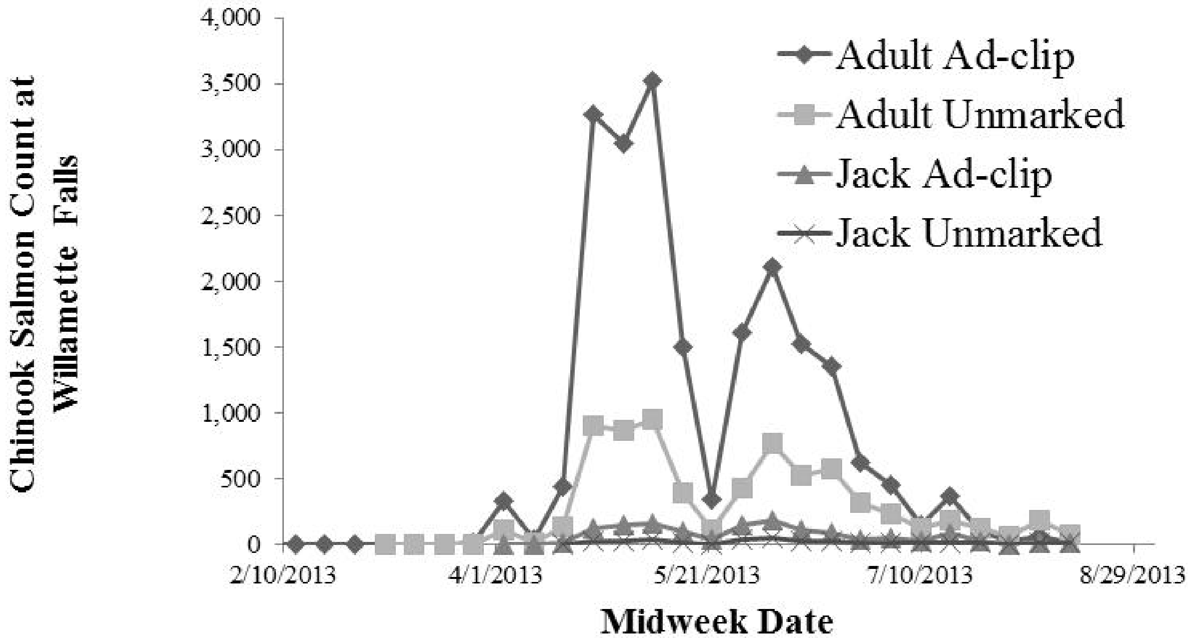

Figure 3. CHS Run timing at Willamette Falls in 2013.

Section 3.1.2 Redd Counts, Redd Distribution, and Spawn Timing:

We used a combination of spawning ground surveys, hatchery records, and dam counts to derive indices of spawner density and estimates of run-size and spawner abundance for hatchery- and natural-origin Chinook salmon in the four basins of interest. For each subbasin, 2013 summary data on redd counts, redd densities, and prespawning mortality rates are provided in the form of maps with pooling of the counts and rates across multiple sample reaches to illustrate general patterns of abundance and distribution. Redd density estimates for 2013 and earlier years are provided in Table 1. Figures 4 and 5 provide spawner abundance estimates over time based on redd count expansion for surveys below and above dams, respectively. For all years, the pooled reaches are generally bounded by points where some measure of control of fish movement exists, such as at traps or dams. In some cases the pooled reaches represent particular tributary streams where special surveys were conducted in 2013 (e.g., Little Fall Creek in the Middle Fork

Willamette). A description of how survey reaches were pooled for which metrics is presented in Appendix 2.

Importantly, redd counts and the record of timing of redd construction were probably seriously compromised by the severe storm event that occurred late in September. We provide the redd counts and inferences on spawn timing as a complete record of the work but the results must be interpreted with caution.

North Santiam River: The North Santiam River (Figures 6-11) was surveyed beginning 3 July and ending October 13, 2013. Redd construction was first observed September 4. Peak redd counts were obtained between September 19 and October 9, depending on the particular river reach surveyed (Table 2). As in previous years, redd density below Minto in 2013 was highest in the section between the Bennett and Minto dams. Within that reach the highest redd densities were observed immediately below Minto Dam (Figure 8).

We estimated that for 2008-2012 the average spawn timing in the North Santiam River was September 28 (Figure 12) based on the inflection point on a sigmoid curve fitted to the cumulative redd counts observed in those years. We did not include the 2013 cumulative redd count data in the estimate because we believe we may not have obtained an accurate peak redd count in that year.

Table 1. Current and recent historical redd densities in comparable spawning reaches.

	Redds/km											
Subbasin, Section	2013[a]	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002
North Santiam												
Below Bennett Dams	0.1	0.3	1	1.7	1.1	0.1	3.8	0.7	0.9	0.9	0.6	0.9
Bennett Dams to Minto	6.3	10.2	10.6	6.3	3.8	3.5	7.8	3.6	4.6	5.1	4.6	4.7
Little North Santiam	0.8	3	3.6	2.1	1	3.8	2.8	1.3	2.3	1.9	1.1	1.1
Above Detroit Reservoir	6.9	6.3	12.4	13.7	--	--	--	--	--	--	--	--
South Santiam												
Foster – Pleasant Valley	48.9	60.1	68.5	92.6	59.9	25.1	58.1	64.3	70.4	46.9	82.5	121.5
Pleasant Valley – Waterloo	1	0.6	2.9	7	3.1	1.7	3.9	2.7	1.4	2.1	1	0.8
Lebanon - Mouth	--	0	0.1	0.5	--	--	--	0.7	0	0.1	0.7	2.3
Above Foster Dam	2.9	6.8	7.1	4.6	2.6	4.1	4.8	--	--	--	--	--
McKenzie												
Below Leaburg Dam	7.8	25.7	22.9	27.4	17.4	24.5	14.7	7.5	7.8	10.3	17.8	12
Leaburg - SF McKenzie	3.5	5.8	10	11.5	4.6	5.2	14.8	5.2	4.1	12.9	9.7	7.5
S. Fork below Cougar Dam	5.5	9.5	13.6	7.4	9.7	11.9	16.6	12.2	12.2	20.2	12.1	15.3
S. Fork above Cougar Dam	5.7	7	8.9	7.1	11	6.3	5.7	6.5	4.4	--	--	--
Above S. Fork	5.6	4.5	11.1	8.6	4.8	5.7	13.2	6.9	12.6	7.9	9.2	7.4
Middle Fork Willamette												
Below Dexter	0.8	5.3	6.9	1.5	2.5	9.3	0.6	7.7	0.6	0.6	1	4.4
North Fork Middle Fork	7.2	6.9	4	4.2	--	--	--	--	--	--	--	--
Fall Creek	0.5	2.2	2.2	2.6	1.4	3.5	1.1	8.3	5.1	8.1	3.8	8.1
Little Fall Creek	2.8	3.8	6.7	--	--	--	--	--	--	--	--	--
Above Hills Cr. Reservoir	4.8	16.3	--	--	--	--	--	--	--	--	--	--

[a]A severe storm event late in the spawning season in 2013 may have compromised the estimate of peak redd counts. Values may be biased low.

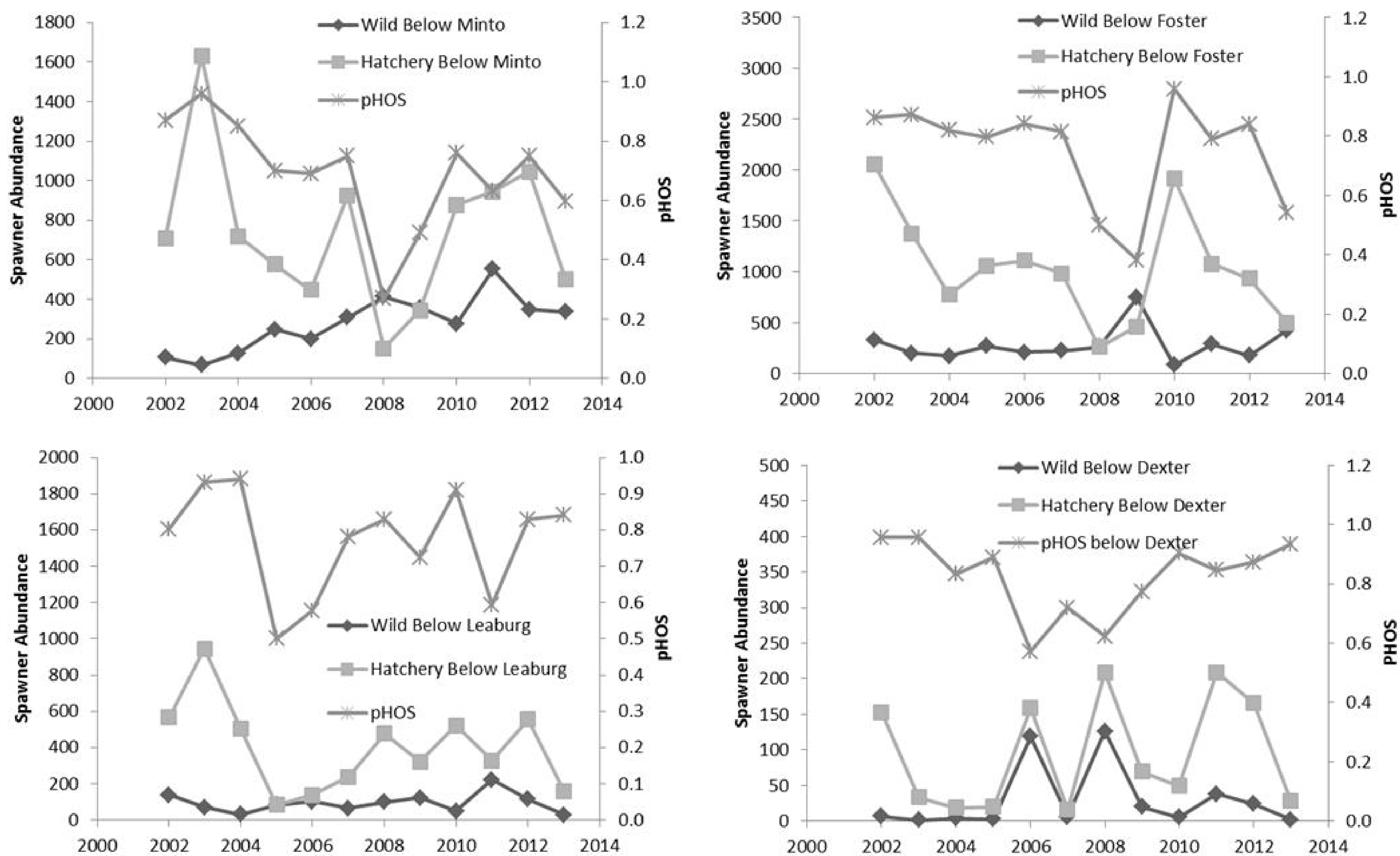

Figure 4. Spawner abundance estimates based on redd count expansion for reaches below dams in 2013. Note variable y-axes.

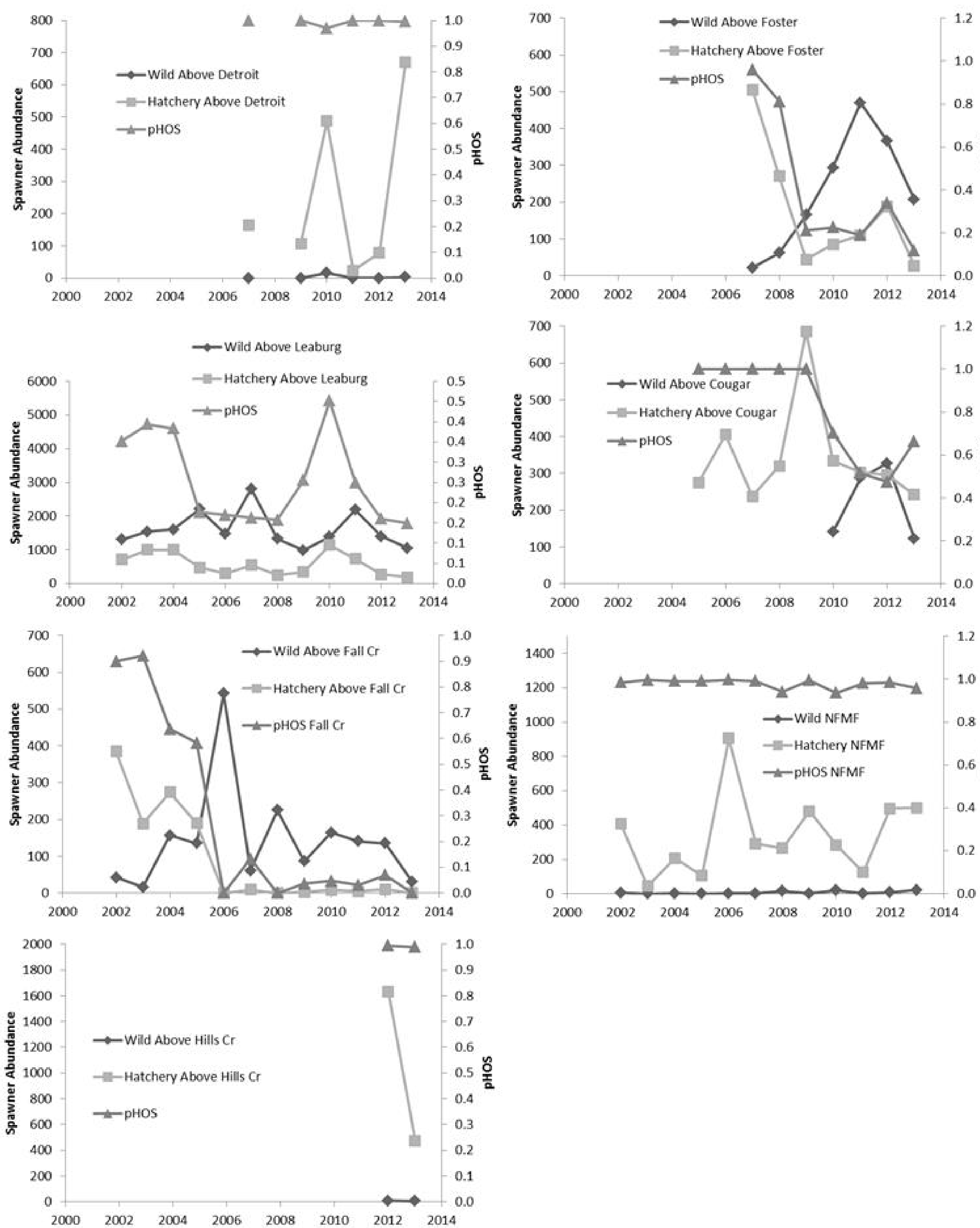

Figure 5. Spawner abundance estimates based on redd count expansion for reaches above dams in 2013. Note variable Y-axes.

Table 2. Peak redd counts, date peak count was recorded, and number of surveys conducted by survey section in the North Santiam subbasin, 2013.LB and RB indicate left and right bank counts.

Subbasin	Survey Section	Peak Redd Count	Date of Peak Count	Number of Surveys
North Santiam Mainstem	Minto Dam to Packsaddle	18	9/18/2013	12
	Packsaddle to Gate's Bridge	128	9/25/2013	14
	Gate's Bridge to Mill City	105	9/25/2013	13
	Mill City to Fisherman's Bend	55	9/18/13 LB, 9/25/13 RB	13
	Fisherman's Bend to Mehama	11	9/25/2013 RB, 10/1/13 LB	12
	Mehama to Powerlines	0	n/a	10
	Powerlines to Upper Bennett	0	n/a	10
	Upper Bennett to Stayton	1	9/18/2013	6
	Lower Bennett to Stayton	0	n/a	5
	Stayton to Shelburn	0	n/a	1
	Shelburn to Green's Bridge	0	n/a	1
	Green's Bridge to Mouth	0	n/a	1
North Santiam Above Detroit	Parish Lake Road to Straight Cr	0	n/a	2
	Straight Cr to Bugaboo	1	10/8/2013	5
	Bugaboo to Horn Cr	12	9/18/2013	5
	Horn Cr	146	10/3/2013	9
	Marion Cr	69	10/3/2013	8
	Horn Cr to Minto Cr	15	9/26/2013	7
	Minto Cr to Pamelia Cr	17	9/20/2013	7
	Pamelia Cr to Whitewater Cr	0	n/a	0
	Whitewater Cr to Misery Cr	0	n/a	0
	Misery Cr to Cooper's Ridge	8	10/10/2013	2
	Coopers Ridge Rd to Idanha Br	0	n/a	2
Breitenbush	S Fk Breitenbush to Hill Cr	0	n/a	2
	Hill Cr to Scorpion Cr	0	n/a	2
	Scorpion Cr to Fox Cr	0	n/a	3
	Fox Cr to Humbug Cr	0	n/a	3
	Humbug Cr to Byars Cr	0	n/a	3
	Byars Cr to Picnic Area	1	9/9/2013	4
Little North Santiam	Elkhorn Bridge to Salmon Falls	7	10/9/2013	11
	Salmon Falls to Camp Cascade	3	10/9/2013	11
	Camp Cascade to Narrows	5	10/9/2013	11
	Narrows to Golf Bridge	1	9/26/2013	10
	Golf Bridge to Bear Creek Br	2	9/12/2013	8
	Bear Creek Br to Lunkers Br	0	n/a	8

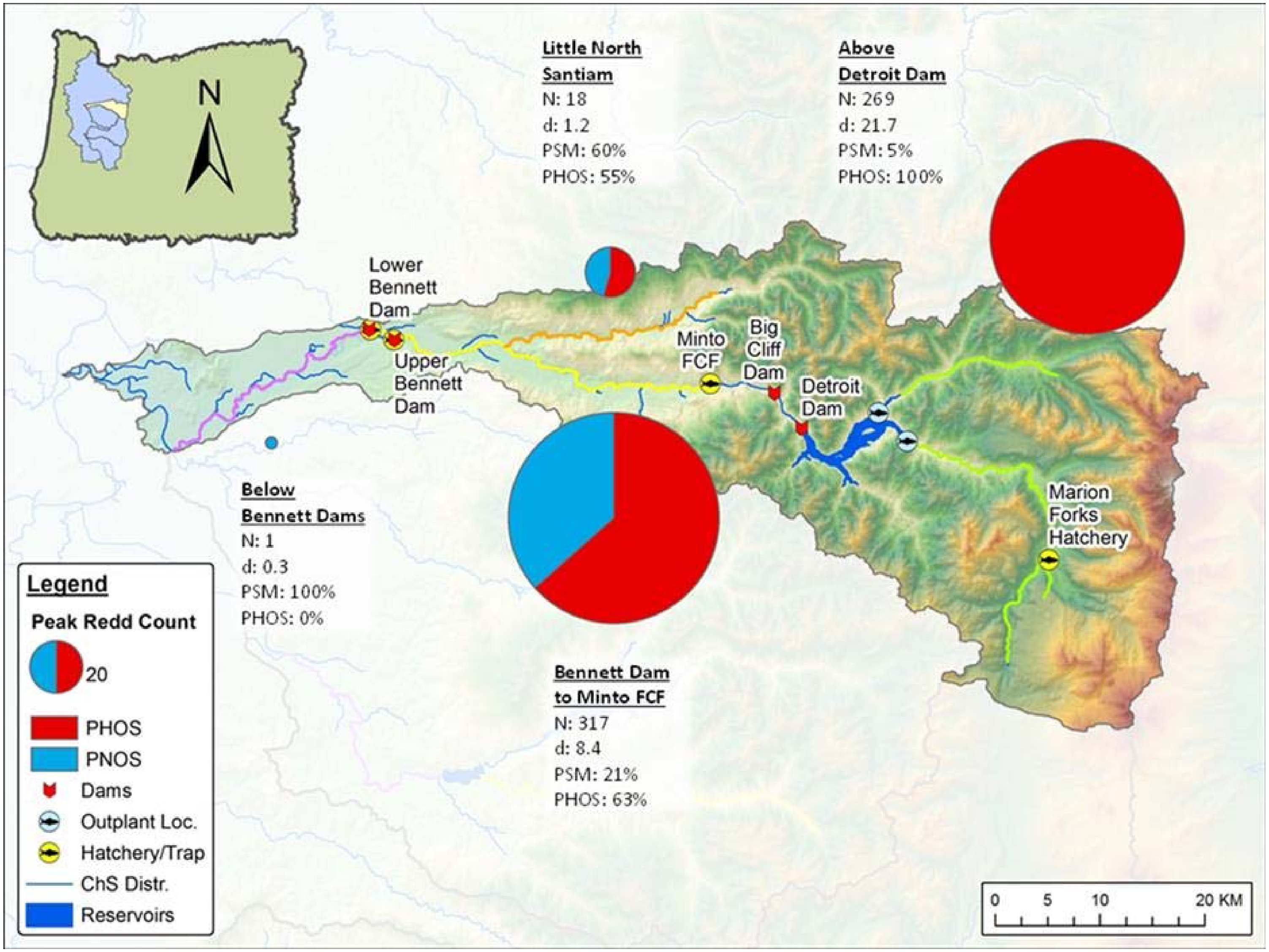

Figure 6. Spawner survey and carcass recovery results for the North Santiam River, 2013. Colored sections indicate major survey reaches. Pie charts indicate peak redd counts (also indicated by "N") by their size and proportion of hatchery-origin spawners.

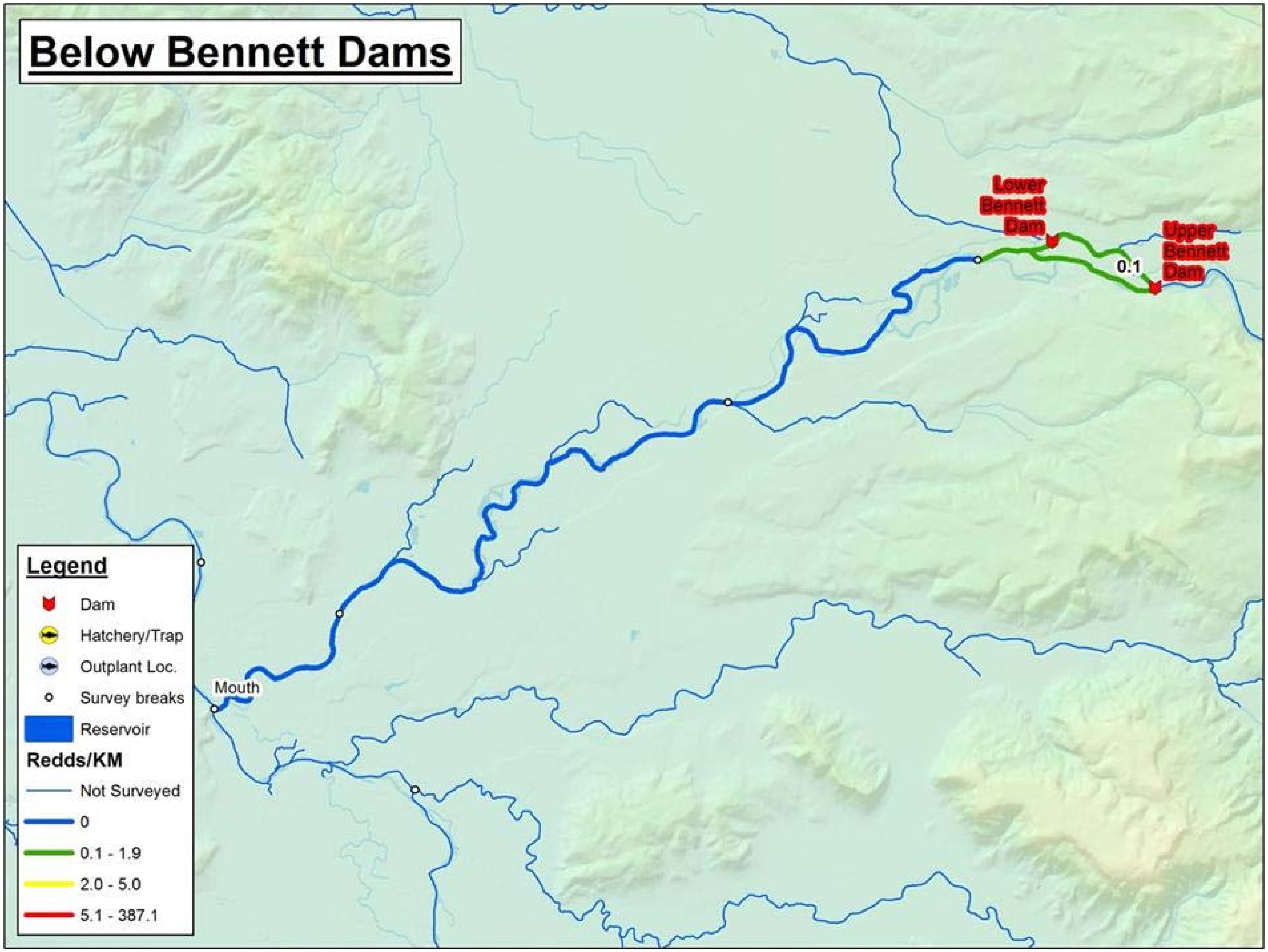

Figure 7. Spawning activity below Bennett dams in the North Santiam subbasin, 2013.

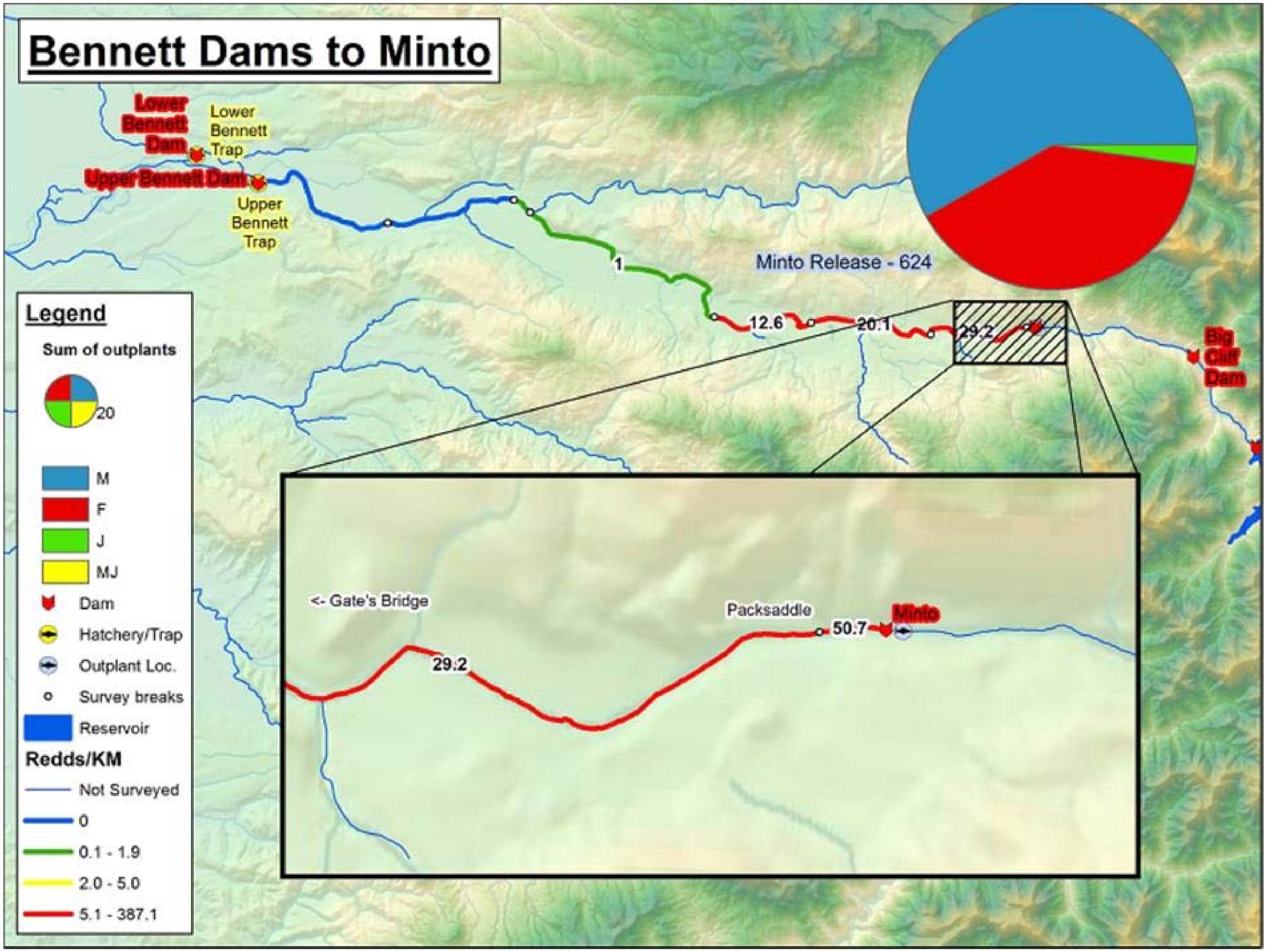

Figure 8. Spawning activity between Bennett dams and Minto Dam on the North Santiam subbasin, 2013.

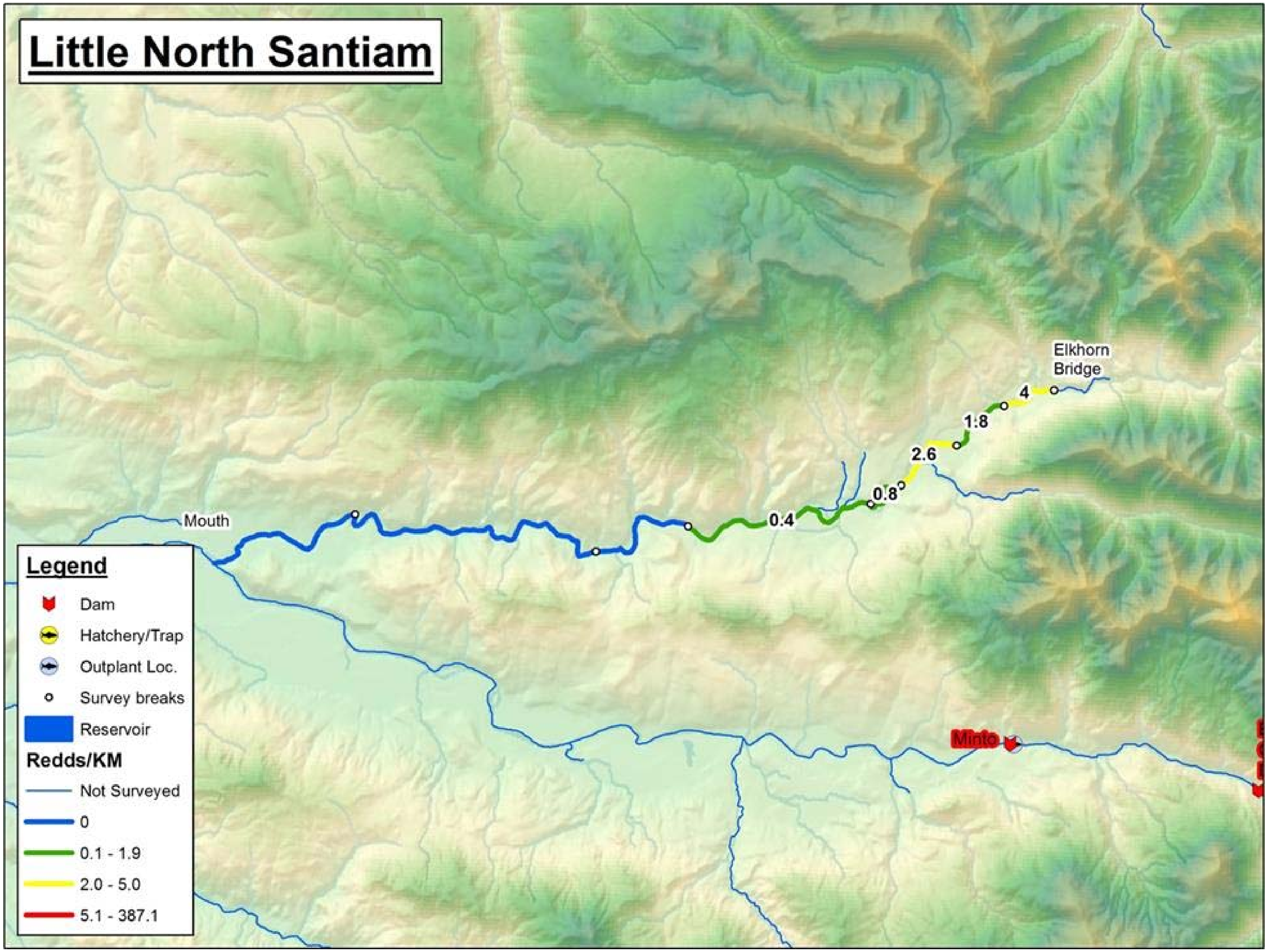

Figure 9. Spawning activity in Little North Santiam, 2013

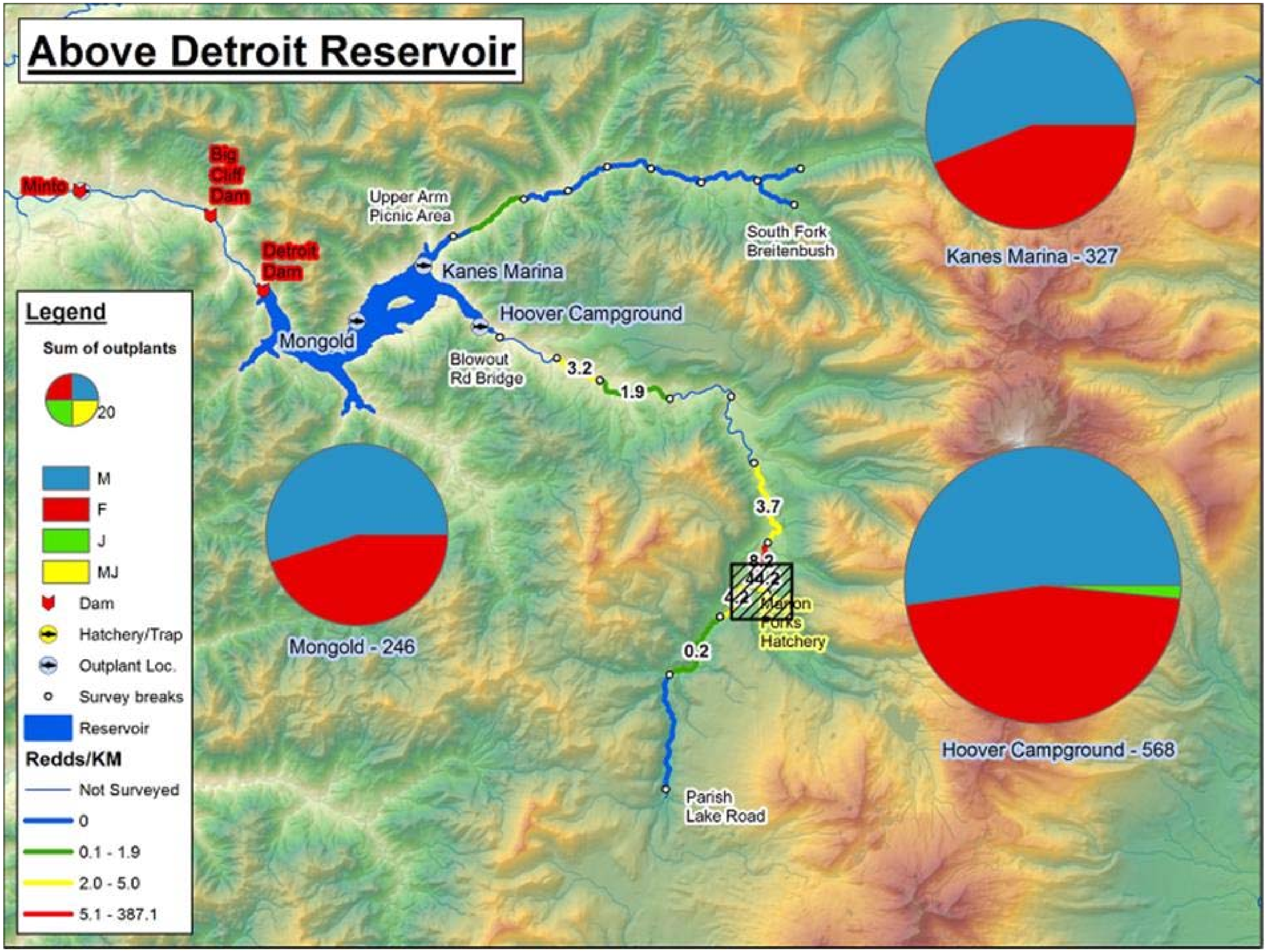

Figure 10. Outplanting of Chinook salmon and spawning activity above Detroit Dam in the North Santiam subbasin, 2013. Pie charts indicate number of Chinook salmon outplanted by site and colors indicate sex ratio. Inset near Marion Forks Hatchery is shown in the following figure.

Figure 11. Detail of spawning activity in 2013 near Marion Forks Hatchery.

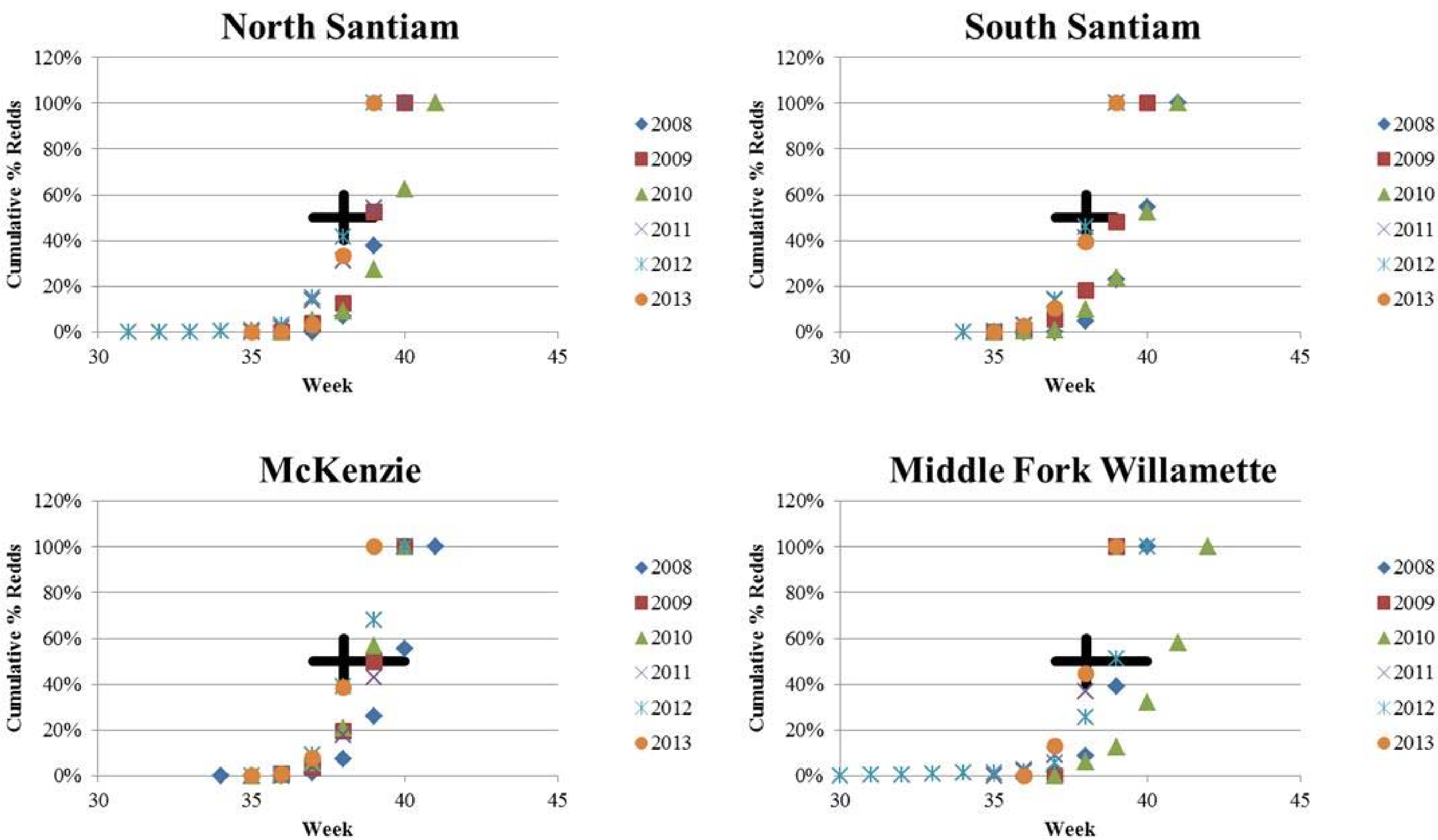

Figure 12. Comparison of spawn timing in the rivers and spawn timing at the hatcheries. Horizontal black line indicates range of spawn timing at hatcheries in 2013. Vertical black line indicates weighted mean spawn timing at the hatcheries in 2013.

South Santiam River: The South Santiam River (Figures 13-15) was surveyed beginning 1 July and ending 8 October, 2013. Redd construction was first observed September 4, 2013 and peak redd counts were obtained between September 17 and September 24, 2013, depending on the particular river reach surveyed (Table 3). As in previous years, the redd density in 2013 was highest in the section between the town of Lebanon and Foster Dam. Within that reach the highest redd densities were observed immediately adjacent to and below Foster Dam, near the South Santiam Hatchery.

We estimated that for 2008-2012 the average spawn timing in the South Santiam River was September 23 (Figure 12) based on the inflection point on a sigmoid curve fitted to the cumulative redd counts observed in those years. We did not include the 2013 cumulative redd count data in the estimate because we believe we may not have obtained an accurate peak redd count in that year.

Table 3. Peak redd counts, date peak count was recorded, and number of surveys conducted by survey section in the South Santiam subbasin, 2013.

Subbasin	Survey Section	Peak Redd Count	Date of Peak Count	Number of Surveys
South Santiam Mainstem	Foster to Pleasant Valley	352	9/24/2013	14
	Pleasant Valley to McDowell Creek Rd	13	9/17/2013	11
	McDowell Creek Rd to Waterloo	3	9/17/2013	11
	Waterloo to Lebanon Dam	0	n/a	0
	Lebanon Dam to Gill's Landing	0	n/a	0
	Gill's Landing to Sanderson's	0	n/a	0
	Sanderson's to mouth	0	n/a	0
South Santiam Above Foster	Falls to Soda Fork	19	9/17/2013	19
	Soda Fork to Little Boulder Cr	8	9/23/2013	22
	Little Boulder Cr to Trout Cr C.G.	22	9/23/2013	21
	Trout Cr C.G. to 2nd Trib	7	9/23/2013	23
	2nd Trib to Gordon Cr Rd	22	9/16/2013	23
	Gordon Cr Rd to Moose Cr Bridge	7	10/9/2013	15
	Moose Cr Bridge to Cascadia	0	n/a	0
	Cascadia to High Deck	4	9/24/2013	19
	High Deck to Shot Pouch	3	10/8/2013	18
	Shot Pouch to Riverbend Park	2	10/8/2013	16
	Riverbend Park to Reservoir	0	n/a	14

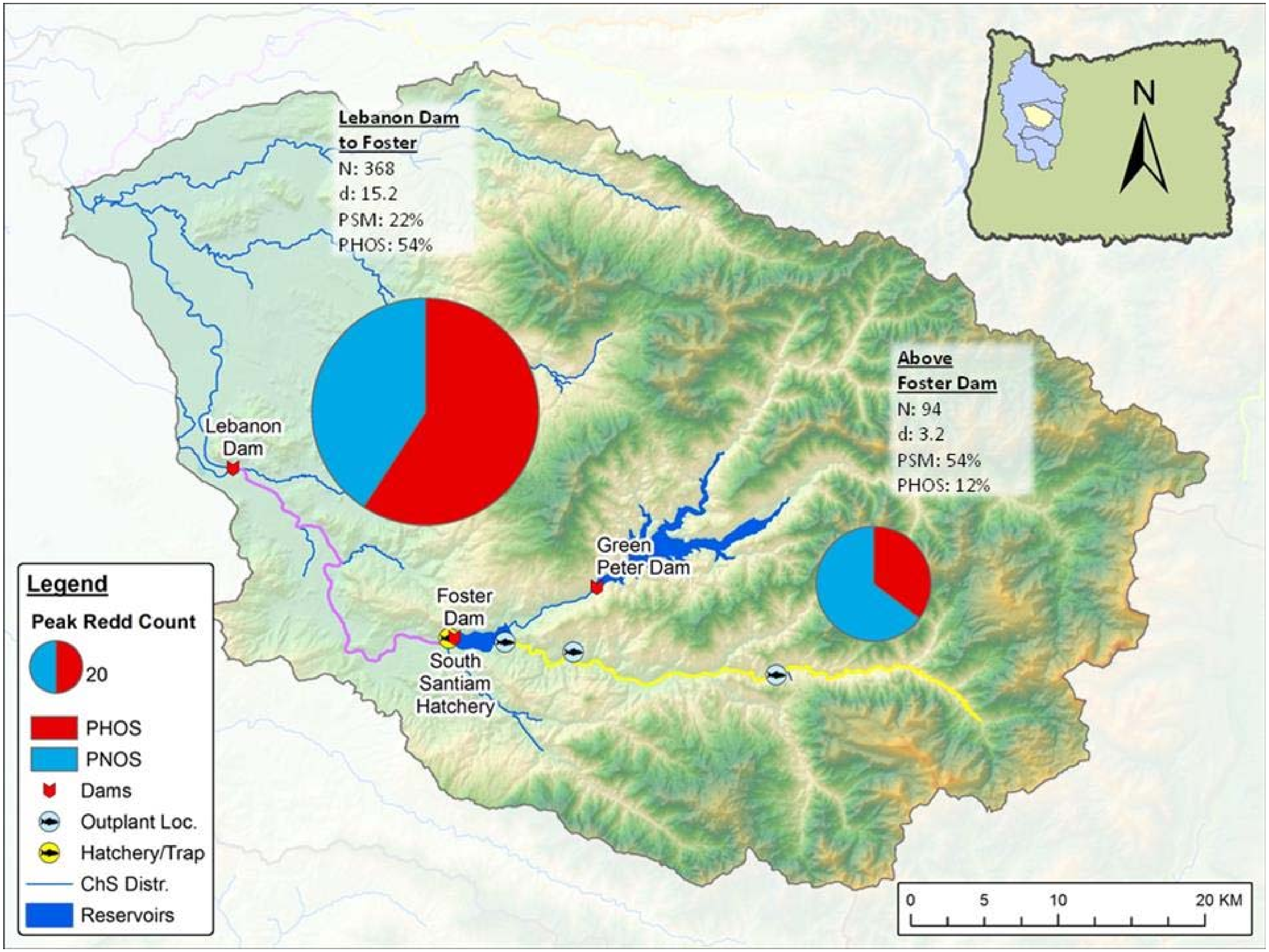

Figure 13. Spawner survey and carcass recovery results for the South Santiam River, 2013. Colored sections indicate major survey reaches. Pie charts indicate peak redd counts (also indicated by "N") by their size and proportion of hatchery-origin spawners (pHOS).

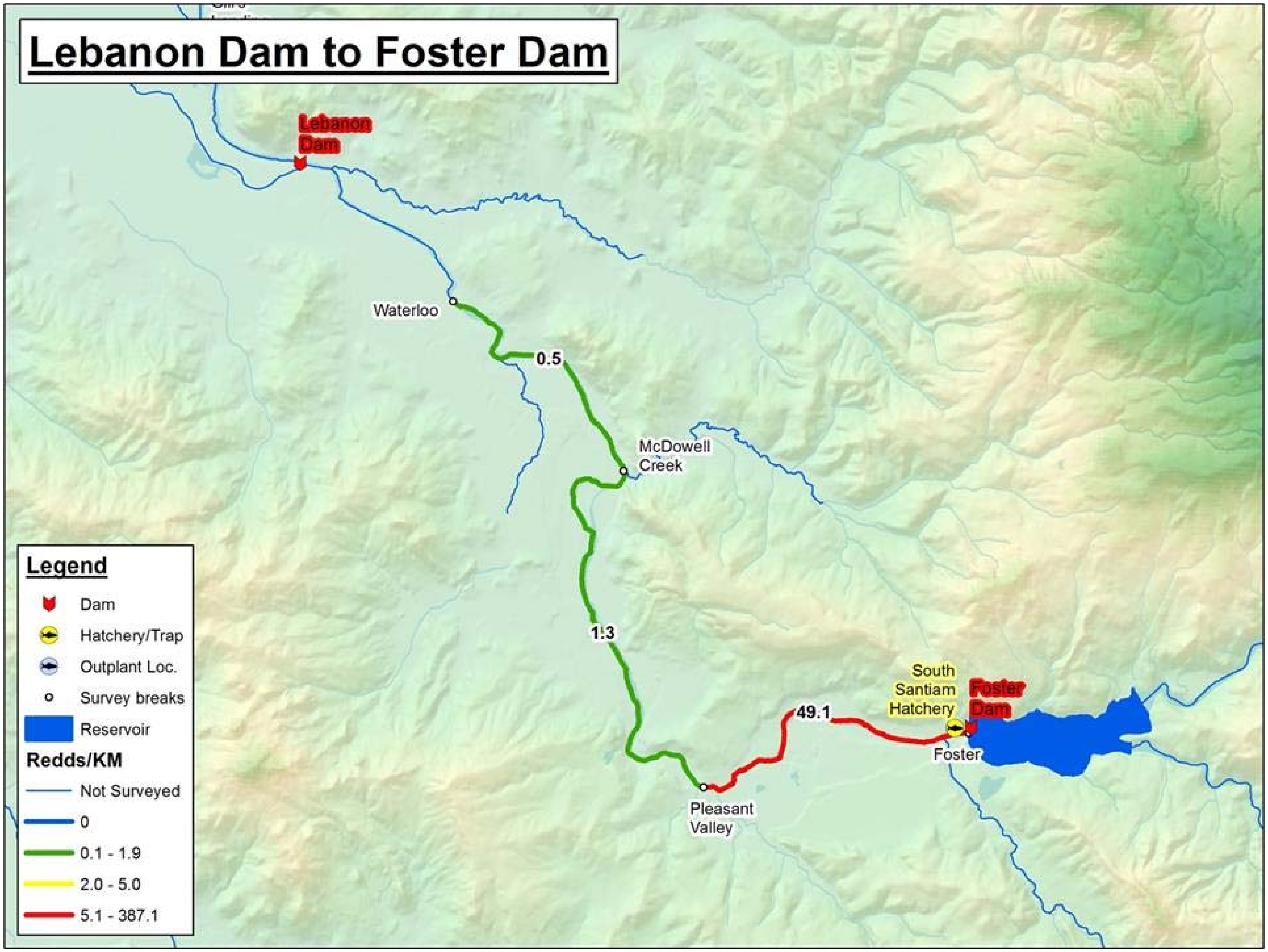

Figure 14. Spawning activity between Lebanon dam and Foster Dam, 2013.

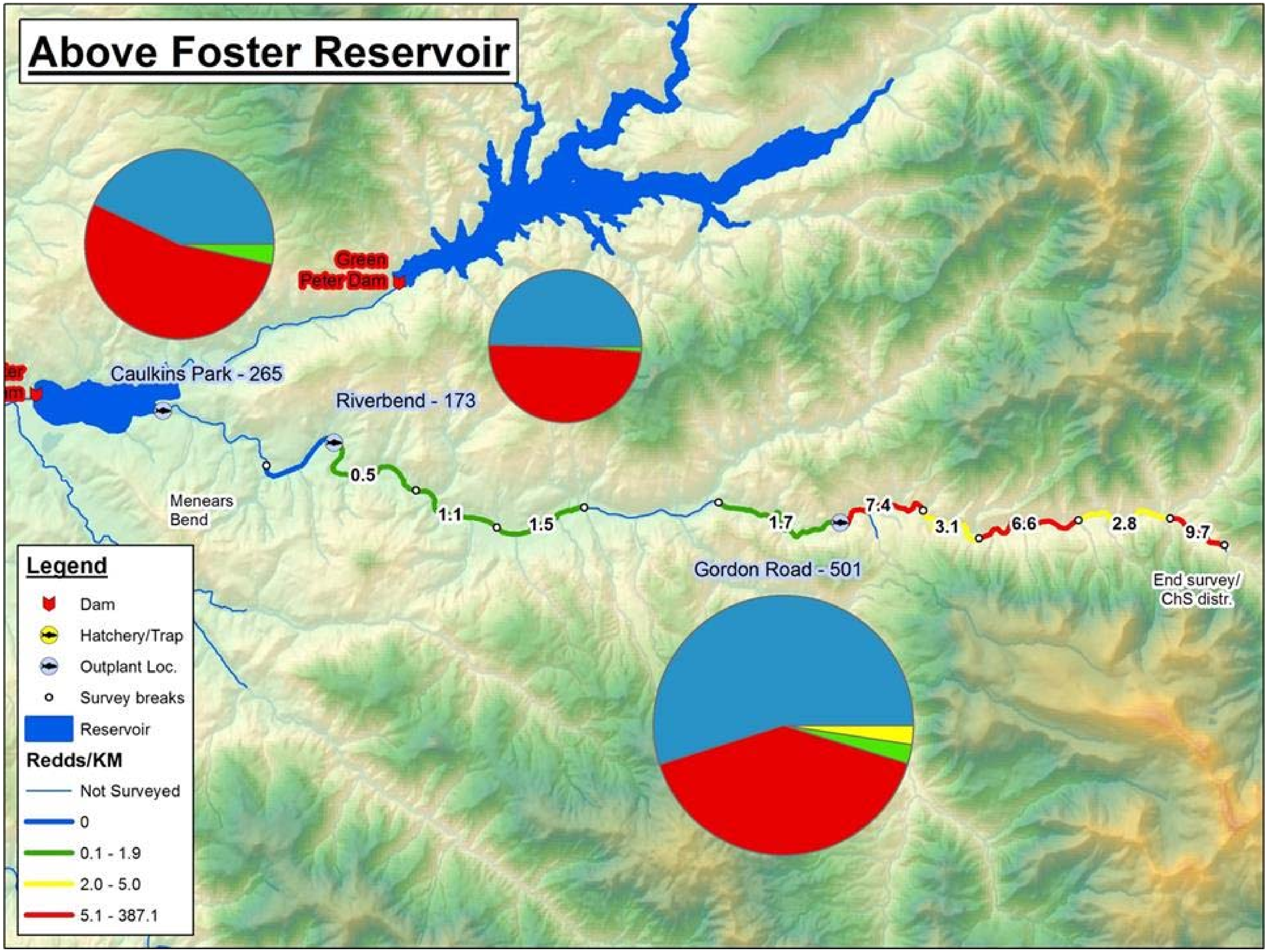

Figure 15. Outplanting and spawning activity above Foster Dam, 2013. Pie charts indicate number of Chinook salmon outplanted by site and colors indicate sex ratio.

McKenzie River: The McKenzie River (Figures 16-20) was surveyed beginning July 8 and ending October 22, 2013. Redd construction was first observed on September 2, 2013 and peak redd counts (Table 4) were observed between September 17 and October 22, 2013, depending on the particular river reach surveyed. As in previous years, the redd density in 2013 was highest in the section below Leaburg Dam. Within that reach the highest redd densities were observed immediately below Leaburg Dam and further downstream near the McKenzie Fish Hatchery. Moderate redd densities were observed above Leaburg Dam with low PSM and a decreasing trend in pHOS upstream. We compared spawner abundance estimates for the reaches above Leaburg Dam based on dam counts and on redd count expansion. Estimates were essentially identical for 2005-2013 but differed greatly for 2002-2004 (Figure 21) with video counts approximately three times that of the estimates from redd count expansion.

We estimated that for 2008-2012 the average spawn timing in the McKenzie River was September 25 (Figure 12) based on the inflection point on a sigmoid curve fitted to the cumulative redd counts observed in those years. We did not include the 2013 cumulative redd count data in the estimate because we believe we may not have obtained an accurate peak redd count in that year.

Table 4. Peak redd counts, date peak count was recorded, and number of surveys conducted by survey section in the McKenzie subbasin, 2013. LB and RB indicate left and right bank count dates.

Subbasin	Survey Section	Peak Redd Count	Date of Peak Count	Number of Surveys
McKenzie Mainstem	Spawning Channel	20	10/2/2013	6
	Olallie C.G. to Belknap	49	9/23/2013 LB, 10/8/13 RB	8
	Belknap to Paradise	33	10/8/2013	7
	Paradise to McKenzie Trail	15	10/8/2013	7
	McKenzie Trail to McKenzie Br	16	10/7/2013	6
	McKenzie Bridge to Hamlin	50	10/7/2013	6
	Hamlin to S.F. McKenzie	0	n/a	6
	S.F. McKenzie to Forest Glen	19	9/23/2013	7
	Forest Glen to Rosboro Bridge	62	9/27/2013	11
	Rosboro Bridge to Ben & Kay	22	10/7/2013	11
	Helfrich to Leaburg Lake	7	10/22/2013	2
	Leaburg Dam to Leaburg Landing	75	10/7/2013	13
	Leaburg Landing to Dearhorn	0	n/a	11
	Dearhorn to Hendricks	0	n/a	3
	Hendricks to Bellinger	0	n/a	0
South Fork McKenzie Below Cougar	Cougar Dam to Bridge	16	10/1/4013	15
	Bridge to Mouth	20	10/4/2013	15
South Fork McKenzie Above Cougar	Elk Cr. To Roaring River	17	10/2/2013	13
	Roaring R to Twin Springs C.G.	11	10/3/2013	13
	Twin Springs C.G. to Homestead	15	10/10/2013	14
	Homestead to Dutch Oven	14	10/3/2013	13
	Dutch Oven to Rebel Cr.	39	10/8/2013	16
	Rebel Cr. to NFD 1980	25	9/25/2013	15
	NFD 1980 to Reservoir	25	10/3/13 LB, 10/8/13 RB	16
Horse Creek	Pothole Creek to Trail Bridge	8	10/4/2013	4
	Trail Bridge to Separation Creek	6	9/26/2013	4
	Separation Creek to Road Access	6	10/4/2013	5
	Road Access to Braids	12	10/4/2013	6
	Braids to Avenue Creek	21	10/4/2013	6
	Avenue Creek to Bridge	37	9/26/2013	6
	Bridge to Mouth	52	9/26/13 RB, 10/9/13 LB	7
Lost Creek	Cascade to Campground	4	10/2/2013	5
	Campground to Split Pt	10	9/17/2013	4
	Split Pt to Hwy Bridge	8	9/17/2013	6
	Hwy Bridge to Mouth	2	9/17/2013	5

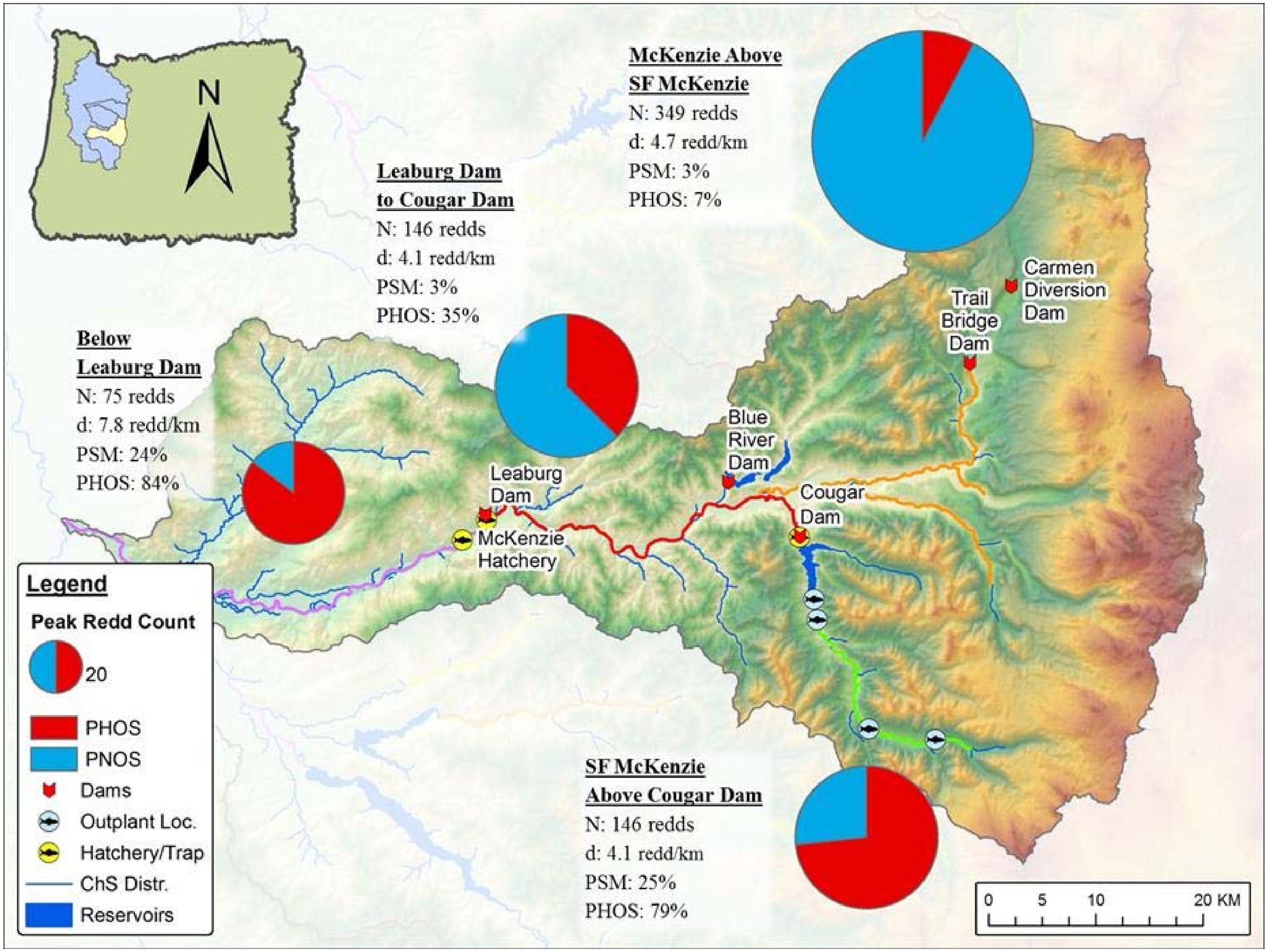

Figure 16. Spawner survey and carcass recovery results for the McKenzie River, 2013. Colored sections indicate major survey reaches. Pie charts indicate peak redd counts (also indicated by "N") by their size and proportion of hatchery-origin spawners (pHOS).

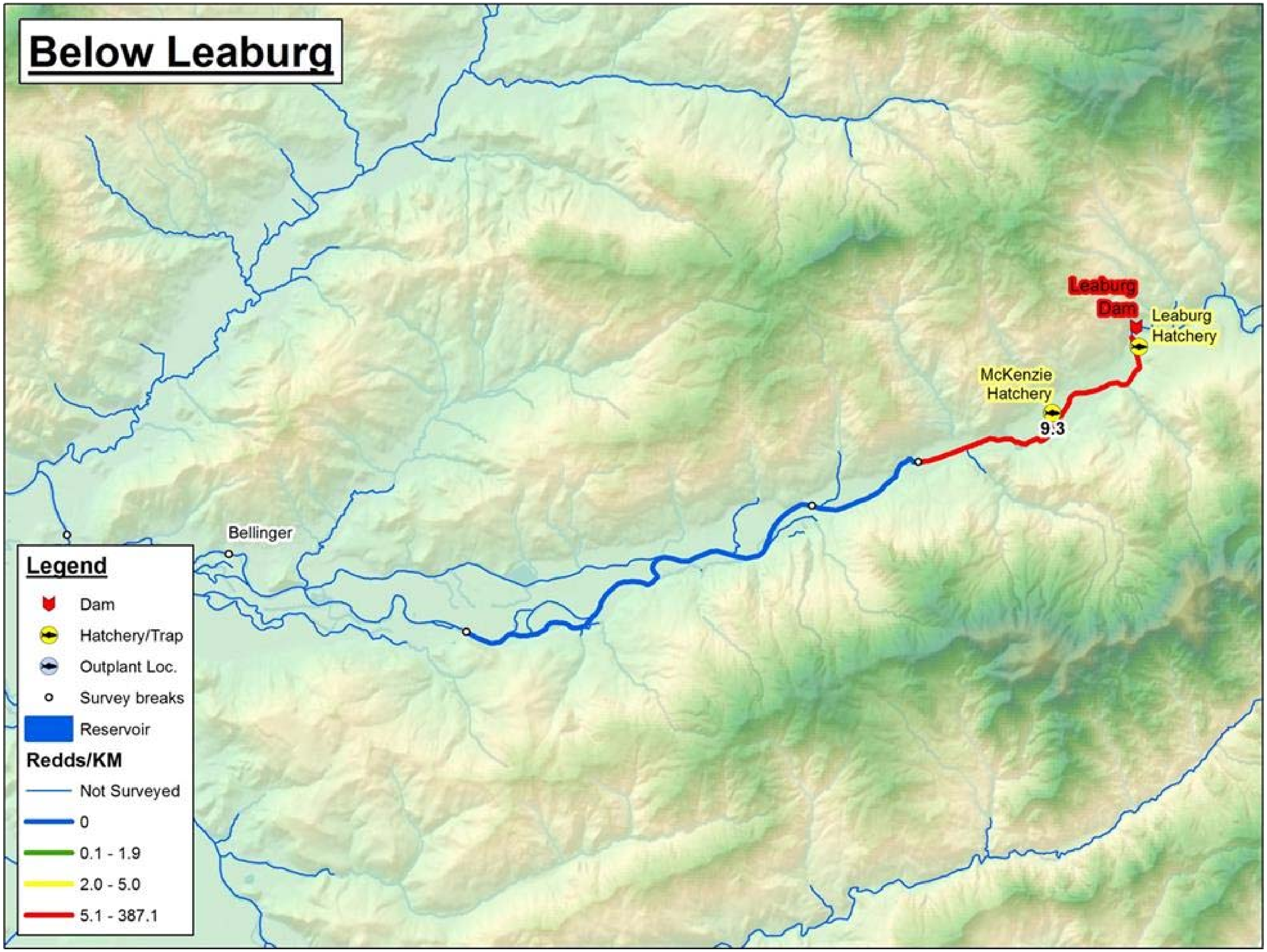

Figure 17. Spawning activity below Leaburg Dam, 2013.

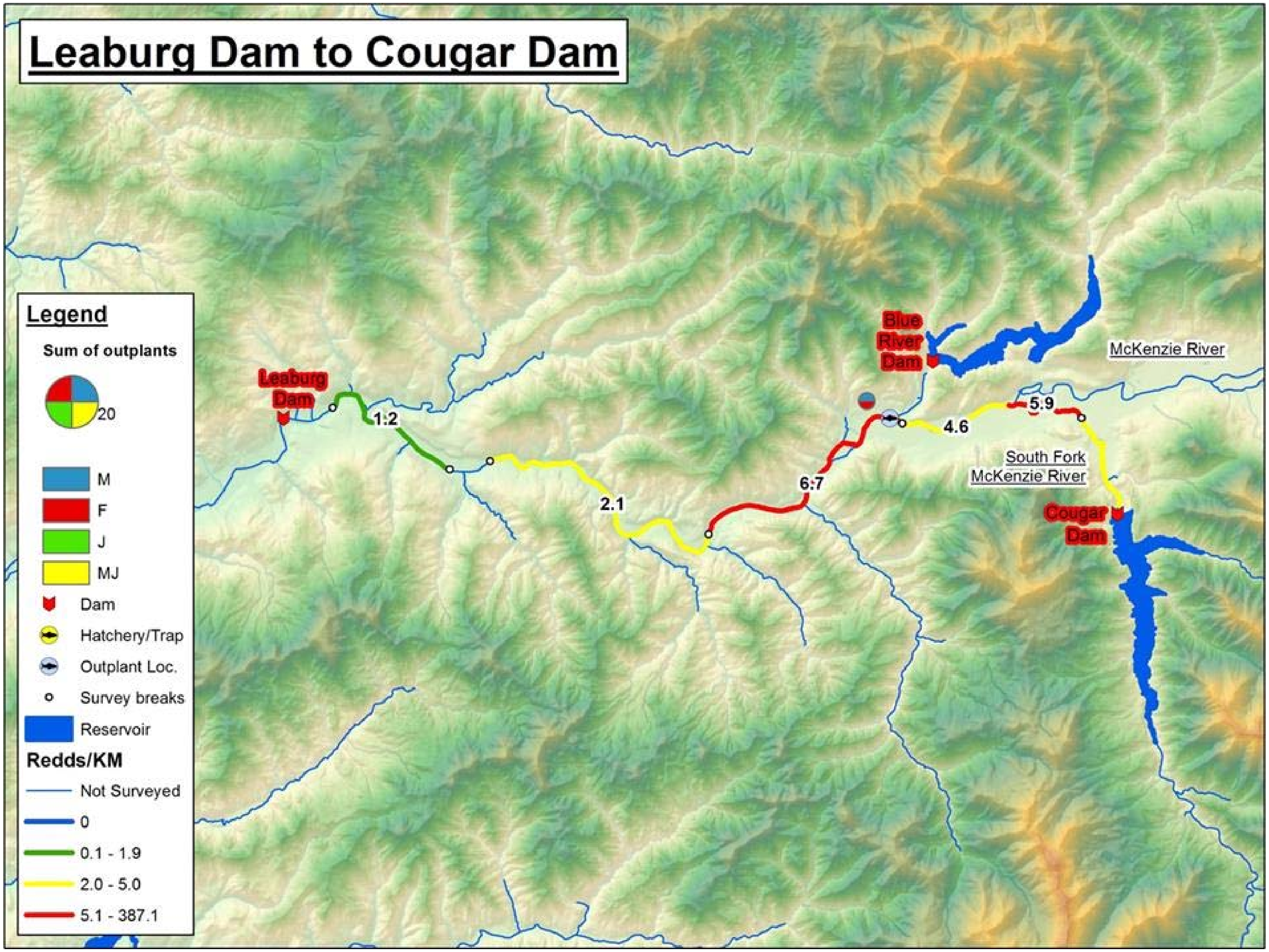

Figure 18. Spawning activity between Leaburg Dam and Cougar Dam, 2013.

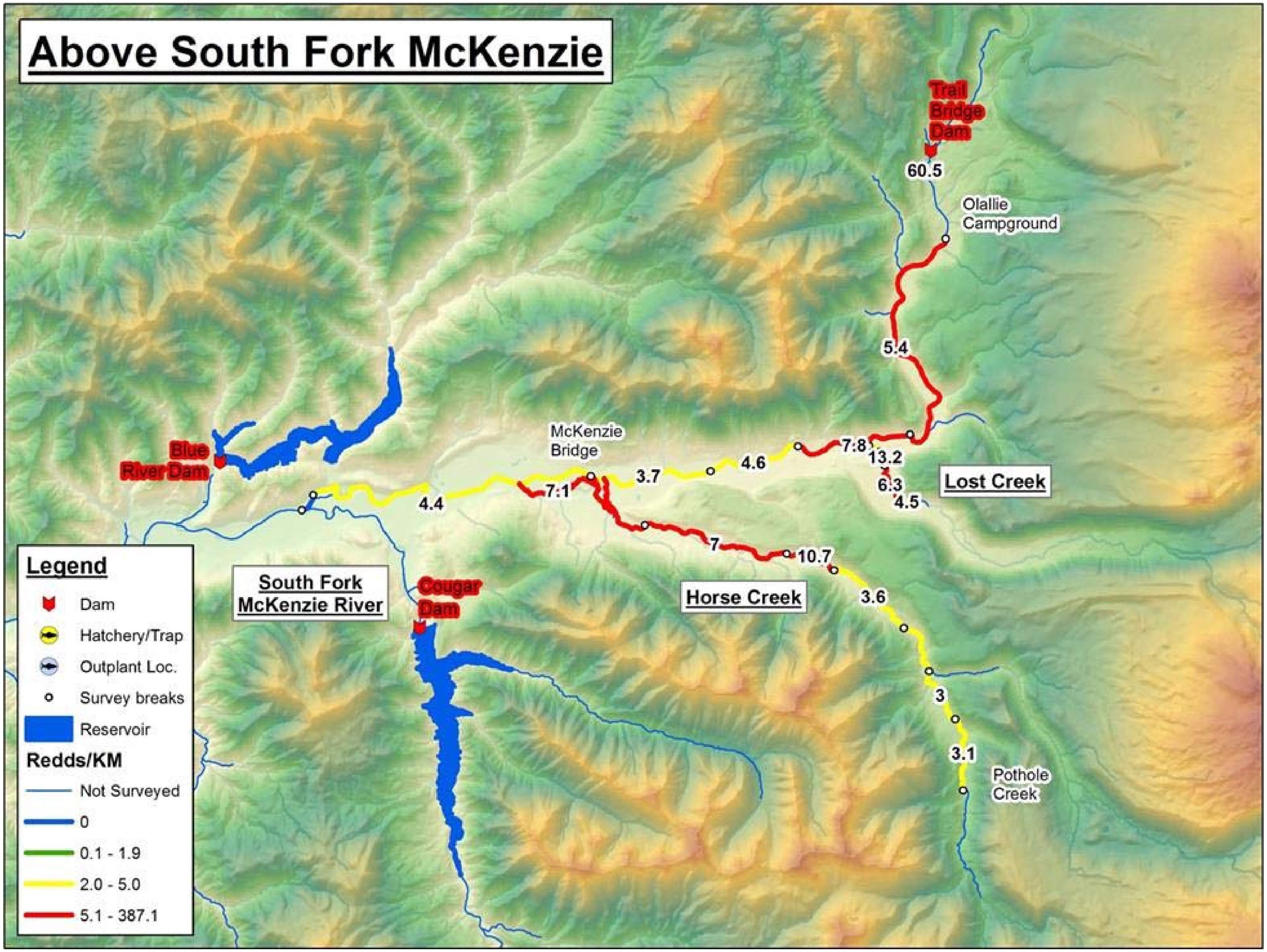

Figure 19. Spawning activity above the confluence of the South Fork McKenzie River, 2013.

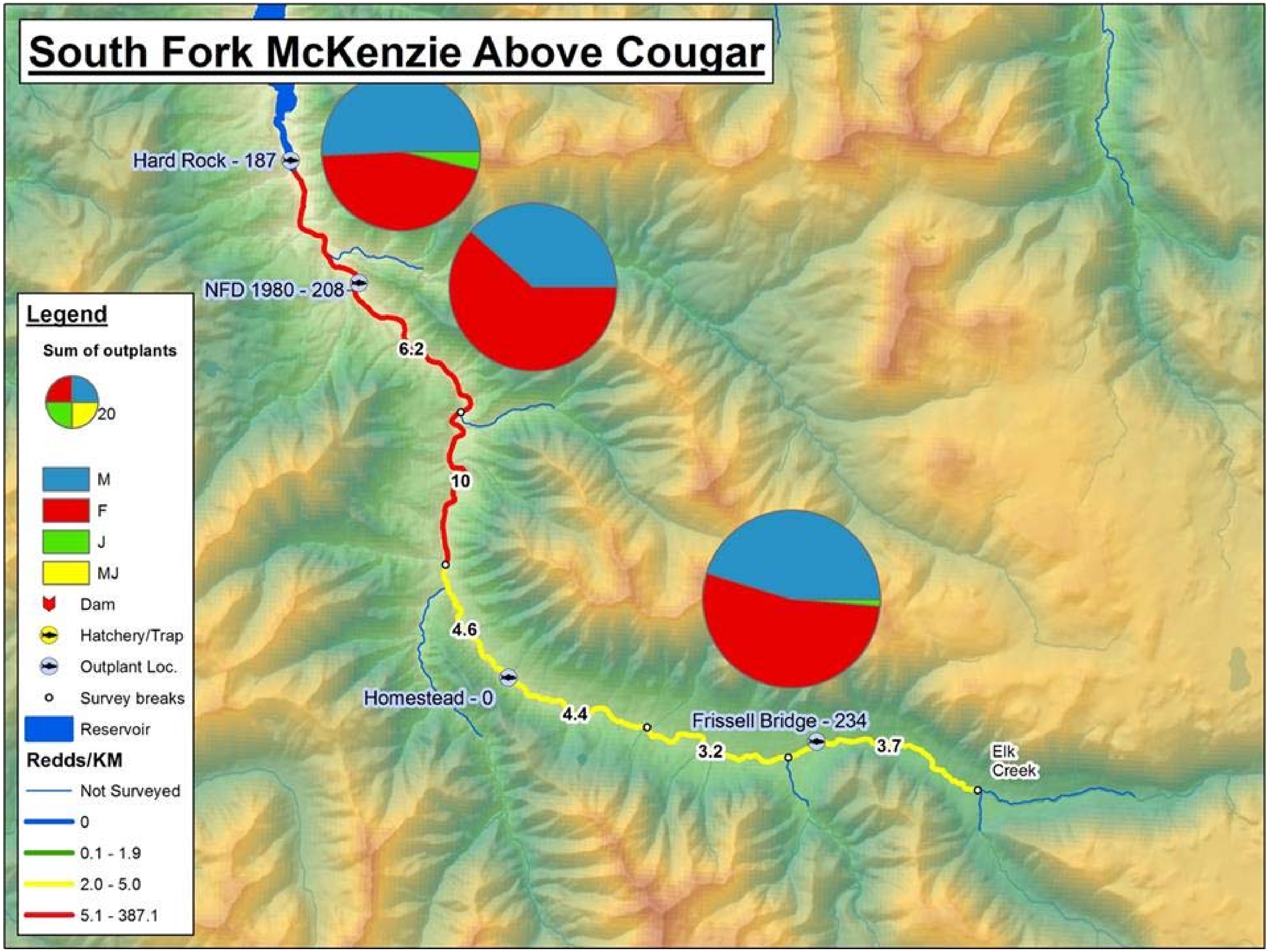

Figure 20. Outplanting and spawning activity above Cougar Dam, 2013. Size of pie chart indicates number of outplanted fish and slices indicate sex ratio.

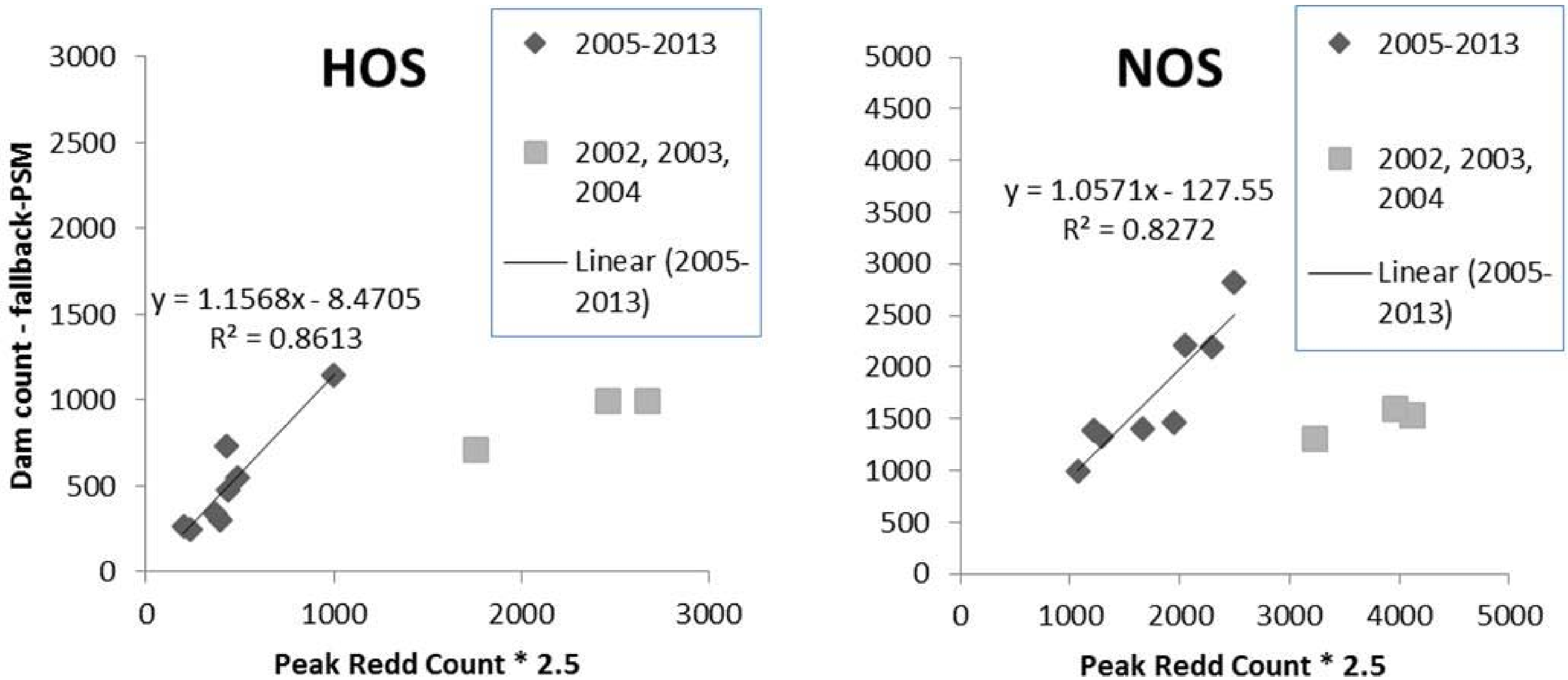

Figure 21. Relationships between spawner abundance estimates above Leaburg Dam, based on redd count expansion and dam counts. HOS and NOS indicate hatchery- and natural-origin spawners, respectively.

Middle Fork Willamette River: The Middle Fork Willamette River (Figures 22-27) was surveyed beginning September 17 and ending October 8, 2013. Few redds were observed and most were constructed in the reach immediately downstream of Dexter Dam. Redd construction was first observed on September 17, 2013. The peak redd count (Table 5) was obtained on October 8, 2013. We estimated that for 2008, 2011, and 2012 the average spawn timing in the Middle Fork Willamette River was September 26 (Figure 27) based on the inflection point on a sigmoid curve fitted to the cumulative redd counts observed in those years. We did not include the 2009, 2010 or 2013 cumulative redd count data in the estimate because we believe we may not have obtained an accurate peak redd count in those years (low sample sizes in 2009 and 2010; poor survey conditions in 2013).

Table 5. Peak redd counts, date peak count was recorded, and number of surveys conducted by survey section in the Middle Fork Willamette subbasin, 2013.LB and RB indicate left and right bank counts.

Subbasin	Survey Section	Peak Redd Count	Date of Peak Count	Number of Surveys
Middle Fork Willamette	Dexter to Pengra	12	9/17/13 LB, 10/8/13 RB	14
	Pengra to Jasper	0	n/a	14
Fall Creek	Johnny Creek Bridge to Big Pool campground	2	9/19/2013	4
	Bedrock campground to Johnny Creek Bridge	0	n/a	7
	Portland Creek to Bedrock campground	0	n/a	9
	NFD 1828 Bridge to Portland Creek	2	10/8/2013	12
	Hehe Creek to NFD 1828 Bridge	4	9/19/2013	11
	NFD 1833 Bridge to Hehe Creek	1	9/12/2013	10
	Gold Creek to NFD 1833 Bridge	2	10/7/2013	7
	Falls to Gold Creek	1	10/7/2013	12
Little Fall Creek	Trib below NFD 400 to NFD 1806 Bridge	7	9/19/2013	6
	NFD 1806 Bridge to NFD 1818 Bridge	4	9/19/2013	6
	NFD 1818 Bridge to Fish Ladder	3	9/26/2013	6
	Fish Ladder to MP 17	0	n/a	5
	MP 17 to Norton Creek	9	9/26/2013	4
North Fk. of the Middle Fk. Willamette	Kiahanie Bridge to Release Site	118	10/7/2013	14
	NFD 1944 Bridge to Kiahanie Bridge	54	10/8/2013	9
	Minute Creek to NFD 1944 bridge	28	9/26/2013	4
	North Fork Trail #3666 trailhead to Minute Cr	9	9/26/2013	2
Middle Fork Willamette Above Hills Creek	Big Swamp to Paddy's Valley Br.	38	10/4/2013	6
	Paddy's Valley to Beaver Cr.	26	9/16/13 RB, 9/25/13 LB	9
	Beaver Cr. to Chuckle Springs	6	9/9/2013	1
	Chuckle Springs to Found Creek	6	10/10/2013	6
	Found Creek to Echo Bridge	1	10/10/2013	7
	Echo Bridge to Young's Cr.	100	10/9/2013	9
	Young's Cr. to Reservoir	15	9/18/13 RB, 10/10/13 LB	7

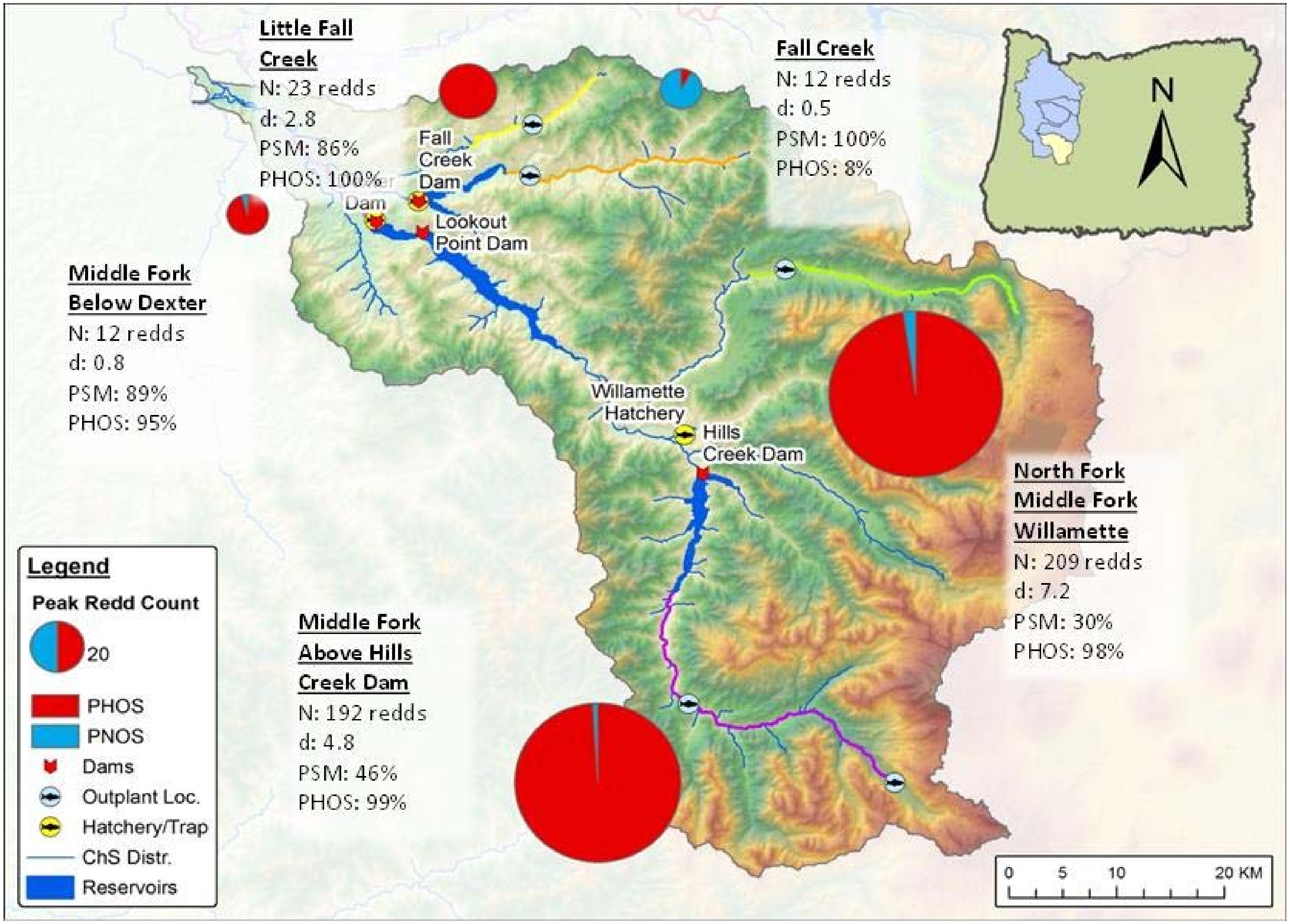

Figure 22. Spawner survey and carcass recovery results for the Middle Fork Willamette River, 2013. Colored sections indicate major survey reaches. Pie charts indicate peak redd counts (also indicated by "N") by their size and proportion of hatchery-origin spawn

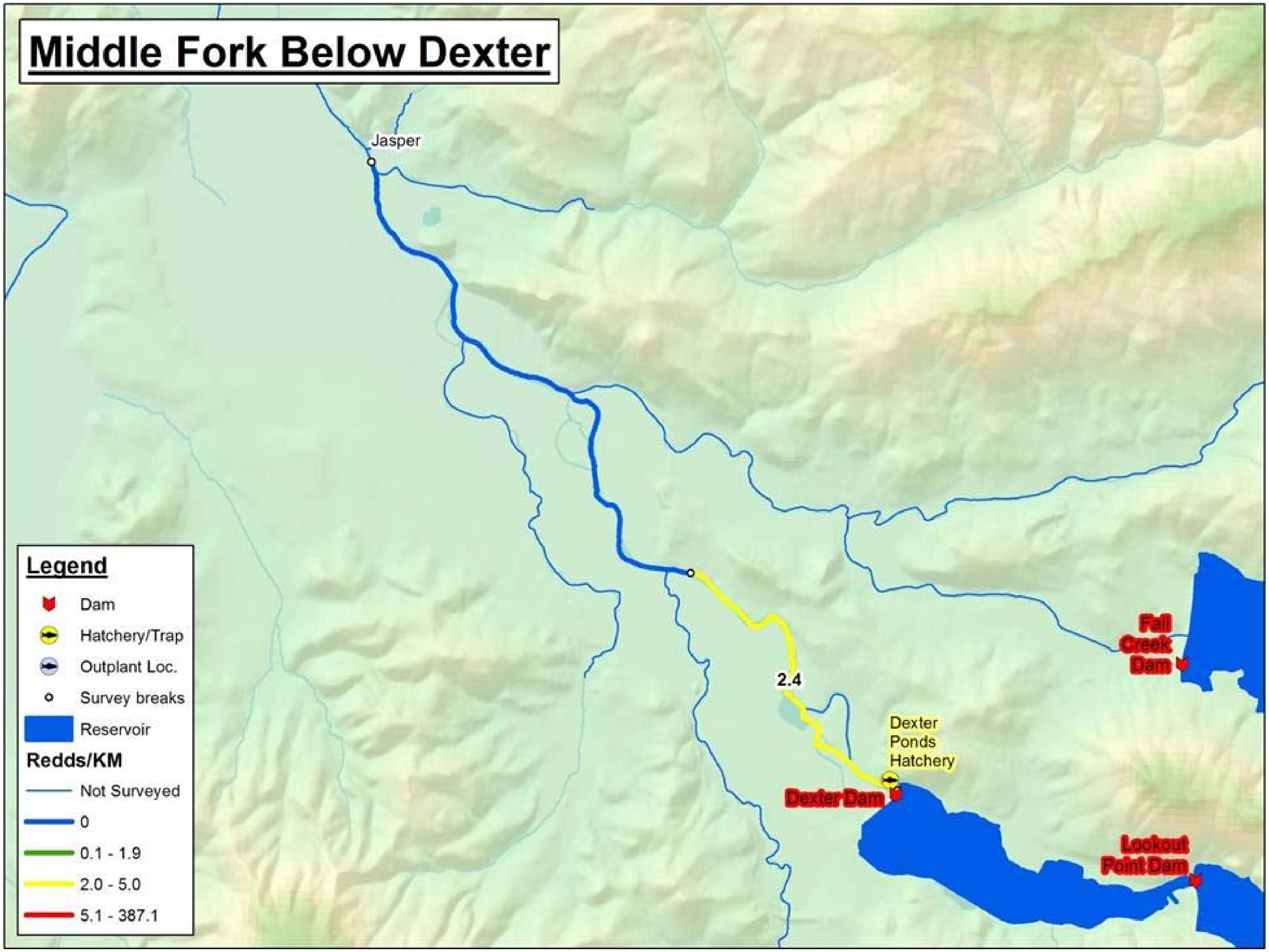

Figure 23. Spawning activity below Dexter Dam, 2013.

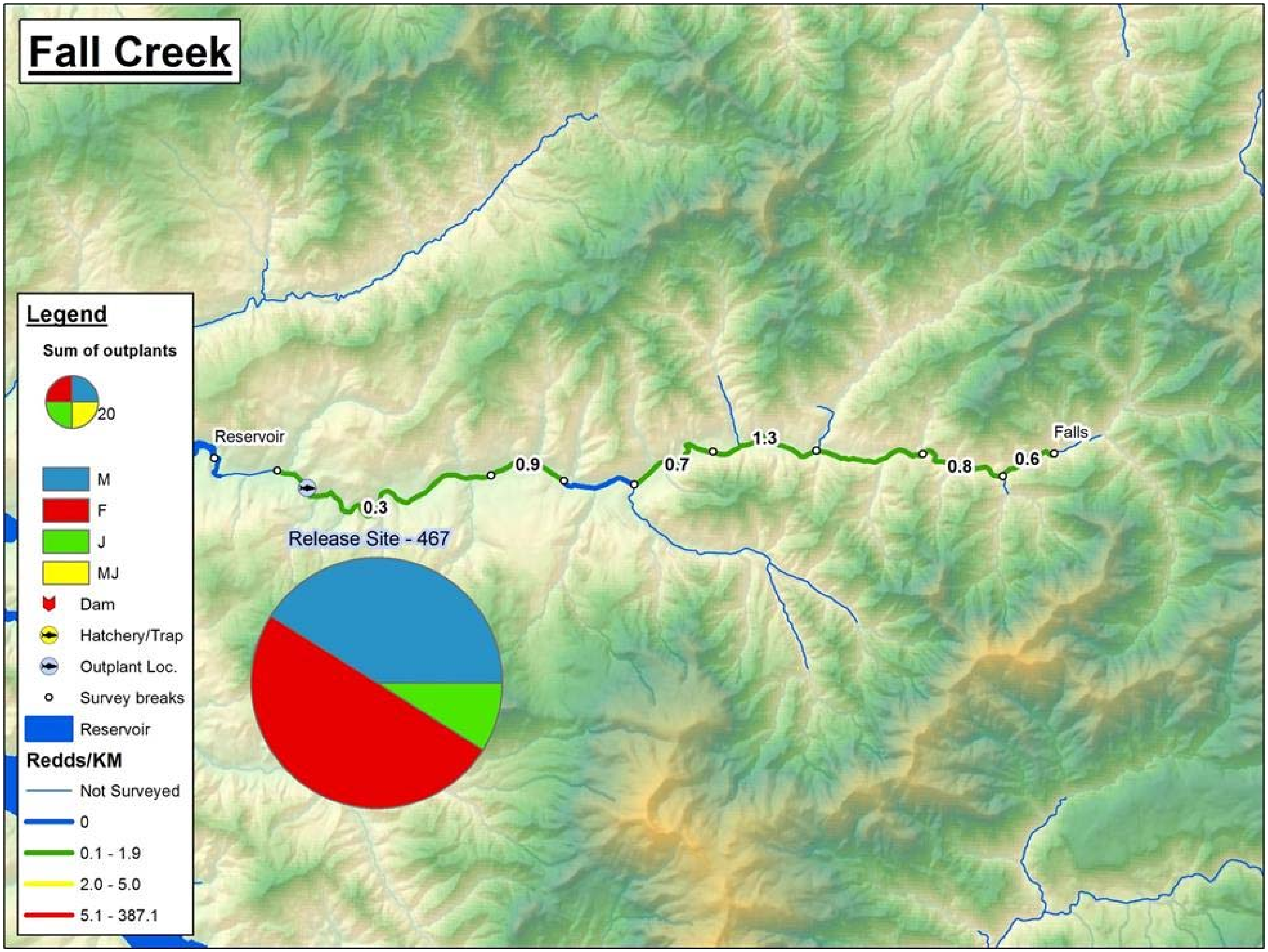

Figure 24. Outplanting and spawning activity in Fall Creek, 2013.

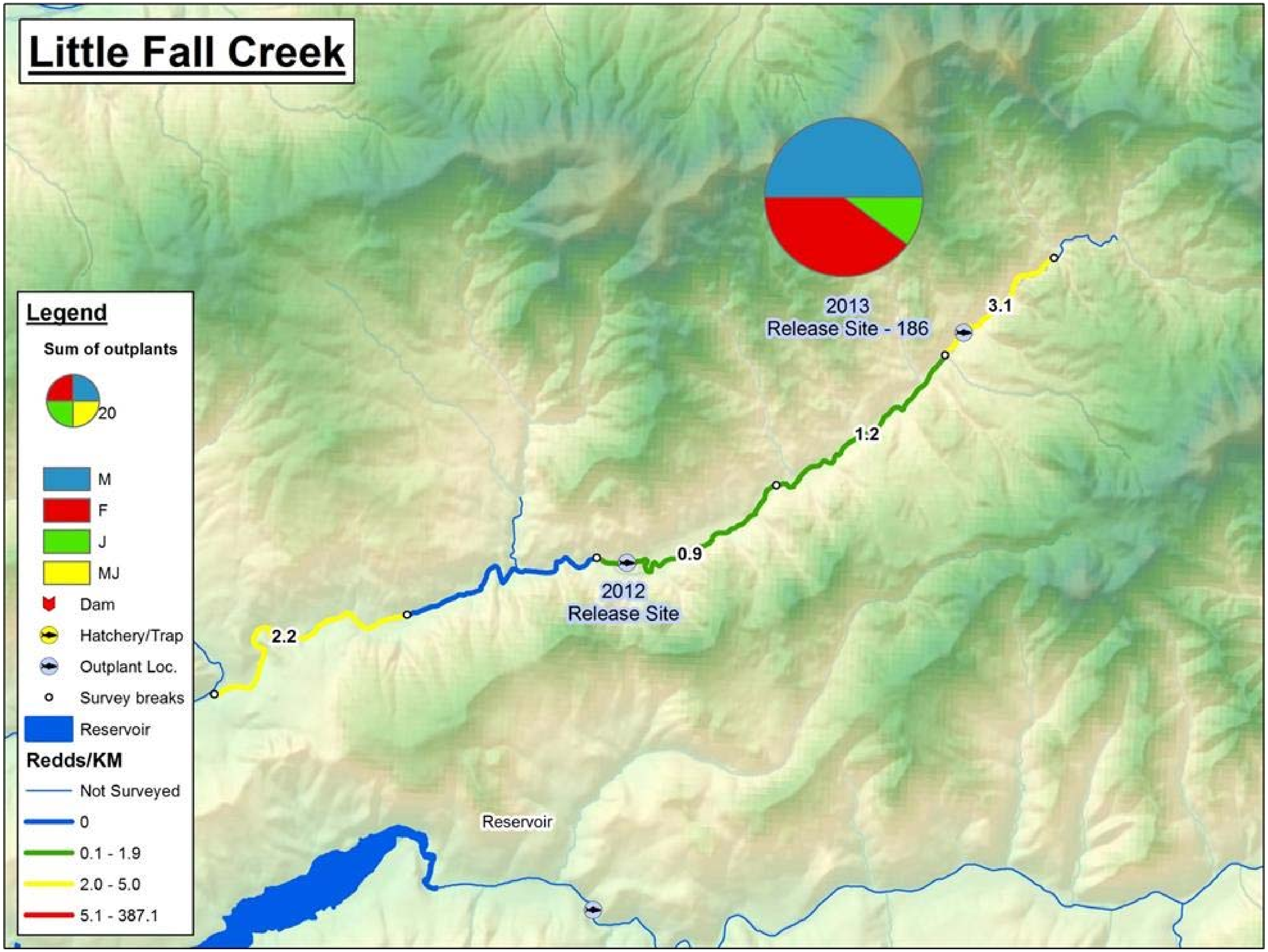

Figure 25. Outplanting and spawning activity in Little Fall Creek, 2013.

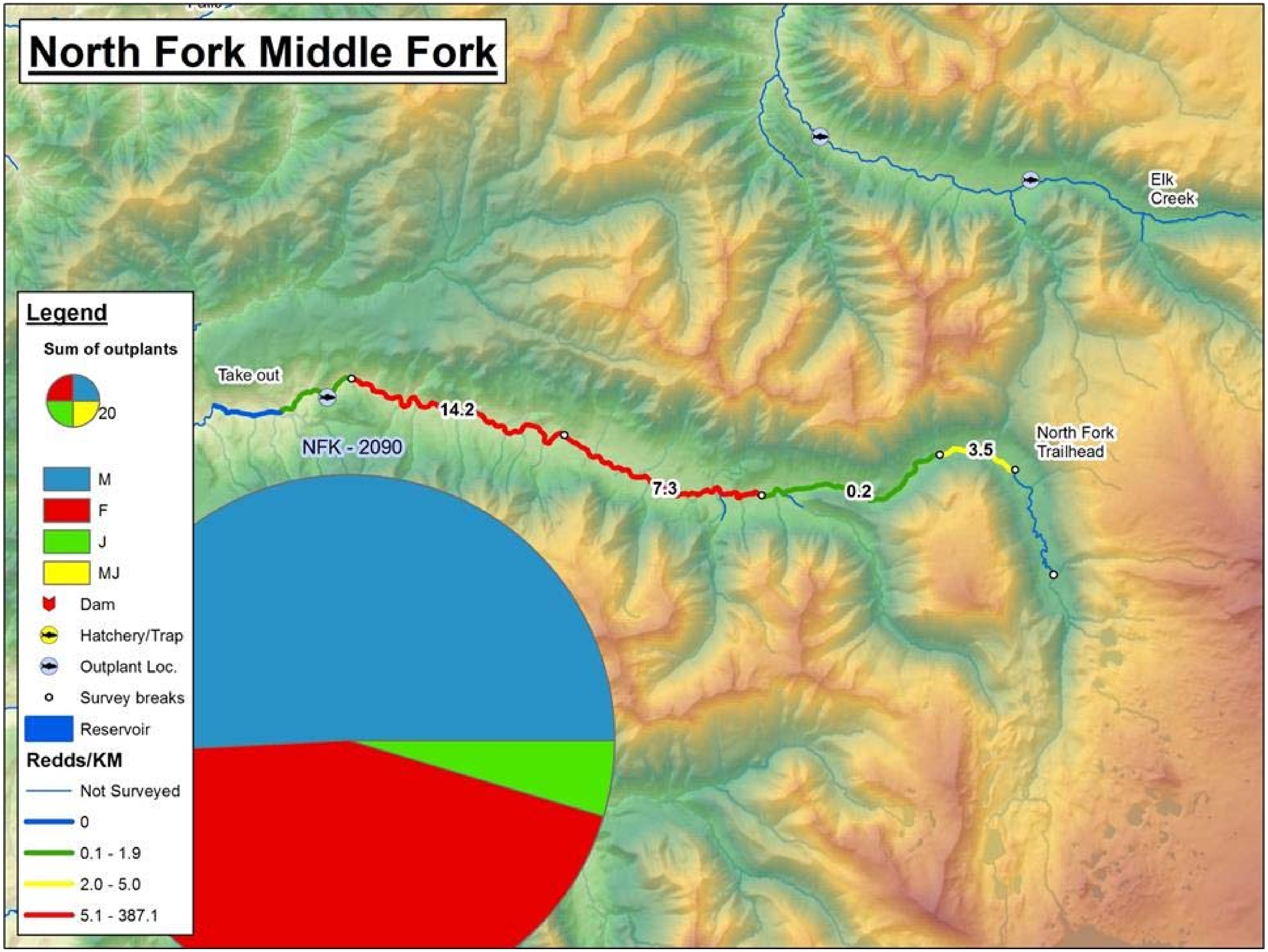

Figure 26. Outplanting and spawning activity in the North Fork Middle Fork Willamette River, 2013.

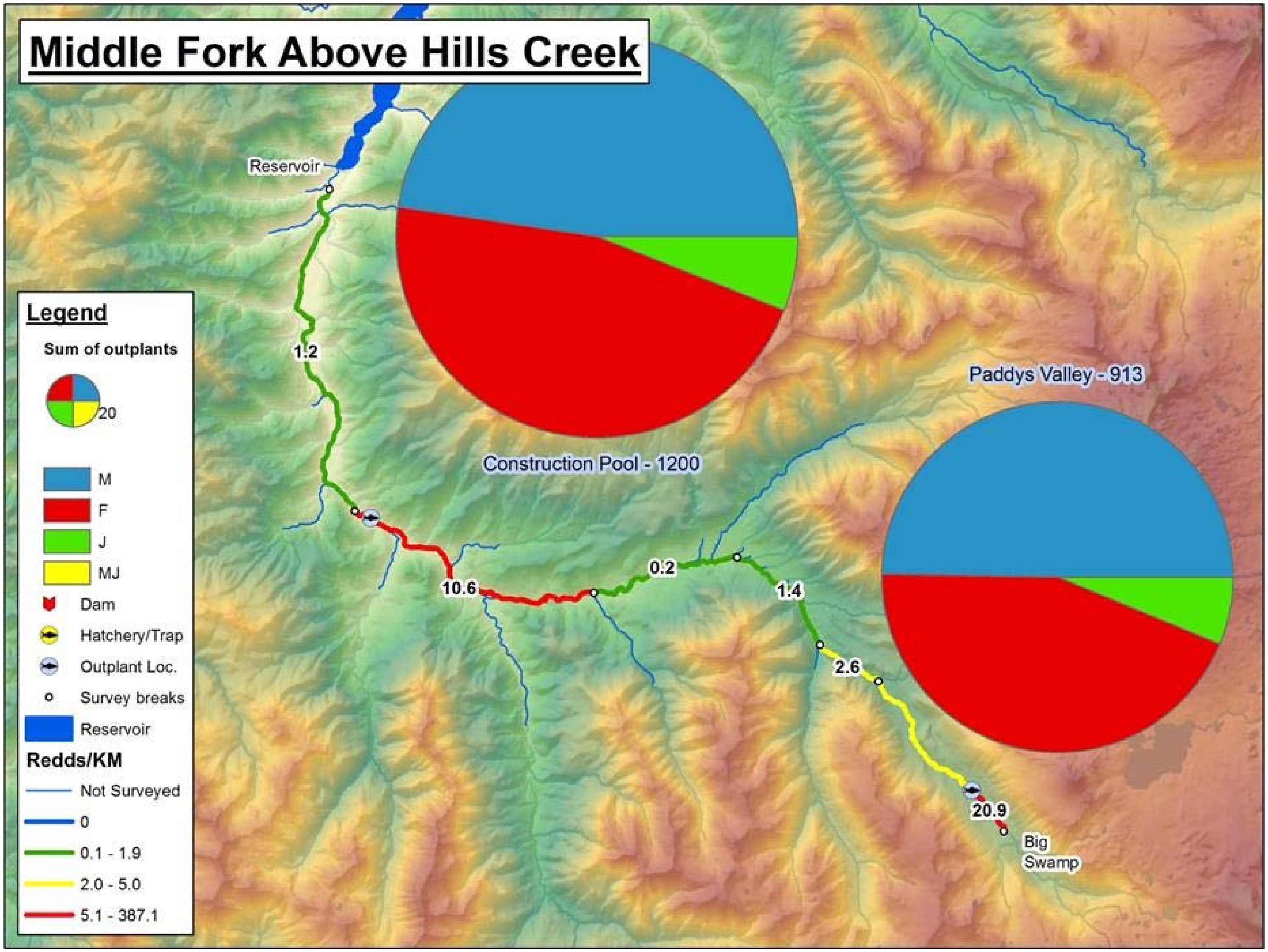

Figure 27. Outplanting and spawning activity in the Middle Fork Willamette River above Hills Creek Reservoir, 2012.

Section 3.1.3 Age Structure and Size Distribution on Spawning Grounds**:**

The age structure of natural- and hatchery-origin fish collected in 2013 during spawner and carcass surveys, as determined from analysis of fish scales and coded wire tags, is presented in Table 6. Historical age structure of natural and hatchery-origin fish is presented in Figure 28.

Size distribution of natural- and hatchery-origin fish collected during spawner and carcass surveys is shown in Table 7.

Section 3.1.4 Spawner Abundance:

Spawner abundance estimates were, as described, obtained by multiplying the peak redd counts in reaches of interest by the expansion factor 2.5 spawners/redd and then parsed into natural- and hatchery-origin spawners using the estimates of pHOS for those specific reaches. Importantly, because of a severe storm event during peak spawning, it is very likely that some redds were not observed and estimates of peak redd counts were biased low.

3.1.4.1: North Santiam River: We estimated that total spawner abundance in the North Santiam subbasin, based strictly on redd count expansion, was 1,178 fish of which 335 were natural-origin and 1,216 were hatchery-origin (Table 8). Spawner abundance above Detroit Dam was 673 fish; 670 hatchery-origin and three natural-origin. We estimated that 25 and 20 natural- and hatchery-origin fish, respectively, spawned in the Little North Santiam River. Hatchery-origin fish must have strayed into that tributary because no outplanting of hatchery fish occurred there in 2013 but some of the wild origin spawners might have resulted from natural production there.

3.1.4.2: South Santiam: We estimated that spawner abundance of natural-origin and hatchery-origin fish in the South Santiam subbasin was 633 and 522 fish, respectively (Table 9). The majority of natural-origin spawning occurred above Foster Dam; we estimated that spawner abundance there was 207 wild and 28 hatchery fish. We observed no redds and infer no spawning occurred below Lebanon Dam in 2013, again supporting the idea that another video

Table 6. Age structure of natural- and hatchery-origin Chinook salmon, 2013. Scales were collected during spawning ground surveys.

	Natural-origin Age					Hatchery-origin Age				
	2	3	4	5	6	2	3	4	5	6
ABOVE PROJECT DAMS										
Above Big Cliff Dam	0	0	0	0	0	0	0	0	0	0
Above Foster Dam	0	13	119	20	1	1	0	6	12	0
Above Leaburg Dam	0	1	33	60	4	0	0	0	1	0
S. Fk McKenzie Abv Cougar Dam	0	0	2	3	0	0	0	11	1	0
Above Fall Creek Dam	0	3	15	1	0	0	0	0	0	0
North Fork Middle Fork	0	0	6	2	0	0	0	2	0	0
Above Hills Creek Dam	0	0	1	1	0	0	0	0	0	0
Above Big Cliff Dam	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Above Foster Dam	0%	8%	78%	13%	1%	5%	0%	32%	63%	0%
Above Leaburg Dam	0%	1%	34%	61%	4%	0%	0%	0%	100%	0%
S. Fk McKenzie Abv Cougar Dam	0%	0%	40%	60%	0%	0%	0%	92%	8%	0%
Above Fall Creek Dam	0%	16%	79%	5%	0%	0%	0%	0%	0%	0%
North Fork Middle Fork	0%	0%	75%	25%	0%	0%	0%	100%	0%	0%
Above Hills Creek Dam	0%	0%	50%	50%	0%	0%	0%	0%	0%	0%

	Natural-origin Age					Hatchery-origin Age				
	2	3	4	5	6	2	3	4	5	6
BELOW PROJECT DAMS										
Below Big Cliff Dam	0	12	25	12	1	0	1	2	2	0
Below Foster Dam	0	16	117	13	1	0	1	3	5	0
Below Leaburg Dam	0	0	2	7	1	0	0	1	0	0
Below Dexter Dam	0	0	4	5	0	0	0	0	1	0
Below Big Cliff Dam	0%	24%	50%	24%	2%	0%	20%	40%	40%	0%
Below Foster Dam	0%	11%	80%	9%	1%	0%	11%	33%	56%	0%
Below Leaburg Dam	0%	0%	20%	70%	10%	0%	0%	100%	0%	0%
Below Dexter Dam	0%	0%	44%	56%	0%	0%	0%	0%	100%	0%

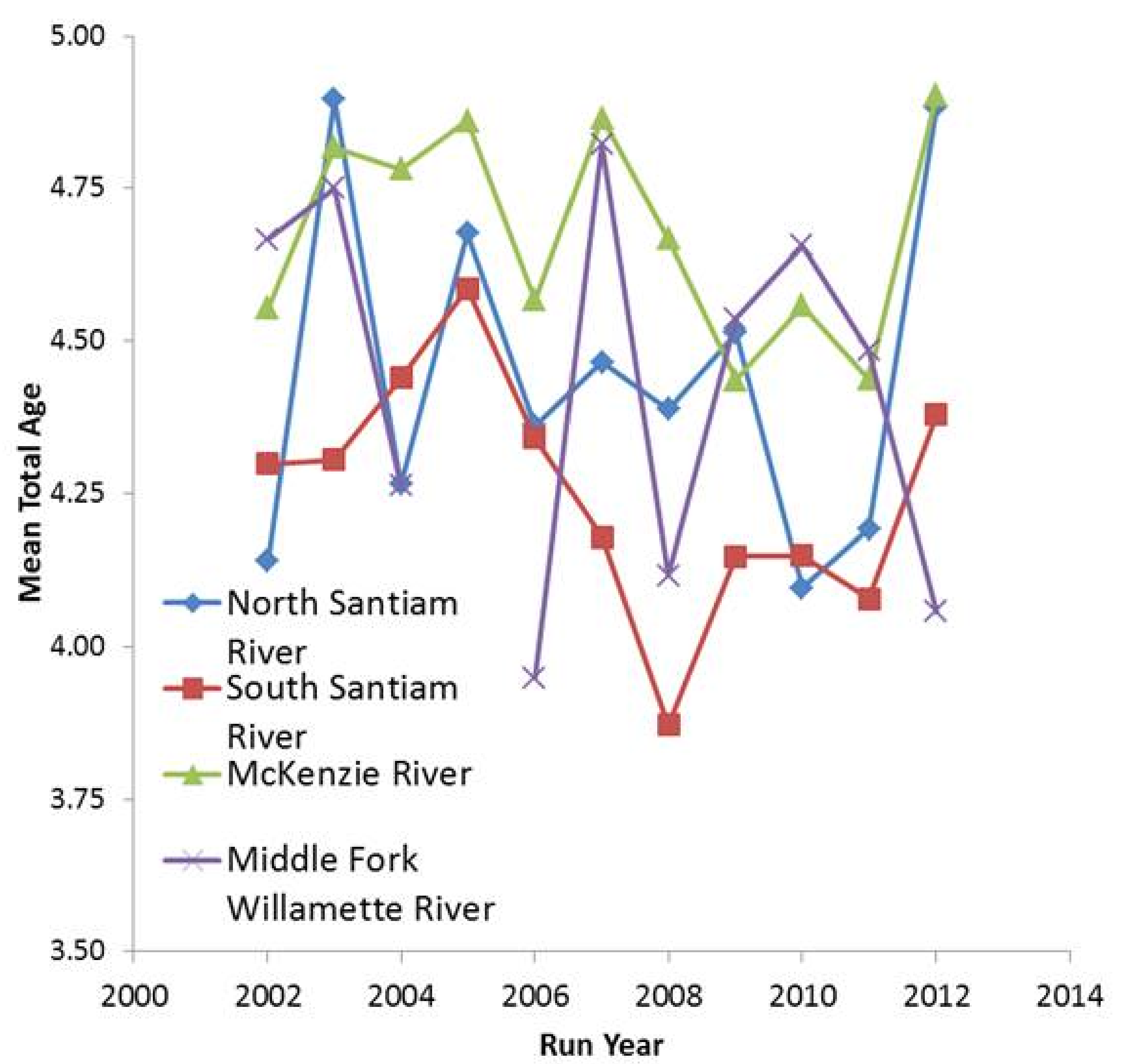

Figure 28. Recent historical mean age of natural-origin Chinook salmon in Upper Willamette subbasins.

Table 7. Size distribution of Chinook salmon collected during spawner and carcass surveys (NOS: Natural-origin Spawners) and during hatchery sampling (HOB: Hatchery-origin Brood), 2013. NSNT, SSNT, McK and MFW indicate North Santiam, South Santiam, McKenzie, and Middle Fork Willamette rivers, respectively.

Fork Length (cm)	NSNT NOS	SSNT NOS	McK NOS	MFW NOS
Below Dam				
50	0	1	0	0
60	1	1	0	0
70	7	9	0	0
80	25	82	2	8
90	18	54	6	1
100	2	13	1	0
110	0	1	1	0
120	0	0	0	0
N	53	161	10	9
Mean	78.0	79.5	85.8	77.6
SEM	1.05	0.64	3.03	1.24
Above Dam				
50	0	0	0	0
60	0	2	0	1
70	0	10	6	10
80	0	98	34	19
90	0	64	41	8
100	1	11	19	1
110	0	0	3	0
120	0	0	1	0
N	1	185	104	39
Mean	98.0	79.4	83.9	75.0
SEM	--	0.51	0.91	1.31
Broodstock	NSNT HOB	SSNT HOB	McK HOB	MFW HOB
50	0	0	0	0
60	10	5	11	33
70	63	47	107	400
80	147	107	487	734
90	73	51	392	169
100	14	9	67	11
110	1	0	3	0
120	0	0	0	0
N	308	219	1067	1347
Mean	76.2	75.7	79.3	73.4
SEM	0.03	0.35	0.07	0.05

monitoring site might be useful at that location because it is likely to detect essentially all spring Chinook spawners returning to the basin.

3.1.4.3: McKenzie: Total spawner abundance in the McKenzie subbasin was estimated at 1,790 spawners in 2013 (1,156 wild origin and 1,194 hatchery-origin; Table 10). By convention, the McKenzie subbasin is divided into four reaches of interest:

- Below Leaburg Dam, where we estimated spawner abundance of 114 and 634 wild- and hatchery-origin spawners respectively.
- Between Leaburg Dam and the confluence with the South Fork McKenzie River plus the South Fork McKenzie River up to Cougar Dam where we estimated spawners at 236 natural-origin and 129 hatchery-origin fish.
- The mainstem McKenzie River above the confluence with the South Fork McKenzie River. In this reach we estimated 815 natural-origin and 58 hatchery-origin spawners.
- The South Fork McKenzie River above Cougar Reservoir. Surveys in this reach support a broad-reaching experiment attempting to evaluate potential for using hatchery-origin fish to achieve recovery in otherwise depauperate habitat, the details of which have been reported elsewhere (Zymonas et al. 2013; Banks et al. 2013). Our expansion of redd counts generated estimates of 76 natural-origin and 289 hatchery-origin spawners above Cougar Dam in 2013.

Table 8. Chinook salmon spawner abundance estimates for the North Santiam subbasin 2013. Estimates derived by redd count expansion were parsed into hatchery- and natural-origin using carcass counts after adjustment using otolith data.

Subbasin, section	Peak Redd Count	Reach Length (km)	Redd Density (redds/km)	Spawner Abundance Estimate (redds*2.5)	Reach-specific pHOS	Hatchery-origin Abundance Estimate	Natural-origin Abundance Estimate
North Santiam							
Below Bennett	1	3.2	0.3	3	0.0%	0	3
Bennett Dams to Minto	317	37.6	8.4	793	61.6%	488	305
Little North Santiam	18	14.9	1.2	45	45.5%	20	25
Above Detroit Reservoir	269	12.3	21.8	673	99.6%	670	3

Table 9. Chinook salmon spawner abundance estimates for the South Santiam River, 2013. Estimates derived by redd count expansion were parsed into hatchery- and natural-origin using carcass counts after adjustment using otolith data.

Subbasin, section	Peak Redd Count	Reach Length (km)	Redd Density (redds/km)	Spawner Abundance Estimate (redds*2.5)	Reach-specific pHOS	Hatchery-origin Abundance Estimate	Natural-origin Abundance Estimate
South Santiam							
Below Lebanon Dam	--	--	--	--	--	--	--
Lebanon Dam to Foster Dam	368	24.0	15.3	920	53.8%	495	425
Above Foster Dam	94	28.8	3.3	235	11.7%	28	207

Table 10. Chinook salmon spawner abundance estimates for the McKenzie River, 2013. Estimates derived by redd count expansion were parsed into hatchery- and natural-origin using carcass counts after adjustment using otolith data.

Subbasin, section	Peak Redd Count	Reach Length (km)	Redd Density (redds/km)	Spawner Abundance Estimate (redds*2.5)	Reach-specific pHOS	Hatchery-origin Abundance Estimate	Natural-origin Abundance Estimate
McKenzie							
Below Leaburg Dam	75	9.6	7.8	188	84.1%	158	30
Leaburg - SF McKenzie	110	29.0	3.8	275	33.8%	93	182
South Fork below Cougar Dam	36	4.3	8.4	90	39.7%	36	54
Above South Fork McKenzie	349	73.9	4.7	873	6.6%	58	815
S Fork McKenzie Above Cougar	146	35.5	4.1	365	79.3%	289	76

3.1.4.4 Middle Fork Willamette: Results from our surveys indicated that 1,120 fish (64 natural-origin and 1,056 hatchery-origin; Table 11) spawned in the Middle Fork Willamette subbasin in 2013. The reaches of interest in the Middle Fork Willamette subbasin include:

- Below Dexter Dam. We estimated that two natural-origin and 28 hatchery-origin fish spawned below Dexter Dam in 2013.
- Little Fall Creek. Hatchery-origin fish were outplanted in Little Fall Creek in 2013 and we estimated that 53 hatchery-origin and five natural-origin fish spawned there in 2013.
- Fall Creek. We estimated that 30 wild-origin and zero hatchery-origin fish spawned above Fall Creek Reservoir.
- North Fork Middle Fork. We estimated that five natural-origin and 500 hatchery-origin fish spawned in the North Fork Middle Fork Willamette River above Lookout Point Reservoir.
- Middle Fork above Hills Creek Reservoir. We estimated that five natural-origin and 475 hatchery-origin fish spawned in the Middle Fork Willamette River above Hills Creek Reservoir.

Table 11. Chinook salmon spawner abundance estimates for the Middle Fork Willamette River, 2013. Estimates derived by redd count expansion were parsed into hatchery- and natural-origin using carcass counts after adjustment using otolith data.

Subasin, section	Peak Redd Count	Reach Length (km)	Redd Density (redds/km)	Spawner Abundance Estimate (redds*2.5)	Reach-specific pHOS	Hatchery-origin Abundance Estimate	Natural-origin Abundance Estimate
Middle Fork Willamette							
Below Dexter	12	14.4	0.8	30	93.3%	28	2
Little Fall Creek	23	8.2	2.8	58	91.9%	53	5
Fall Creek	12	26.1	0.5	30	0.0%	0	30
North Fork Middle Fork	209	29.0	7.2	523	95.8%	500	22
Above Hills Creek Reservoir	192	40.0	4.8	480	99.0%	475	5

Section 3.1.5 Estimates of prespawning mortality:

Prespawning mortality varied widely among subbasins and among river reaches within subbasins (Table 12). Several factors can potentially affect estimates of pre-spawning mortality derived from recovery of female carcasses. Survey efforts can vary spatially and temporally from year to year. These differences can affect recovery of salmon carcasses: scavengers and high river flow can affect the length of time that carcasses remain in river sections where they can be located and recovered by surveyors. Late season carcasses can be difficult to recover after flows begin to increase, and since these fish are more likely to be successful spawners, there is the potential for systematic bias. We believe that pre-spawning mortality estimates of outplanted fish are affected by the following factors: the time of the year that fish are released upstream of dams, the quality of release sites, and water temperature. For those reasons we view our estimates of pre-spawning mortality in relative terms of low, medium or high corresponding to estimates of less than 20%, between 20 and 50%, and above 50%, respectively, rather than as absolute values. Of particular importance in 2013 is the potential for the severe storm event during peak spawning to have influenced estimates of prespawning mortality. If the storm prevented collection of fish that had spawned then the PSM estimated might be (and probably were) biased high.

3.1.5.1 North Santiam: The greatest rate of prespawning mortality in the North Santiam River was observed in the Little North Santiam River (Table 12), excluding consideration of the single unspawned female collected below Bennett Dam. Conditions contributing to PSM in the North Santiam subbasin in 2013 appeared to be relatively benign basinwide, especially considering that the estimates may, as noted above, be biased high.

3.1.5.2 South Santiam: The highest estimates of PSM in the South Santiam River in 2013 were obtained above Foster Dam. Below Foster PSM estimates were technically “moderate” but, again, we think the estimate was biased high.

We also tested for association between probability of survival to spawning for years 2009 – 2013 and fish size (fork length; cm), outplant site, and outplant timing (week). In 2013 there was a weak tendency for the probability of survival to spawning to increase with timing of outplants but in other years there was either no association between the factors and probability of survival or there was a very week tendency for late outplants to exhibit lower survival. An effort is

Table 12. Estimates of prespawning mortality of Chinook salmon in 2013. Estimate is based of inspection of female carcasses. Any female carcass containing more than a visually estimated 50% of its eggs was counted as a prespawn mortality. Importantly, the 2013 surveys were truncated because of an extreme weather event and PSM estimates may have been biased with magnitude and direction of bias unknown.

Subbasin, section	Processed Carcasses	Males	Spawned Females	Unspawned Females	PSM	PSM Lower 95% CI	PSM Upper 95% CI
North Santiam							
Below Bennett	1	0	0	1	100%	100%	100%
Bennett Dams to Minto	123	45	62	16	21%	12%	29%
Little North Santiam	11	6	2	3	60%	17%	103%
Above Detroit Reservoir	228	113	109	6	5%	1%	9%
TOTAL	363	164	173	26	13%	8%	18%
South Santiam							
Below Lebanon Dam	0	0	0	0	--	--	--
Lebanon Dam to Foster Dam	355	149	160	46	22%	17%	28%
Above Foster Dam	215	125	41	49	54%	44%	65%
TOTAL	570	274	201	95	32%	27%	37%
McKenzie							
Below Leaburg Dam	61	36	19	6	24%	7%	41%
Leaburg - SF McKenzie	53	29	24	0	0%	0%	0%
South Fork below Cougar Dam	11	4	6	1	14%	-12%	40%
Above South Fork McKenzie	66	29	36	1	3%	-3%	8%
S. Fk McKenzie Above Cougar	30	10	15	5	25%	6%	44%
TOTAL	221	108	100	13	12%	6%	17%
Middle Fork Willamette							
Below Dexter	77	24	6	47	89%	80%	97%
Little Fall Creek	35	23	0	12	100%	100%	100%
Fall Creek	24	9	0	15	100%	100%	100%
North Fork Middle Fork	347	195	107	45	30%	22%	37%
Above Hills Creek Reservoir	200	98	55	47	46%	36%	56%
TOTAL	683	349	168	166	50%	44%	55%

underway by OSU researchers to more thoroughly synthesize the historical PSM data and, especially, model the effect of variance in carcass recovery probabilities within and among years (OSU/D. Tyrell Deweber, personal communication). That factor is not considered here. Carcass recovery probability may have a strong likelihood of biasing estimates of survival. Table 13 provides details on tagged fish releases and recoveries. Table 14 provides the Akaike Information Criterion scores for the various models tested.

3.1.5.3 McKenzie: Prespawning mortality throughout the McKenzie was generally low but was moderate in the reaches below Leaburg Dam and in the South Fork McKenzie above Cougar Dam (Table 12).

3.1.5.1 Middle Fork Willamette: Prespawning mortality estimates were highly variable throughout the Middle Fork Willamette River (Table 12) ranging from moderate in the North Fork Middle Fork (30%) to essentially 100% in Fall Creek and Little Fall Creek.

Section 3.1.6 Origin on Spawning Grounds:

During surveys in 2013, we sampled unclipped Chinook salmon carcasses and collected 56 readable otoliths in the North Santiam River, 363 in the South Santiam River, 117 in the McKenzie River, and 103 in the Middle Fork Willamette River. Fish were initially categorized as naturally produced based on absence of an adipose fin clip. Final estimates of the proportion of hatchery-origin spawners were derived after otolith analyses (Tables 15 and 16) allowed adjustments based on the proportions of unclipped hatchery-origin fish. The exception was in the McKenzie. An equipment malfunction in 2009 at the McKenzie Hatchery prevented thermal marking for that brood. Therefore, four-year-old hatchery adults in 2013 were not thermally marked and we used the average otolith mark rate from 2008 through 2012 to adjust counts of clipped and unclipped fish. From 2008 through 2012 the average thermal mark rates for above and below Leaburg dam were 5.2 and 19.0%, respectively. Subbasin-wide pHOS estimates (all reaches above and below dams in each subbasin pooled) ranged from 35.4% (McKenzie) to 94.3% (Middle Fork). However, pHOS estimates in the South Santiam above Foster Dam, Fall

Table 13. Releases of tagged adult Chinook salmon above Foster Dam, 2009 – 2013, and recoveries of spawned and prespawn mortality females.

Year	Floy-tagged Adult Releases	Spawned Female Recoveries	Prespawn Mortality Female Recoveries	PSM
2009	310	12	1	8%
2010	728	21	2	9%
2011	1,210	56	14	20%
2012	1,040	58	17	23%
2013[1]	927	54	23	54%

[1] Note that PSM estimates in 2013 may have been biased high.

Table 14. Akaike Information Criterion (AIC) scores for PSM models tested in the South Santiam subbasin above Foster Dam.

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
random week	5	269.13	0	0.65	0.65	-129.45
random week/length	6	271.04	1.91	0.25	0.9	-129.37
random week/outplant site	7	272.87	3.74	0.1	1	-129.23
outplant week	3	283.15	14.02	0	1	-138.53
random intercept	2	285.44	16.31	0	1	-140.7
outplant site	4	286.2	17.07	0	1	-139.02
fork length	3	287.39	18.26	0	1	-140.65
random fork length	5	290.09	20.96	0	1	-139.93
random outplant site	9	296.13	27	0	1	-138.73

Creek, and the McKenzie River above the South Fork McKenzie were notably low (11.7, 0.0, and 6.6%, respectively).

3.1.6.1 North Santiam: As in previous years the pHOS estimates (Table 16) in the North Santiam River exceeded the long-term recovery goal of 10% basinwide. Achieving a basinwide pHOS < 10% would require substantial natural production above Detroit Dam and pHOS below Big Cliff Dam not to exceed 21%. We estimate that the basinwide pHOS in 2013, including all reaches below Minto and all reaches above Detroit Reservoir, was 77.9%. We recognize that that estimate is probably biased high because of the unresolved issue on how to estimate pHOS and spawner abundance, both necessary to calculate an true aggregate pHOS for the subbasin, between Minto and Big Cliff dams where only unclipped fish are currently passed.

3.1.6.2 South Santiam: As in previous years the pHOS estimates (Table 16) in the South Santiam River exceeded the recovery goal of < 10% above Foster and < 30% overall. Unlike outplanting operations in the North Santiam River, only unclipped Chinook salmon are outplanted above Foster Dam but, because a substantial number of unclipped fish were actually hatchery-origin (11.7%, based on thermal marks), pHOS targets were exceeded even there. We estimate that the basinwide pHOS in 2013, including all reaches above and below Foster Reservoir, was 45.2%.

3.1.6.3 McKenzie: As in previous years the pHOS estimates (Table 16) in the McKenzie River exceeded the recovery goal of 10%. However, pHOS in the McKenzie is the lowest among the subbasins and, in the reaches above the confluence with the South Fork McKenzie River, the pHOS estimate was 6.6%. We estimate that the basinwide pHOS in 2013, including all reaches above and below Leaburg Dam but excluding reaches above Cougar Dam, was 24.2%. Including the reaches above Cougar Dam increased the estimated pHOS to 35.4%.

3.1.6.4 Middle Fork Willamette: As in previous years the pHOS estimates (Table 16) in the Middle Fork Willamette River greatly exceeded the recovery goal of 10%. However, as in the South Santiam above Foster Dam, only unclipped fish are outplanted in Fall Creek. None of the otoliths collected from Fall Creek carcasses 2013 were thermally marked so we estimate that pHOS was 0.0% in that portion of the subbasin meeting recovery goals. The remainder of the subbasin was dominated by hatchery spawners. We estimate that the basinwide pHOS in 2013, including all reaches above and below Dexter Dam, was 94.3%.

Table 15. Analysis results for otoliths collected from spawning ground surveys in 2013 and examined for thermal marks to verify wild status of unclipped adults. Percent marked indicates the proportion of unclipped hatchery-origin fish sampled. Note that the McKenzie otolith data reported here were not used in 2013 to estimate pHOS. See text.

Subbasin	Section	Total Readable Otoliths	Thermally Marked Otoliths	% Marked
North Santiam River	Below Bennett Dam	1	0	0.0%
	Bennett to Minto Dam	50	5	9.1%
	Little North Santiam	6	0	0.0%
	North Santiam Above Detroit	0	0	--
	Marion Forks Hatchery	0	0	--
	North Santiam Total	**56**	**5**	**8.2%**
South Santiam River	South Santiam Below Foster	166	9	5.1%
	South Santiam Above Foster	197	21	9.6%
	South Santiam Total	**363**	**30**	**7.6%**
McKenzie River	McKenzie Below Leaburg	12	2	14.3%
	Leaburg to S. Fk McKenzie	33	0	0.0%
	South Fork McKenzie Below Cougar	7	0	0.0%
	Above S. Fk McKenzie	60	0	0.0%
	South Fork McKenzie Above Cougar	5	0	0.0%
	McKenzie Hatchery	0	0	--
	McKenzie Total	**117**	**2**	**1.7%**
Middle Fork Willamette River	Middle Fork Below Dexter	6	1	14.3%
	Fall Creek	21	0	0.0%
	Little Fall Creek	2	0	0.0%
	North Fork Middle Fork	13	2	13.3%
	Middle Fork Above Hills Creek	2	0	0.0%
	Willamette Hatchery	59	14	19.2%
	Middle Fork Total	**103**	**17**	**14.2%**

Table 16. Estimates of pHOS in 2013 based on counts of clipped and unclipped carcasses after adjustments following otolith analyses.

Subbasin, section	Processed Carcasses	Peak Redd Count	Unclipped	Clipped	% Thermally Marked Otoliths from Unclipped Carcasses	Wild Estimate	Hatchery Estimate	PHOS	PHOS Lower 95% CI	PHOS Upper 95% CI
North Santiam										
Below Bennett	1	1	1	0	0.0%	1	0	0.00	0.00	0.94
Bennett Dams to Minto	123	317	52	71	9.1%	47	76	0.62	0.53	0.71
Little North Santiam	11	18	6	5	0.0%	6	5	0.45	0.16	0.82
Above Detroit Reservoir	228	269	1	227	0.0%	1	227	1.00	0.99	1.01
South Santiam										
Below Lebanon Dam	0	0	0	0	0.0%	0	0	0.00	--	--
Lebanon Dam to Foster Dam	355	368	173	182	5.1%	164	191	0.54	0.49	0.59
Above Foster Dam	215	94	210	5	9.6%	190	25	0.12	0.07	0.16
McKenzie										
Below Leaburg Dam	61	75	12	49	19.0%	10	51	0.84	0.75	0.96
Leaburg - SF McKenzie	53	110	37	16	5.2%	35	18	0.34	0.21	0.48
S. Fork below Cougar Dam	11	36	7	4	5.2%	7	4	0.40	0.11	0.75
Above South Fork McKenzie	66	349	65	1	5.2%	62	4	0.07	0.00	0.09
S. Fork McKenzie Above Cougar	32	146	7	25	5.2%	7	25	0.79	0.65	0.97
Middle Fork Willamette										
Below Dexter	77	12	6	71	14.3%	5	72	0.93	0.88	1.01
Little Fall Creek	37	23	3	34	0.0%	3	34	0.92	0.83	1.05
Fall Creek	24	12	24	0	0.0%	24	0	0.00	0.00	0.17
North Fork Middle Fork	347	209	17	330	13.3%	15	332	0.96	0.94	0.98
Above Hills Creek Reservoir	200	192	2	198	0.0%	2	198	0.99	0.98	1.01

Section 3.1.7 Straying:

We define straying as the incidence of hatchery-origin fish released as juveniles in one subbasin that are recovered as adults in a different subbasin. As in past years the vast majority of tags were recovered in their subbasin of origin, in both samples collected at hatcheries and on spawning ground surveys (Table 17). The exception was for South Santiam stock fish that were reared at the Willamette Hatchery and released directly into the Molalla River; more straying from "Molalla" fish into the Santiam subbasins occurred in 2013. Recoveries at McKenzie hatchery are biased slightly low because an unknown, but probably small, number of CWT hatchery fish were captured at the hatchery but not sampled for CWTs. Instead, they were used to supplement low numbers of natural-origin fish that were passed above Cougar Dam. At other hatchery facilities CWT recovery rates were assumed to be 100%. The CWT recovery rates during spawning ground surveys are unknown but we are developing a method to estimate the recovery rate and will report our results later.

Table 17. Analysis of CWT recoveries during spawning ground surveys, at hatchery traps, and at hatcheries during 2013. Values are expansions based on the proportion of the release group that received CWTs. Shaded cells indicate recoveries in the basins into which fish were released. Recovery locations with "SGS" indicate spawning ground survey recoveries. All other recoveries were from hatcheries or traps.

RECOVERY LOCATION	RELEASE LOCATION										
	N SANTIAM R	DETROIT RES	S SANTIAM R	MCKENZIE R	MIDDLE FORK WILLAMETTE R	LOOKOUT PT RES	CST FK WILLAMETTE R	MOLALLA R	UMATILLA R	LEWIS R	WARM SPRINGS R
N SANTIAM R SGS	14	6	27					6			
LITTLE N FK SANTIAM R SGS								3			
MINTO FCF	1,361	210	40					22			
S SANTIAM R SGS			91								
S SANTIAM H			1,999		6						
MCKENZIE R SGS				20							
S FK MCKENZIE R SGS				10							
HORSE CR - MCKENZIE R SGS				7				3			
MCKENZIE H				748				3			
MIDDLE FORK WILLAMETTE SGS					69		1				
WILLAMETTE H					4,485	9		3	6		
DEXTER PONDS					1,660	4				1	2

Section 3.1.8 Video Monitoring*:*

3.1.8.1 North Santiam (Upper and Lower Bennett Dams): Counts of spring Chinook salmon and other species passing upstream of Upper Bennett Dam and Lower Bennett Dam in 2013 are provided in Tables 18 - 20. The first unclipped adult Chinook salmon was observed in April and the first clipped adult was noted in March. The peak count for both unclipped and clipped adults occurred in June. The final observations of unclipped and clipped adults occurred in September and November, respectively. Adipose clips on jack salmon could not readily be discerned because of the size of the fish and fin; those counts were pooled. The Lower Bennett video system was operated continuously from 5/25/2013 to 12/10/2013. The Upper Bennett video system was operated continuously throughout the year.

3.1.8.2 McKenzie River (Leaburg Dam): Counts of spring Chinook salmon and other species passing upstream of Leaburg Dam in 2013 are provided in Table 21. The first unclipped adult Chinook salmon was observed in March and the first clipped adult was noted in May. The peak count for both clipped and unclipped adults occurred in June but a secondary peak occurred in September. The final observations of unclipped and clipped adults occurred in October and September, respectively. Only nine jacks were observed, three unclipped and six clipped. Thirty-two adipose clipped adult Chinook salmon were removed from the ladder and transported to McKenzie Hatchery in September to help reduce pHOS in the subbasin. Both left-bank and right-bank video systems were operated continuously from 1/1/2013 through 12/31/2013.

Table 18. Number of marked and unmarked spring Chinook salmon and other species counted at Upper Bennett Dam by month, 2013. Counts of jacks are provided but were not differentiated between marked and unmarked.

	Steelhead			Chinook					
Month	**Clipped**	**Unclipped**	**Unknown Mark**	**Clipped**	**Unclipped**	**Unknown Mark**	**Jacks**	**Coho**	**Lamprey**
January	0	0	1	0	0	0	0	0	0
February	0	15	1	0	0	0	0	0	0
March	8	322	2	1	0	0	0	0	0
April	42	268	5	6	4	0	0	0	0
May	103	40	14	558	143	30	5	0	8
June	291	18	1	1,908	576	9	69	0	25
July	96	6	0	390	218	0	53	0	110
August	14	2	0	40	73	0	25	0	96
September	57	1	0	17	49	0	8	193	53
October	55	10	1	0	12	0	1	913	30
November	13	3	0	0	1	0	0	128	1
December	3	5	0	0	0	0	0	7	0
Total 2013	682	690	25	2,920	1,076	39	161	1,241	323

Table 19. Number of marked and unmarked spring Chinook salmon and other species counted at Lower Bennett Dam by month, 2013. Counts of jacks are provided but were not differentiated between marked and unmarked.

	Steelhead			Chinook					
Month	**Clipped**	**Unclipped**	**Unknown Mark**	**Clipped**	**Unclipped**	**Unknown Mark**	**Jacks**	**Coho**	**Lamprey**
April 25-30	1	5	0	1	0	0	0	0	0
May	56	22	0	53	17	-1	0	0	1
June	99	8	0	72	14	0	6	0	4
July	16	1	0	35	16	0	13	0	0
August	10	0	0	6	13	0	9	0	1
September	16	2	0	13	24	0	2	34	3
October	11	5	0	0	20	0	3	186	4
November	8	2	0	0	1	0	0	41	0
Dec. 1-10	0	0	0	0	0	0	0	2	0
Total 2013	217	45	0	180	105	-1	33	263	13

Table 20. Net movement of fish counted on video at Upper and Lower Bennett dams combined on the North Santiam River in 2013. Note that Lower Bennett Dam was only in operation April 25 through December 10.

	Steelhead			Chinook					
Month	**Clipped**	**Unclipped**	**Unknown Mark**	**Clipped**	**Unclipped**	**Unknown Mark**	**Jacks**	**Coho**	**Lamprey**
January	0	0	1	0	0	0	0	0	0
February	0	15	1	0	0	-1	0	0	0
March	8	322	2	1	0	0	0	0	0
April	43	273	5	7	4	0	0	0	0
May	159	62	14	611	160	30	5	0	9
June	390	26	1	1,980	590	9	75	0	29
July	112	7	0	425	234	0	66	0	110
August	24	2	0	46	86	0	34	0	97
September	73	3	0	30	73	0	10	227	56
October	66	15	1	0	32	0	4	1,099	34
November	21	5	0	0	2	0	0	169	1
December	3	5	0	0	0	0	0	9	0
Total 2013	899	735	25	3,100	1,181	38	194	1,504	336

Table 21. Net number of marked and unmarked spring Chinook salmon, steelhead trout, bull trout and lamprey counted at Leaburg Dam by month, 2013.

Month	Marked Chinook Adults	Unmarked Chinook Jacks	Marked Chinook Adults	Marked Chinook Jacks	Marked Chinook Adults Removed	Net Marked Chinook Adults Upstream	Unmarked Steelhead	Marked Steelhead	Bull Trout	Lamprey
January	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	-1	0	0	0
March	1	0	0	0	0	0	1	2	1	0
April	1	0	0	0	0	0	1	25	2	0
May	111	0	6	0	0	6	5	126	19	0
June	652	0	108	1	0	108	26	288	7	3
July	318	3	47	0	0	47	20	191	5	19
August	63	0	14	1	0	14	1	50	0	7
September	86	0	86	4	32	54	3	27	0	2
October	4	0	0	0	0	0	1	34	0	1
November	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0
Total 2013	1,236	3	261	6	32	229	57	743	34	32

Section 3.2: Reintroduction Efforts

Section 3.2.1 Number of Chinook Salmon Released Upstream of Dams:

3.2.1.1 North Santiam: Outplanting of adult Chinook salmon above Detroit Dam in the North Santiam in 2013 (Table 22) was accomplished using, for the first time, the new Minto Fish Collection Facility. All outplants occurred in or near the reservoir pending construction of suitable release locations in the Breitenbush and upper North Santiam rivers. Essentially, only adipose-clipped fish were outplanted and DNA samples were obtained from all.

3.2.1.2 South Santiam: Outplanting operations at Foster Dam were successful in 2013. All unclipped fish captured in the trap were DNA sampled and trucked to release sites above Foster Dam. Although only unclipped Chinook salmon are outplanted, 9.6% of otoliths collected from carcasses during spawner surveys above Foster Dam indicated the fish were unclipped hatchery adults. A summary of outplanting activities is provided in Table 22.

3.2.1.3 McKenzie: Outplanting activities in the McKenzie subbasin were successful in 2013. The principal activities included outplanting to sites above Cougar Dam as part of a DNA pedigree study where hatchery-origin spring Chinook salmon were outplanted from the McKenzie Hatchery in numbers roughly equal to natural-origin spring Chinook salmon outplanted from a trapping operation below Cougar Dam (Table 22).

3.2.1.4 Middle Fork Willamette: Outplanting efforts in the Middle Fork Willamette River were successful in 2013. Adult spring Chinook salmon were captured at the Dexter Dam trap and trucked to various release locations in the Middle Fork and North Fork Middle Fork in support of an ongoing project examining prespawning mortality rates. A relatively small number of fish (186) were outplanted in Little Fall Creek and we continued spawning surveys in that tributary to assess the potential for recovery of the species there. Outplanting in Fall Creek was conducted by USACE staff, and involved transportation of 467 fish above Fall Creek Reservoir. A summary of outplanting activities in the Middle Fork Willamette River is provided in Table 22.

Table 22. Adult Chinook salmon outplanted, 2013.

Subbasin	Release Site Name	# Chinook Salmon Outplanted			
		Males	Females	Jacks	Total
North Santiam	Kane’s Marina	162	131	8	301
	Hoover Campground	313	259	18	590
	Mongold	104	134	9	247
South Santiam	Caulkins Park	113	143	8	264
	Gordon Road	277	200	12	489
	Riverbend	86	85	3	174
South Fork McKenzie	Frissell Bridge (from McK Hatchery)	106	125	3	234
	1980 Bridge (from Mck Hatchery)	79	127	2	208
	Hard Rock (from Cougar Dam trap)	95	85	7	187
Middle Fork Willamette	Fall Creek	233	192	42	467
	Little Fall Creek	93	74	19	186
	Construction Pool	572	556	72	1,200
	Paddy's Valley	454	402	57	913
	North Fork Middle Fork Willamette	996	875	95	1,966

Section 3.2.2 Origin of Chinook Salmon Released Upstream of Dams:

3.2.2.1 North Santiam: Only adipose-clipped adult Chinook salmon were intended to be outplanted above Detroit Reservoir in the North Santiam River but a single unclipped carcass was recovered. Because of a procedural error the otoliths from that fish were not sampled. Because only 9% of the otoliths sampled below Minto were otolith marked we assumed that a negligible number of genuinely natural-origin fish were outplanted above Detroit Dam and pHOS was effectively 100% (Table 16).

3.2.2.2 South Santiam: Only unclipped fish were intended to be outplanted from the Foster Dam trap to the South Santiam River above the dam but surveyors found five fish they judged to be adipose clipped. Analyses were conducted on otoliths collected during pre-spawning mortality and spawner surveys. We found thermal marks on 9.6% of the 210 readable otoliths from carcasses sampled during prespawn mortality and spawner surveys. Therefore, we estimate that pHOS above Foster Dam in 2012 was 12% (Table 16).

3.2.2.3 McKenzie: A mixture of clipped and unclipped fish were released above Cougar Dam in the South Fork McKenzie River. Otolith marks were not a reliable indicator of unclipped hatchery fish in 2013 because the 2009 brood was not successfully thermally marked. Instead, we assumed that the 2008 -2012 average thermal mark rate for fish above Leaburg Dam (5.2%) could be applied to the unmarked fish passed above Cougar Dam. Seven unclipped and 25 clipped carcasses were sampled during surveys above Cougar and we estimate that pHOS was 79%.

3.2.2.4 Middle Fork Willamette: Seventeen otoliths were recovered from unclipped carcasses above Dexter Dam in the North Fork Middle Fork Willamette River, 13.3% of which were thermally marked. Given that we recovered 17 unclipped and 330 clipped carcasses we estimate that pHOS was 96%. Surveys above Hills Creek Dam on the Middle Fork Willamette recovered two unclipped and 198 clipped carcasses. Neither of the otoliths from unclipped fish were thermally marked but because some of the unclipped fish in the in the North Fork Middle Fork were naturally produced we estimate that pHOS above Hills Creek Reservoir was 99% (Table 16). In Fall Creek only unclipped fish were trucked upstream of Fall Creek Dam and otolith analyses indicated that none of the unmarked fish were of hatchery origin; we estimated that pHOS in Fall Creek in 2013 was 0% (Table 16).

Section 3.3 Broodstock Sampling at Hatcheries

Section 3.3.1 Origin of Broodstock:

3.3.1.1 North Santiam: All broodstock for the North Santiam Hatchery program were collected at the new Minto Dam Fish Collection Facility. All broodstock were clipped hatchery fish; pNOB in 2013 was zero (Table 23).

3.3.1.2 South Santiam: All broodstock for the South Santiam Hatchery program were collected at the Foster Dam trap. Only adipose clipped fish are incorporated into the South Santiam broodstock. Therefore, in 2013 pNOB was zero (Table 23).

3.3.1.3 McKenzie: All broodstock for the McKenzie Hatchery program in 2013 were collected at the hatchery. Only adipose clipped fish are incorporated into the broodstock. Therefore, in 2013 pNOB was zero (Table 23).

3.3.1.4 Middle Fork Willamette: A mixture of adipose clipped and unclipped fish were incorporated in to the Willamette Hatchery program. Thermal marks in otoliths from the unclipped fish indicated that 19.2% were actually unclipped hatchery fish and pNOB was therefore 2.2% (Table 23).

Table 23. Estimates of integration of natural-origin spawners as broodstock in Willamette hatcheries, 2013.

Stock	Hatchery	# Clipped Spawners	# Unclipped Spawners	Otoliths Read	Unclipped Thermal Marks	pNOB (%)
North Santiam	Marion Forks	912	0	0	0	0
South Santiam	South Santiam	688	0	0	0	0
McKenzie	McKenzie	990	0	0	0	0
M. Fk Willamette	M. Fk Willamette	2,036	59	59	14	2.2

Section 3.3.2 Broodstock Collection, Disposition, Age, and Size Distributions:

3.3.2.1 North Santiam: Collection and disposition of broodstock for the North Santiam hatchery program is provided in Table 24. A comparison of broodstock collection timing to the timing that unclipped and clipped Chinook entered the trap in 2013 is provided in Figure 29. The collection of clipped fish for broodstock closely followed the timing that unclipped fish, putatively wild, entered the trap and there was no indication that the timing of the fish actually sequestered for broodstock differed from the timing clipped fish were available for collection.

We compared the spawn timing Minto Fish Collection Facility in 2013 to the range and average spawn timing of fish in the North Santiam River below Minto Dam for the period 2008 – 2012 (Figure 12). The mean date of spawning in 2013 preceded the mean date of natural spawning by approximately one week.

We also compared the size and age of fish used as broodstock (HOB) in the North Santiam Hatchery program in 2013 to size and age of natural origin spawners (NOS) in the North Santiam River in 2013. We found that median size of HOB was approximately 20 mm FL smaller than NOS (Mann Whitney, U = 6862, $P = 0.04$). Median age (age 4) did not differ between NOS and HOB (Mann Whitney, U = 6457, $P = 0.14$).

3.3.2.2 South Santiam: As with the North Santiam hatchery program, there was little indication that the timing of broodstock collection in 2013 differed either from run timing of wild fish and availability of fish for collection into brood (Table 26 and Figure 29).

We compared the spawn timing at the South Santiam Hatchery in 2013 to the range and average spawn timing of fish in the South Santiam River below Foster Dam for the period 2008 – 2012 (Figure 12). The mean date of hatchery spawning in 2013 preceded the mean date of natural spawning by approximately one week.

We also compared the size and age of fish used as broodstock in the South Santiam Hatchery program in 2013 to size and age of natural origin spawners in the South Santiam River in 2013. We found that median size of hatchery-origin brood was approximately 40 mm FL smaller than natural-origin spawners (Mann Whitney, U = 27273, $P < 0.001$). Median age was 4 years for both but statistically, natural-origin spawners were slightly older than HOB (Mann-Whitney U = 23140, $P = 0.025$).

3.3.2.3 McKenzie: Collection timing of broodstock closely followed the timing of entry of clipped fish into the hatchery but, unlike in the North and South Santiam hatchery programs, collection of broodstock differed greatly from timing of entry of hatchery fish into the trap. It is, however, probably not the case that the run timing of fish used for brood differs from actual run timing of wild fish in the McKenzie. When collection timing of broodstock is compared to run timing of wild fish passing the counting stations at Leaburg Dam, the curves in the McKenzie panel of Figure 29 are much more closely aligned. The reason for the very large difference in trap entry timing of clipped and unclipped fish into the hatchery in 2013 is unknown.

We compared the spawn timing at the McKenzie Hatchery in 2013 to the range and average spawn timing of fish in the river for the period 2008 – 2012 (Figure 12). The mean date of spawning in 2013 preceded the mean date of natural spawning by approximately one week.

We also compared the size and age of fish used as broodstock in the McKenzie Hatchery program in 2013 to size and age of natural origin spawners in the McKenzie River in 2013. We found that median size of hatchery-origin brood was approximately 50 mm FL smaller than natural-origin spawners (Mann Whitney, U = 86272, $P < 0.001$). Median age was 4 years for HOB and 5 years for NOS, a difference that was statistically significant (Mann-Whitney U = 62387, $P < 0.001$).

3.3.2.4 Middle Fork Willamette: Collection timing of broodstock for the Middle Fork Willamette Hatchery program in 2013 did not closely match the timing of either clipped or unclipped fish entry into the trap at Dexter Dam. The majority of the broodstock for the Middle Fork Willamette program were collected relatively early, compared to the timing of both clipped and unclipped fish. However, it may not be the case that differences in collection timing actually advances run timing for the hatchery program. Hatchery program staff explained that by the time broodstock collection commences, most of the hatchery run has entered the Middle Fork and congregated below Dexter Dam. Therefore, some of the fish collected for brood have been in the river for some time and the collection is actually a mixture of early and later-run fish (Dan Peck, ODFW, personal communication).

We compared the spawn timing at the Willamette Hatchery in 2013 to the range and average spawn timing of fish in the Middle Fork Willamette River for the period 2008 – 2012 (Figure 12). The mean date of spawning in 2013 preceded the mean date of natural spawning by approximately one week.

We also compared the size and age of fish used as broodstock in the Middle Fork Willamette Hatchery program in 2013 to size and age of natural origin spawners in the Middle Fork Willamette River in 2013. We found that median size of HOB appeared to be approximately 20 mm FL smaller than NOS but the difference was not statistically significant (Mann-Whitney U = 40,619, $P = 0.08$). Median age was 4 years for both hatchery-origin brood and natural-origin spawners (Mann-Whitney U = 23,374, $P = 0.957$).

Table 24. Collection and spawning of Chinook salmon adults in the North Santiam subbasin, 2013. All fish were clipped.

Broodstock Collected				Spawned[1]		
Date	M	F	J	M	F	J
5/31	28	30	1			
6/8	9	3	0			
6/10	4	7	0			
6/13	18	20	0			
6/14	4	3	0			
6/17	37	27	4			
6/24	116	128	7			
6/25	73	64	3			
6/28	18	29	0			
7/1	22	21	1			
7/3	21	31	1			
7/5	41	28	0			
7/8	6	10	0			
7/12	21	21	0			
7/16	42	35	0			
7/18	0	0	1			
7/22	35	26	4			
7/25	0	0	6			
7/29	23	18	5			
8/1	47	24	2			
8/7	0	7	4			
8/13	30	19	5			
8/29	8	14	3			
9/3	48	32	7			
9/9	36	30	5			
9/10				92	92	0
9/11	18	22	2			
9/16	14	18	0			
9/17				128	130	2
9/18	0	0	3			
9/19				128	130	2
9/23	0	0	2			
9/24				104	104	0
	719	**667**	**66**	**452**	**456**	**4**

[1]Actual collection date of individual ChS spawned is unknown.

Table 25. Collection and spawning of marked and unmarked Chinook salmon adults in the South Santiam subbasin, 2013.

	Broodstock Collected (ad clipped)			Spawned (ad clipped)		
Date	M	F	J	M	F	J
6/13/13	34	35	0			
6/17/13	37	31	10			
6/24/13	10	7	0			
7/8/13	30	43	5			
7/11/13	104	113	15			
7/16/13	18	16	2			
7/22/13	1	3	0			
7/26/13	12	18	0			
8/1/13	9	9	0			
8/7/13	2	6	1			
9/4/13	49	39	0			
9/10/13	40	75	0			
9/11/13				109	109	0
9/17/13	0	20	0			
9/18/13				141	145	4
9/25/13				90	90	0
	346	415	33	340	344	4

Table 26. Collection and spawning of Chinook salmon adults in the McKenzie subbasin, 2013. All fish were clipped.

	Broodstock Collected			Spawned[1]		
Date	M	F	J	M	F	J
5/20	97	92	11			
5/30	6	28	0			
6/5	105	70	13			
6/11	3	2	0			
6/12	6	70	0			
6/20	117	96	0			
7/2	166	98	12			
7/8	10	81	0			
7/17	42	35	0			
7/24	22	18	4			
7/30	2	0	0			
8/6	36	10	0			
8/19	18	6	0			
9/3	99	23	20			
9/6	2	0	0			
9/9	59	9	0	26	26	0
9/13	49	31	5			
9/16	35	33	4	201	201	0
9/17	0	6	2			
9/23	0	43	0	178	178	0
9/30	0	0	0	90	90	0
	874	**751**	**71**	**495**	**495**	**0**

[1]Actual collection date of individual ChS spawned is unknown.

Table 27. Collection and spawning of Chinook salmon adults in the Middle Fork Willamette subbasin, 2013. All fish were clipped.

	Broodstock Collected			Spawned[1]		
Date	M	F	J	M	F	J
6/10	8	7	0			
6/12	500	413	10			
6/20	351	263	0			
6/24	153	411	12			
6/26	8	80	0			
6/27	5	60	0			
7/10	1	1	0			
7/16	3	64	0			
7/30	24	108	0			
8/7	3	42	0			
8/13	0	53	0			
8/22	21	34	0			
8/29	23	26	2			
9/5	44	69	2			
9/10				251	257	6
9/12	77	78	0			
9/17				220	222	2
9/18	27	27	0			
9/20				183	186	3
9/24				126	126	0
9/25	0	5	0			
9/27				40	40	0
10/1				30	30	0
	1,248	**1,741**	**26**	**850**	**861**	**11**

[1]Actual collection date of individual ChS spawned is unknown.

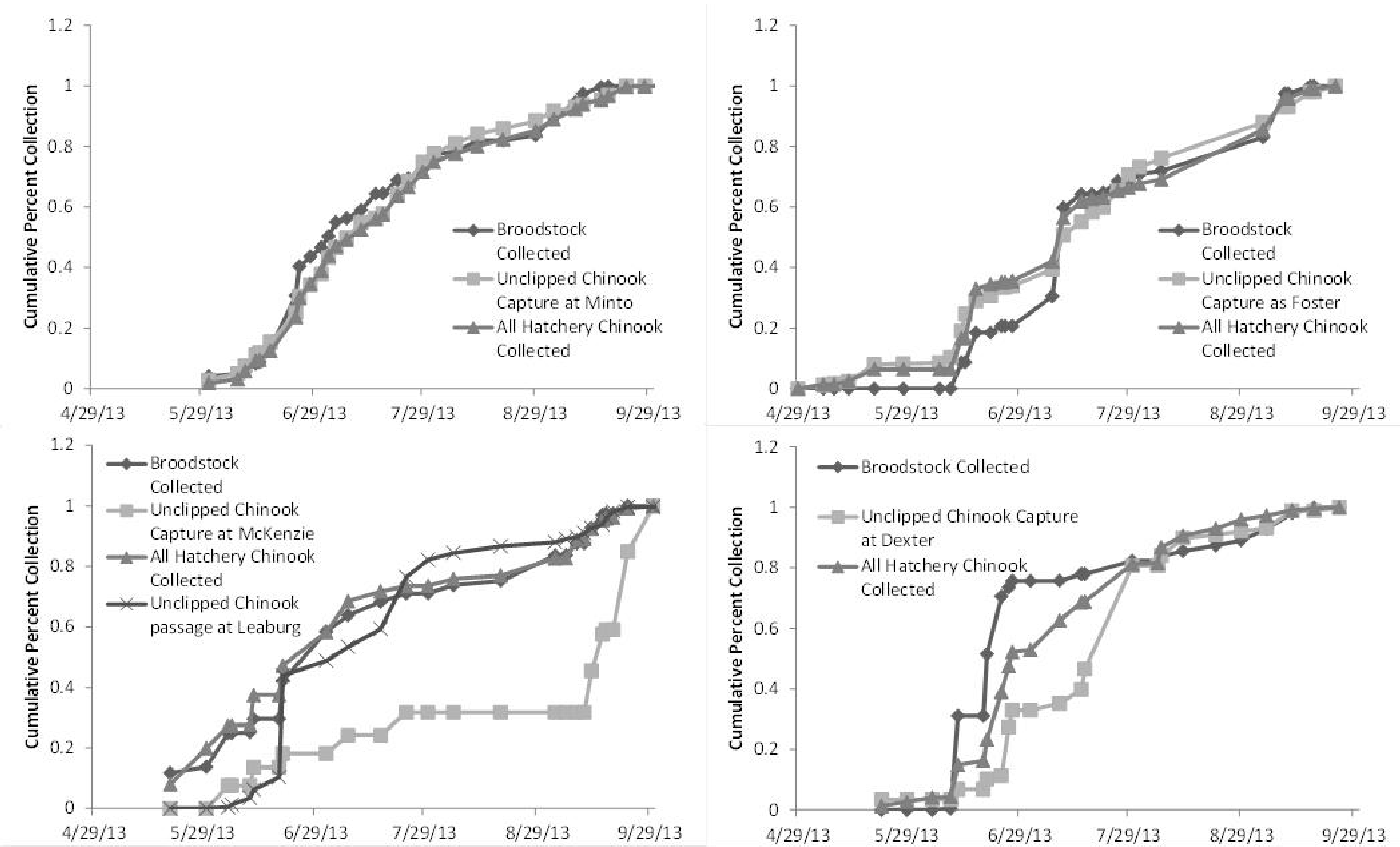

Figure 29. Comparison of broodstock collection timing to run timing of clipped and unclipped Chinook salmon, 2013.

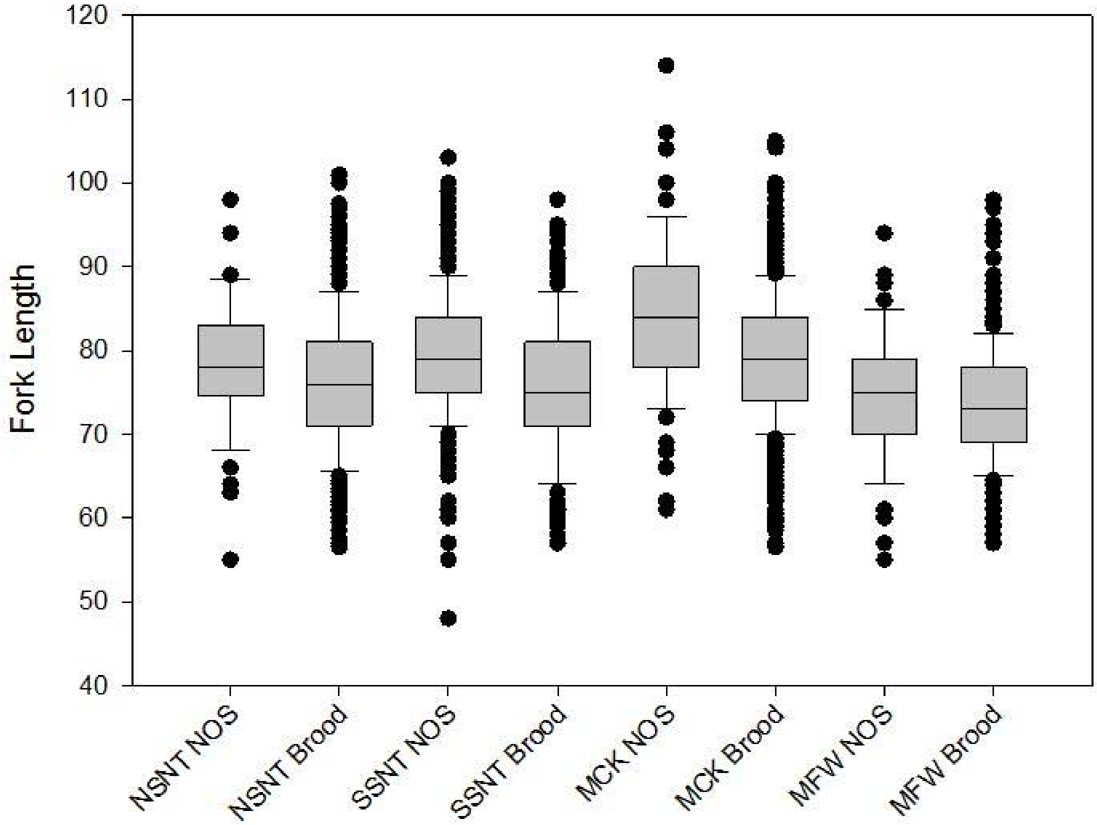

Figure 30. Size of Chinook salmon used in broodstock in 2013 compared to size distributions of NOS. Broodstock were significantly smaller than natural origin spawners in the North Santiam, South Santiam, and McKenzie rivers (P < 0.05) but not in the Middle Fork Willamette River (P = 0.08). See text.

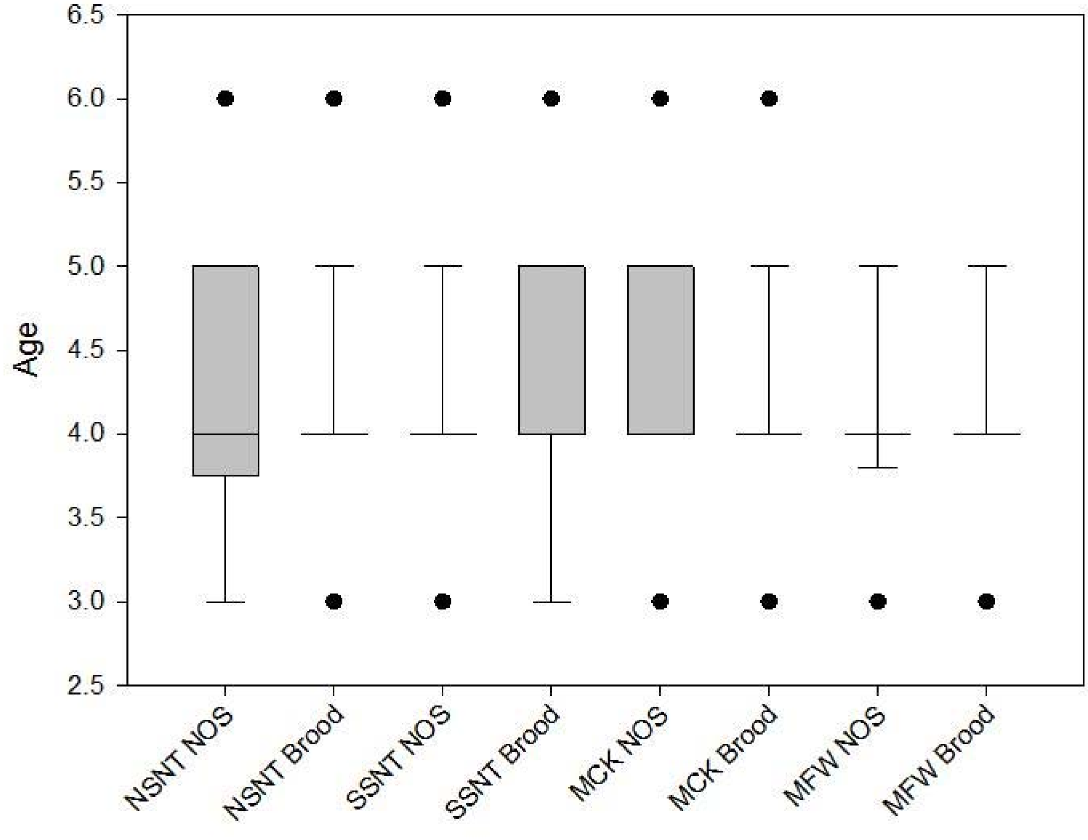

Figure 31. Age structure of Chinook salmon used for broodstock in 2013 compared to age structure of NOS. Broodstock were significantly younger in the South Santiam and McKenzie rivers (P < 0.05) but not in the North Santiam and Middle Fork Willamette rivers (P > 0.05) See tex..

Section 4: Discussion

In 2013 spawner surveys were conducted in all reaches that have traditionally been surveyed, both below project dams for naturally escaped adult Chinook salmon, and in the majority of the reaches above project dams for outplanted fish. However, a severe storm event in late September at the same time that we would normally expect to obtain our peak redd counts and collect the largest number of carcasses created very poor survey conditions (high, turbid water). In many cases, our inability to get a reliable count of redds means that the estimates of spawner abundance may be biased low to an unknown degree. Our inability to collect carcasses at a time most fish were actively spawning means that our estimates of PSM may be biased high, also to an unknown degree. We think that our estimates of spawner distribution and pHOS were probably not biased.

We were successful at outplanting large numbers of adult Chinook salmon into otherwise depauperate habitat in the North and South Santiam, McKenzie and Middle Fork Willamette rivers in 2013.

We did not attempt to compare redd densities in 2013 to the densities in recent years because, as noted above, redd surveys were compromised by poor survey conditions late in the season. In the two instances where we have reliable abundance estimates from video counts, independent of spawner surveys, it appears that NOS abundance in the North Santiam is stable or increasing compared to recent years and NOS abundance in the McKenzie was slightly lower than recent years. We think the video counts were reliable (unaffected by the late storm event) because at both Bennett dams and at Leaburg Dam the vast majority of fish passed well before the storm. There were three instances where we obtained counts of unclipped fish returning to a spawning tributary (South Santiam above Foster Dam, South Fork McKenzie above Cougar Dam and Fall Creek above Fall Creek Dam). Unclipped fish counts at the Foster Dam trap in 2013 suggest that that population is stable, possibly increasing. Unclipped fish counts at the Cougar Dam trap were substantially lower than in recent years, confirming the genetic analyses that concluded the population is not replacing itself (Banks et al. 2013, 2014). Unclipped fish counts at the Fall Creek Dam trap were similar to counts in recent years.

We think that our carcass recovery difficulties late in the spawning season prevent confident conclusions about the influence of environmental conditions and outplanting procedures on PSM rates. In broad terms, our actual estimates for PSM were low to moderate in 2013 and, because we think it most likely that the poor survey conditions tended to decrease our sampling rate of carcasses from *successful* spawners, spawner holding conditions and outplant protocols were probably relatively benign throughout the subbasins in 2013. Significant exceptions were apparent in the Middle Fork Willamette River below Dexter Dam and in Fall Creek, where it seems unlikely that the very high PSM estimates were entirely due to bias caused by poor survey conditions.

In the North Santiam River above Detroit Reservoir adult fish were outplanted at the head of reservoir outplant sites near the mouths of the Breitenbush and upper North Santiam rivers because suitable outplant sites in the tributaries themselves had not been completed. Clearly, few fish actually entered the Breitenbush River (only one redd was noted in 2013). In future years it will be important to derive methods to increase distribution of spawners which, if successful, must include consideration of protocols for monitoring PSM rates in the currently unused spawning habitat. For example, hatchery-origin fish could be collected and held at the Minto Fish Collection Facility until approximately mid-September and then outplanted near desired locations at a time close to the peak spawning date. Floy or PIT tags could be used to track spawning location and success of individual fish. Also, spawner densities in Horn Creek on the Marion Forks Hatchery grounds were extremely high in 2013, as in prior years when large numbers of hatchery fish were outplanted, resulting in very heavy redd superimposition. Excluding some fish from Horn Creek with a weir may force spawners to distribute into other suitable habitat.

In the South Santiam River estimates of PSM rates were greater above Foster Dam compared to below the dam and, because habitat quality for spawner holding above the dam is thought to be superior to that below the dam, the higher PSM rates might be associated with the stress of capture, crowding, anesthesia (via CO_2), loading, transport, and release of outplanted fish. Efforts to estimate the association between timing and location of outplants and the probability of successful spawning were hampered by low sample sizes (recovery of floy-tagged female fish). We noted, as in 2012, a weak (non-significant) tendency for fish outplanted late to spawn successfully at a higher rate than fish outplanted early. That outcome is supported by other ongoing research (Naughton et al. 2013) and deserves further consideration. A new Fish Collection Facility below Foster Dam is scheduled for completion in 2014 and it may be worth considering use of delayed outplants to increase successful spawning, especially in years where in-river conditions are predicted to be poor or marginal (Schreck et al. 2013).

In the McKenzie River PSM rates were relatively low in 2013 but they were significantly elevated below Leaburg Dam compared to rates above Leaburg.

One of the more pressing Conservation and Recovery goals in the Upper Willamette subbasins is to achieve subbasin-wide pHOS goals (ODFW and NOAA 2010) of 10% or less (30% or less in the South Santiam). Clearly, that goal is ambitious. In one instance where only unclipped fish are passed into the spawning reaches above a dam (Foster Dam on the South Santiam River) the pHOS goal was still exceeded because of the number of unclipped hatchery fish returning. In the other instance where only unclipped fish are passed upstream (Fall Creek) pHOS is low but Fall Creek Dam is currently not associated with any hatchery releases. In general, when fish collection facilities are in close proximity to large aggregations of hatchery-origin fish we do not think that the issue can be resolved by increasing the clipping rate of hatchery fish because the automated tagging and clipping trailers already perform with very high efficiency. The sheer size of juvenile fish releases necessary to support fisheries translates into returns of relatively abundant fish that cannot be visually identified as hatchery origin. Sorting procedures based solely on presence or absence of a fin clip will not always be adequate to permit creation of wild fish sanctuaries that meet existing pHOS goals for the sanctuary itself (pHOS $\simeq$ 0 – 5%) or adequately mitigate for hatchery fish abundance elsewhere in the subbasins such that subbasin-wide pHOS goals can be met. Finally, the ultimate intent for fish passage at Cougar Dam on the South Fork McKenzie River is to pass only natural origin adult Chinook salmon. Given the similarities between Fall Creek and the South Fork McKenzie where collection facilities are not associated with large aggregations of hatchery fish it appears that the Cougar program may ultimately succeed when downstream passage issues are resolved.

Protocols for collection and spawning of hatchery broodstock were in reasonably close compliance with guidelines in the draft HGMPs for each production facility. There did not appear to be a consistent tendency for collection of broodstock with biologically relevant differences in run timing or size distribution from naturally-produced fish in the North Santiam, South Santiam, McKenzie or Middle Fork Willamette hatcheries. We did detect statistically significant differences is size between some hatchery-origin brood and natural-origin spawners, but the magnitude of the differences were very small and we believe statistical significance was driven more by large sample sizes (resulting in high statistical power), not biologically relevant differences. Broodstock collection timing in the Middle Fork Willamette River occurred early, compared to the timing of entry of unclipped Chinook salmon into the Dexter trap. However, in all cases we think that returning adults are well mixed with respect to run timing before broodstock collection is complete and it is unlikely that the Dexter trapping operation actively selects for early run timing. In some cases (S. Santiam and McKenzie) hatchery-origin fish tended to be younger than natural-origin fish, an observation supported by Johnson and Friesen (2013), who showed a gradual decline in size and age of Willamette basin hatchery-origin spring Chinook salmon. They suggested incorporating some larger, older fish in hatcheries to counteract the tendency for over-representation of smaller, younger fish in the broodstock. Smaller fish would likely be selected against under natural conditions. We suggest that the Corps and fisheries managers consider evaluating this strategy experimentally.

Actual peak spawning of hatchery broodstock in 2013 generally occurred shortly before our estimated average peak spawning date on the spawning grounds (by approximately one week). We are not certain if this is a biologically relevant difference but it does appear to be consistent; a similar outcome was apparent in 2012. We intend to reconstruct the spawn timing at the upper Willamette hatcheries in relation to spawn timing metrics from river surveys for years prior to 2012 and those results will be reported in the future. It is likely that spawn timing in the hatcheries is less variable than spawn timing in the rivers; redds are always observed before spawning of broodstock begins and new redds or live spawners are always observed after hatchery spawning ends. Altering hatchery protocols to more closely match variance in spawn timing poses many significant logistic challenges. Both early spawners and late spawners would need to be incorporated into the brood to avoid altering timing of peak spawning. Identifying the rare early spawners would require sorting all brood at a time most of the remaining fish are fragile (approaching final maturation). Spawning of late-maturing broodstock would require protracted operation and maintenance of the broodstock holding ponds.

In 2013, as in earlier years, we estimated that very small numbers of hatchery fish released in one subbasin returned to potentially spawn in another subbasin. Those observations, in combination with the results of genetics analyses by Johnson and Friesen (2014), suggest that inter-basin straying of hatchery fish in the Willamette is a minor issue. One possible exception is the tendency for increased stray rates of fish of South Santiam stock reared at the Willamette Hatchery and released directly into the Molalla River. We think that further work is warranted to see if those particular practices contribute to undesired levels of inter-subbasin gene flow. However, beginning in 2013 acclimation ponds in the Molalla system are in place and direct releases (without acclimation) will be reduced or eliminated.

We expect that during the 2014 funding cycle we will conduct surveys and perform monitoring at hatcheries and traps for Chinook salmon very similar in scope to that of the work described in this document. In addition, we anticipate increasing the scope of work towards monitoring winter- and summer-run steelhead, dependent upon availability of funding. Finally, an important synthesis of results of monitoring under the current BiOp by the HRME project is scheduled to occur during the 2014 funding cycle. The intent of the comprehensive review is to identify where the project is and is not aligned with research, monitoring and evaluation work necessary to address both conservation and mitigation goals for Chinook salmon and steelhead trout in the upper Willamette Basin.

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Appendix 1: Summary of Tasks

Summary of anadromous fish monitoring and hatchery sampling tasks.

RPA=reasonable and prudent alternative (NMFS 2008).

SPRING CHINOOK SALMON

Task 1.1: Determine abundance, distribution, & percent hatchery-origin fish on spawning grounds [RPA 9.5.1(2)]

Conduct surveys downstream of federal dams in the North Santiam, South Santiam, McKenzie, MF Willamette basins

1. Conduct spawning surveys to count redds

2. Assess variability in redd counts among crews with re-surveys

3. Conduct spawning surveys to collect carcasses for differentiating hatchery fish from wild fish (fin clips & otoliths)

4. Estimate pre-spawning mortality

5. Assess straying of hatchery fish between basins using coded-wire tags recovered from carcasses

Task 1.2: Monitor clipped & unclipped fish passing Leaburg and Upper Bennett dams [RPA 9.5.1(2)]

Collect information on run size & composition of run (using data from Task 1.1), removal of hatchery fish

1. Operate video recording equipment and count clipped and unclipped fish passing Leaburg Dam

2. Operate adult fish trap in the Leaburg Dam fishway when feasible to remove clipped fish [RPA 6.1.4, interim measure]

3. Operate video recording equipment and count clipped and unclipped fish passing upper Bennett Dam

4. Investigate feasibility of video monitoring at Lower Bennett and Lebanon dams

Task 2.1: Collection, spawn timing, and H/W composition for broodstock management [RPA 9.5.1(1) & 6.2.2]

Hatchery monitoring of returns and broodstocks

1. Record data on return date, numbers of clipped & unclipped fish, disposition (collect biological data on outplants and spawned fish)

2. Collect otoliths on unclipped fish used for broodstock to determine proportion of wild fish

3. Operate Leaburg fishway trap to collect unclipped fish to supplement broodstock [see Task 1.2(2)]

4. Develop monitoring of fin-clipped and unclipped fish at Bennett dams for index of broodstock management (under Task 1.2)

Task 2.2: Determine survival of outplanted fish and abundance of spawners [RPA 9.5.1(3) & 6.2.3; Proposed Action 2.10.1]

Conduct surveys upstream of federal dams in the North Santiam, South Santiam, McKenzie, MF Willamette basins

1. Record numbers, clip information, date, release locations for outplanted Chinook salmon

2. Collect tissue samples from outplanted Chinook salmon to determine spawning success and parentage analysis of returning adults

3. Conduct spawning surveys to count redds as measure of abundance, survival, and distribution of outplants

4. Conduct spawning surveys to collect carcasses for proportion of hatchery and wild fish in some outplant areas

5. Estimate pre-spawning mortality for outplanted Chinook salmon

6. Assist in collection of information needed for condition study in Middle Fork Willamette River and Fall Cr.

STEELHEAD

Task 3.1: Determine the extent of summer steelhead reproduction in the wild [RPA 9.5.2(1) and 6.1.9].

1. Develop a study plan for genetics study and initiate field collections

2. Work with geneticists (Services, OSU) to develop study plan to determine parentage and introgression

3. Review plan and design with ODFW managers, and with independent review group

4. Initiate field collections of tissue samples in North and South Santiam using traps, electrofishing, seines

5. Collect tissue samples on unclipped steelhead smolts in Willamette at Sullivan Plant and using seines or electrofishing

6. Collect tissue samples on winter-run and summer-run steelhead adults if needed to increase reference samples

7. Collect tissue samples from adult resident and hatchery rainbow trout - potential parentage sources

Task 3.2: Evaluate release strategies for summer steelhead to increase migration and reduce impacts on wild fish [RPA 6.1.6]. a

1. Develop study plans to implement volitional releases and monitor outmigration, and initiate field work

2. Develop plans to implement volitional emigration from release facilities and evaluate factors influencing volitional emigration

3. Develop plans to monitor outmigration of summer steelhead releases past Willamette Falls

4. Develop plans to monitor presence, distribution, and size of residual hatchery steelhead in tributaries and main stem.

Appendix 2: Spatial Scales Associated With Abundance, Spatial Distribution, and Diversity Metrics

Subbasin	River Section	Survey Reach (downstream to upstream extent)	Carcass Surveys	Redd Surveys	Peak Redd Count	Redd Density	pHOS	PSM	Escape-ment
							X		
									X
		downstream of Upper Bennett Dam			X	X	X	X	
		Green's Bridge to Shelburn	X	X	X				
		Shelburn to Stayton	X	X	X				
		Stayton to South Channel-Upper Bennett Dam	X	X	X				
		Stayton to North Channel-Stayton Island	X	X	X				
	downstream of Minto Dam	Upper Bennett Dam to Minto Dam			X	X	X	X	
		Stayton to North Channel-Stayton Island	X	X	X				
		Upper Bennett (Stayton Island) to Powerlines	X	X	X				
		Powerlines to Mehama	X	X	X				
North Santiam		Mehama to Fisherman's Bend	X	X	X				
		Fisherman's Bend to Mill City	X	X	X				
		Mill City to Gate's Bridge	X	X	X				
		Gate's Bridge to Packsaddle	X	X	X				
		Packsaddle to Minto Dam	X	X	X				
	upstream of Minto Dam	Minto to Big Cliff Dam (Not currently surveyed)			X	X	X	X	
					X	X	X	X	X
		Lunkers Bridge to Bear Creek Bridge	X	X	X				
	Little North Santiam	Bear Creek Bridge to Golf Bridge	X	X	X				
		Golf Bridge to Narrows	X	X	X				
		Narrows to Camp Cascade	X	X	X				
		Camp Cascade to Salmon Falls	X	X	X				
		Salmon Falls to Elkhorn Bridge	X	X	X				
South Santiam									X

Subbasin	River Section	Survey Reach (downstream to upstream extent)	Carcass Surveys	Redd Surveys	Peak Redd Count	Redd Density	pHOS	PSM	Escape-ment
		downstream of Lebanon Dam			X	X	X	X	
		Sanderson's to Gill's Landing	X	X	X				
	downstream of Foster Dam	Lebanon Dam to Foster Dam			X	X	X	X	
		Waterloo to McDowell Creek	X	X	X				
		McDowell Creek to Pleasant Valley	X	X	X				
		Pleasant Valley to Foster Dam	X	X	X				
					X	X	X	X	X
		River Bend Park to Shot Pouch Road	X	X	X				
		Shot Pouch Rd to High Deck Road	X	X	X				
		High Deck Rd to Cascadia Park	X	X	X				
		Cascadia Park to Moose Creek Bridge	X	X	X				
	upstream of Foster Dam	Moose Creek Bridge to Gordon Creek Road	X	X	X				
		Gordon Cr. Rd to 2nd Trib. downstream of C.G.	X	X	X				
		2nd Trib. downstream of C.G. to Trout Creek C.G.	X	X	X				
		Trout Creek C.G. to Little Boulder Creek	X	X	X				
		Little Boulder Creek to Soda Fork	X	X	X				
		Soda Fork to Falls	X	X	X				
	downstream of Leaburg Dam				X	X	X	X	X
		Leaburg Landing to Leaburg Dam	X	X	X				
							X		X
		Leaburg Dam to Forest Glen			X	X	X	X	
		Leaburg Lake to Helfrich	X	X	X				
		Ben & Kay to Rosboro Bridge	X	X	X				
McKenzie		Rosboro Bridge to Forest Glen	X	X	X				
	upstream of Leaburg Dam	upstream of Forest Glen			X	X	X	X	
		Forest Glen to South Fork McKenzie	X	X	X				
		South Fork McKenzie to Hamlin	X	X	X				
		Hamlin to McKenzie Bridge	X	X	X				
		McKenzie Bridge to McKenzie Trail	X	X	X				
		McKenzie Trail to Paradise	X	X	X				
		Paradise to Belknap	X	X	X				
		Belknap to Olallie C.G.	X	X	X				

Subbasin	River Section	Survey Reach (downstream to upstream extent)	Carcass Surveys	Redd Surveys	Peak Redd Count	Redd Density	pHOS	PSM	Escape-ment
		Spawning Channel	X	X	X				
		Horse Creek							
		Mouth to Bridge	X	X	X				
		Bridge to Avenue Creek	X	X	X				
		Avenue Creek to Braids	X	X	X				
		Braids to Road Access	X	X	X				
		Road Access to Separation Creek	X	X	X				
		Separation Creek to Trail Bridge	X	X	X				
		Trail Bridge to Pothole Creek	X	X	X				
		Lost Creek							
		Mouth to Hwy Bridge	X	X	X				
		Hwy Bridge to Split Pt	X	X	X				
		Split Pt to Campground	X	X	X				
		Campground to Cascade	X	X	X				
		South Fork McKenzie downstream of Cougar Dam			X	X	X	X	
		Mouth to Bridge	X	X	X				
		Bridge to Cougar Dam	X	X	X				
	South Fork McKenzie River, upstream of Cougar Dam				X	X	X	X	X
		Reservoir to Hardy	X	X	X				
		Hardy Creek to Rebel Creek	X	X	X				
		Rebel Creek to Dutch Oven	X	X	X				
		Dutch Oven C.G. to Homestead C.G.	X	X	X				
		Homestead C.G. to Twin Springs C.G.	X	X	X				
		Twin Springs C.G. to Roaring River	X	X	X				
		Roaring River to Elk Creek	X	X	X				
		SF 1 mile upstream of confluence of Elk Creek	X	X	X				
Middle Fork Willamette	Jasper to Dexter Dam				X	X	X	X	X
		Jasper to Pengra	X	X	X				
		Pengra to Dexter Dam	X	X	X				
	Fall Creek				X	X	X	X	X
		Reservoir to Release Site	X	X	X				
		Release Site to Johnny Creek Bridge	X	X	X				
		Johnny Creek Bridge to Bedrock campground	X	X	X				

Subbasin	River Section	Survey Reach (downstream to upstream extent)	Carcass Surveys	Redd Surveys	Peak Redd Count	Redd Density	pHOS	PSM	Escape-ment
		Bedrock campground to Portland Creek	X	X	X				
		Portland Creek to NFD 1828 Bridge	X	X	X				
		NFD 1828 Bridge to Hehe Creek	X	X	X				
		Hehe Creek to Gold Creek	X	X	X				
		Gold Creek to Falls	X	X	X				
	Little Fall Creek				X	X	X	X	X
		Fish Ladder to NFD 1818 Bridge	X	X	X				
		NFD 1818 Bridge to NFD 1806 Bridge	X	X	X				
	North Fork Middle Fork Willamette				X	X	X	X	X
		Minute Creek to 2nd to last pullout	X	X	X				
		NFD 1944 Bridge to Minute Creek	X	X	X				
		Kiahanie Bridge to NFD 1944 Bridge	X	X	X				
		Release Site to Kiahanie Bridge	X	X	X				

Appendix 3: Survey reaches for upper Willamette subbasin prespawn mortality and spawner surveys

Subbasin	River	Description	Start River Mile	End River Mile	Total Distance	Comment
Santiam	**Santiam**	**Mouth to I-5 Bridge**	**0**	**6.4**	**6.4**	
Santiam	Santiam	I-5 Bridge to Jefferson	6.4	10	**3.6**	
Santiam	Santiam	Jefferson to Confluence	10	12.1	**2.1**	covered on N/S surveys
N. Santiam	**N. Santiam**	**Mouth/Jefferson to Green's Bridge**	**0**	**2.9**	**2.9**	**covers part of MS Santiam**
N. Santiam	N. Santiam	Green's Bridge to Shelburn	2.9	11.1	**8.2**	
N. Santiam	N. Santiam	Shelburn to Stayton	11.1	16.6	**5.5**	
N. Santiam	N. Santiam	Stayton to North Channel-Stayton Is	16.6	19.8	**3.2**	
N. Santiam	N. Santiam	Stayton to South Channel-Upper Bennett	19.8	23	**3.2**	
N. Santiam	N. Santiam	Upper Bennett to Powerlines	23	26.5	**3.5**	
N. Santiam	N. Santiam	Powerlines to Mehama	26.5	30	**3.5**	
N. Santiam	N. Santiam	Mehama to Fisherman's Bend	30	36.5	**6.5**	
N. Santiam	**Little N. Santiam**	**Mouth to NF Park**	**0**	**3**	**3**	
N. Santiam	Little N. Santiam	NF Park to Lunkers Bridge	3	7	**4**	
N. Santiam	Little N. Santiam	Lunkers Bridge to Bear Creek Bridge	7	8.9	**1.9**	
N. Santiam	Little N. Santiam	Bear Creek Bridge to Golf Bridge	8.9	12.3	**3.4**	
N. Santiam	Little N. Santiam	Golf Bridge to Narrows	12.3	13.2	**0.9**	
N. Santiam	Little N. Santiam	Narrows to Camp Cascade	13.2	14.4	**1.2**	
N. Santiam	Little N. Santiam	Camp Cascade to Salmon Falls	14.4	15.3	**0.9**	
N. Santiam	Little N. Santiam	Salmon Falls to Elkhorn Bridge	15.3	16.3	**1**	
N. Santiam	N. Santiam	Fisherman's Bend to Mill City	36.5	38.5	**2**	
N. Santiam	N. Santiam	Mill City to Gate's Bridge	38.5	42.3	**3.8**	
N. Santiam	N. Santiam	Gate's Bridge to Packsaddle	42.3	45.1	**2.8**	
N. Santiam	N. Santiam	Packsaddle to Minto Dam	45.1	45.3	**0.2**	
N. Santiam	**Breitenbush**	**Upper Arm Picnic Area to Byars Creek**	**0**	**1.4**	**1.4**	
N. Santiam	Breitenbush	Byars Creek to Humbug Creek	1.4	2.9	**1.5**	
N. Santiam	Breitenbush	Humbug Creek to Fox Creek	2.9	4.3	**1.4**	
N. Santiam	Breitenbush	Fox Cr. to Scorpion Cr	4.3	5.7	**1.4**	
N. Santiam	Breitenbush	Scorpion Cr. to Hill Cr	5.7	7.3	**1.6**	
N. Santiam	Breitenbush	Hill Cr. to SF Breitenbush	7.3	9.2	**1.9**	
N. Santiam	N. Santiam abv Detroit	Cooper's Ridge to Misery Cr	73.8	76.2	**2.4**	river mile
N. Santiam	N. Santiam abv Detroit	Misery Cr. to Whitewater Cr.	76.2	78.4	**2.2**	
N. Santiam	N. Santiam abv Detroit	Whitewater Cr. to Pamelia	78.4	81.15	**2.75**	
N. Santiam	N. Santiam abv Detroit	Pamelia Creek to Minto Creek	81.15	83.95	**2.8**	
N. Santiam	N. Santiam abv Detroit	Minto Creek to Horn Creek	83.95	85.15	**1.2**	
N. Santiam	**Marion Creek**	**Mouth to Hatchery Weir**	**0**	**0.7**	**0.7**	
N. Santiam	**Horn Creek**	**Mouth to Hatchery Weir**	**0**	**0.5**	**0.5**	
N. Santiam	N. Santiam abv Detroit	Horn Creek to Bugaboo Creek	0.7	2.4	**1.7**	
N. Santiam	N. Santiam abv Detroit	Bugaboo to Straight Cr	2.4	5	**2.6**	

Subbasin	River	Description	Start River Mile	End River Mile	Total Distance	Comment
N. Santiam	N. Santiam abv Detroit	Straight Cr. to Parish Lake Road	5	8.5	**3.5**	
S. Santiam	**S. Santiam**	**Mouth/Jefferson to Sanderson's**	**0**	**10**	**10**	**Covers part MS Santiam**
S. Santiam	S. Santiam	Sanderson's to Gill's Landing/Lebanon	10	19.7	**9.7**	
S. Santiam	S. Santiam	Waterloo to McDowell Creek	19.7	24	**4.3**	
S. Santiam	S. Santiam	McDowell Creek to Pleasant Valley	24	29.4	**5.4**	
S. Santiam	S. Santiam	Pleasant Valley to Foster	29.4	33.9	**4.5**	
S. Santiam	S. Santiam abv Foster	River Bend Park to Shot Pouch Rd	46.6	48.9	**2.3**	river mile +2.6
S. Santiam	S. Santiam abv Foster	Shot Pouch Rd to High Deck Rd	48.9	50.6	**1.7**	
S. Santiam	S. Santiam abv Foster	High Deck Rd to Cascadia Park	50.6	52.2	**1.6**	
S. Santiam	S. Santiam abv Foster	Cascadia Park to Moose Creek Bridge	52.2	53.7	**1.5**	
S. Santiam	S. Santiam abv Foster	Moose Creek Bridge to Gordon Creek Rd	53.7	56.4	**2.7**	
S. Santiam	S. Santiam abv Foster	Gordon Creek Rd to 2nd Trib below C.G.	56.4	58.2	**1.8**	
S. Santiam	S. Santiam abv Foster	2nd Trib below C.G. to Trout Creek C.G.	58.2	59.7	**1.5**	
S. Santiam	S. Santiam abv Foster	Trout Creek C.G. to Little Boulder Creek	59.7	61.8	**2.1**	
S. Santiam	S. Santiam abv Foster	Little Boulder Creek to Soda Fork	61.8	63.6	**1.8**	
S. Santiam	S. Santiam abv Foster	Soda Fork to Falls	63.6	66.1	**2.5**	distance is estimated?
McKenzie	**McKenzie**	**Armitage to Hayden**	**4.1**	**14.3**	**10.2**	**4.1 to mouth**
McKenzie	McKenzie	Hayden to Bellinger	14.3	18.7	**4.4**	manually measured
McKenzie	McKenzie	Bellinger to Hendricks	18.7	24.2	**5.5**	manually measured
McKenzie	McKenzie	Hendricks to Dearhorn	24.2	31.8	**7.6**	
McKenzie	McKenzie	Dearhorn to Leaburg Landing	31.8	33.9	**2.1**	
McKenzie	McKenzie	Leaburg Landing to Leaburg Dam	33.9	39.9	**6**	
McKenzie	McKenzie	Leaburg Lake to Helfrich	39.9	44.3	**4.4**	
McKenzie	McKenzie	Ben & Kay to Rosboro Bridge	44.3	50.8	**6.5**	
McKenzie	McKenzie	Rosboro Bridge to Forest Glen	50.8	56.5	**5.7**	
McKenzie	McKenzie	Forest Glen to S.F. McKenzie	56.5	58.9	**2.4**	
McKenzie	**S. Fork McKenzie**	**Mouth to Bridge**	**0**	**2.1**	**2.1**	
McKenzie	S. Fork McKenzie	Bridge to Cougar Dam	2.1	4.4	**2.3**	
McKenzie	S. Fork McK abv Cougar	Cougar Reservoir to NFD 1980	9.1	11.1	**2**	river mile
McKenzie	S. Fork McK abv Cougar	NFD 1980 to Rebel Creek	11.1	13.8	**2.7**	
McKenzie	S. Fork McK abv Cougar	Rebel Creek to Dutch Oven C.G.	13.8	16.2	**2.4**	
McKenzie	S. Fork McK abv Cougar	Dutch Oven C.G. to Homestead C.G.	16.2	18.1	**1.9**	
McKenzie	S. Fork McK abv Cougar	Homestead C.G. to Twin Springs C.G.	18.1	20.2	**2.1**	
McKenzie	S. Fork McK abv Cougar	Twin Springs C.G. to Roaring River	20.2	22.3	**2.1**	
McKenzie	S. Fork McK abv Cougar	Roaring River to Elk Creek	22.3	25.1	**2.8**	
McKenzie	McKenzie	S.F. McKenzie to Hamlin	58.9	59.2	**0.3**	
McKenzie	McKenzie	Hamlin to McKenzie Bridge	59.2	67.5	**8.3**	
McKenzie	**Horse Creek**	**Mouth to Bridge**	**0**	**2.4**	**2.4**	
McKenzie	Horse Creek	Bridge to Avenue Creek	2.4	5.9	**3.5**	
McKenzie	Horse Creek	Avenue Creek to Braids	5.9	7.1	**1.2**	
McKenzie	Horse Creek	Braids to Road Access	7.1	9.2	**2.1**	
McKenzie	Horse Creek	Road Access to Separation Creek	9.2	10.7	**1.5**	

Subbasin	River	Description	Start River Mile	End River Mile	Total Distance	Comment
McKenzie	Horse Creek	Separation Creek to Trail Bridge	10.7	11.8	**1.1**	
McKenzie	Horse Creek	Trail Bridge to Pothole Creek	11.8	13.5	**1.7**	
McKenzie	McKenzie	McKenzie Bridge to McKenzie Trail	67.5	69.1	**1.6**	
McKenzie	McKenzie	McKenzie Trail to Paradise	69.1	70.6	**1.5**	
McKenzie	McKenzie	Paradise to Belknap	70.6	73.9	**3.3**	
McKenzie	**Lost Creek**	**Mouth to Hwy 126 Bridge**	**0**	**0.5**	**0.5**	
McKenzie	Lost Creek	Hwy 126 Bridge to Split Pt	0.5	1	**0.5**	
McKenzie	Lost Creek	Split Pt to Limberlost CG	1	2.5	**1.5**	
McKenzie	Lost Creek	Limberlost CG to Cascade	2.5	3	**0.5**	
McKenzie	Lost Creek	Cascade to Spring	3	5.3	**2.3**	
McKenzie	McKenzie	Belknap to Olallie C.G.	73.9	79.4	**5.5**	
McKenzie	McKenzie	to Spawning Channel	79.4	79.5	**0.1**	
M. Fork	**Fall Creek**	**Reservoir to Release Site**	**13.7**	**15**	**1.3**	**release site RM -1.3**
M. Fork	Fall Creek	Release Site to Johnny Creek Bridge	15	19.7	**4.7**	
M. Fork	Fall Creek	Johnny Cr Bridge to Bedrock campground	19.7	21	**1.3**	
M. Fork	Fall Creek	Bedrock campground to Portland Creek	21	22	**1**	RM for portland creek
M. Fork	Fall Creek	Portland Creek to NFD 1828 Bridge	22	23.7	**1.7**	
M. Fork	Fall Creek	NFD 1828 Bridge to Hehe Creek	23.7	25.5	**1.8**	
M. Fork	Fall Creek	Hehe Creek to Gold Creek	25.5	29	**3.5**	
M. Fork	Fall Creek	Gold Creek to Falls	29	30	**1**	
M. Fork	**Little Fall Creek**	**Fish Ladder to NFD 1818 Bridge**	**12.9**	**15.4**	**2.5**	**ladder RM measured manually**
M. Fork	Little Fall Creek	NFD 1818 Bridge to NFD 1806 Bridge	15.4	17.9	**2.5**	manually measured
M. Fork	Little Fall Creek	NFD 1806 Bridge to Trib below NFD 400	17.9	21.7	**3.8**	exact Loc'n?
M. Fork	M. Fork	Jasper to Pengra	195.1	200.3	**5.2**	topo RM
M. Fork	M. Fork	Pengra to Dexter	200.3	203	**2.7**	
M. Fork	**N. Fork M. Fork**	**1926 Bridge to Release Site**	**15.5**	**18.3**	**2.8**	
M. Fork	N. Fork M. Fork	Release Site to Kiahanie Bridge	18.3	22.8	**4.5**	
M. Fork	N. Fork M. Fork	Kiahanie Bridge to 1944 Bridge	22.8	28.2	**5.4**	
M. Fork	N. Fork M. Fork	1944 Bridge to Minute Creek	28.2	32.1	**3.9**	
M. Fork	N. Fork M. Fork	Minute Creek to 2nd to last pullout/RM 33.6	32.1	33.6	**1.5**	
M. Fork	N. Fork M. Fork	2nd to last pullout/RM 33.6 to Skookum Cr	33.6	36.4	**2.8**	

Appendix 4: Juvenile Chinook Salmon and Steelhead Liberation in 2013

Appendix Table 4-1. Numbers and pounds of UWR hatchery spring Chinook salmon (ChS) and summer steelhead (StS) released in the UWR basin in 2013. Data are from HMIS and parsed by rearing or release facility and stock.

Hatchery	Release Date	Release Location	BY	Species	Stock Name (code)	Release Number	Release/ Acclimation	Marks
Marion Forks	3/18/13	N. Santiam	2011	ChS	N Santiam R. (21)	234,000		100% AD OT; 100K CWT
Marion Forks	3/19/13	N. Santiam	2011	ChS	N Santiam R. (21)	234,000		100% AD OT
Marion Forks	4/15/13	N. Santiam	2011	ChS	N Santiam R. (21)	343,494		100% AD OT 229K CWT
Marion Forks	6/11/13	N. Santiam	2011	ChS	N Santiam R. (21)	14,674		100% AD OT
Marion Forks	6/27/13	Detroit Res	2012	ChS	N Santiam R. (21)	66,543		100% AD OT PIT
Marion Forks	6/27/13	N. Santiam	2012	ChS	N Santiam R. (21)	33,270		100% AD OT PIT
NSNT Total						**925,981**		
South Santiam	2/13/13	S. Santiam	2011	ChS	S Santiam R. (24)	305,703		100% AD OT; 30K CWT
Willamette	2/27/13	S. Santiam	2011	ChS	S Santiam R. (24)	126,594	S. Santiam	100% AD OT; 31K CWT
Willamette	2/28/13	S. Santiam	2011	ChS	S Santiam R. (24)	125,405	S. Santiam	100% AD OT
South Santiam	3/22/13	S. Santiam	2011	ChS	S Santiam R. (24)	4,750		100% AD OT
South Santiam	10/31/13	S. Santiam	2012	ChS	S Santiam R. (24)	298,759		100% AD OT; 51K CWT
SSNT Total						**861,211**		
McKenzie	2/8/13	McKenzie	2011	ChS	McKenzie R. (23)	302,416		100% AD OT; 104K CWT
McKenzie	2/25/13	Row R.	2011	ChS	McKenzie R. (23)	103,179		100% AD OT; 27K CWT
McKenzie	2/25/13	Coast fork	2011	ChS	McKenzie R. (23)	112,591		100% AD OT; 28K CWT
McKenzie	2/25/13	Mosby Cr.	2011	ChS	McKenzie R. (23)	54,490		100% AD OT
McKenzie	3/5/13	McKenzie	2011	ChS	McKenzie R. (23)	218,100		100% AD OT; 111K CWT

Hatchery	Release Date	Release Location	BY	Species	Stock Name (code)	Release Number	Release/ Acclimation	Marks
McKenzie	3/5/13	Row R.	2011	ChS	McKenzie R. (23)	18,700		100% AD OT
McKenzie	3/6/13	Coast Fork	2011	ChS	McKenzie R. (23)	81,400		100% AD OT
McKenzie	11/4/13	McKenzie	2012	ChS	McKenzie R. (23)	361,493		100% AD OT; 101K CWT
McK Total						**1,252,369**		
Willamette	5/31/13	Hills Cr. Res.	2012	ChS	Willamette R. (22)	33,376		100% AD OT PIT
Willamette	5/31/13	Lookout Point Res.	2012	ChS	Willamette R. (22)	74,631		100% AD OT PIT
Willamette	5/31/13	Middle Fk, Willamette	2012	ChS	Willamette R. (22)	37,340		100% AD OT PIT
Willamette	6/21/13	Hills Cr. Res.	2012	ChS	Willamette R. (22)	57,505		100% AD OT PIT
Willamette	2/6/13	Middle Fk, Willamette	2011	ChS	Willamette R. (22)	691,537	Dexter	100% AD OT; 82K CWT
Willamette	3/5/13	Middle Fk, Willamette	2011	ChS	Willamette R. (22)	551,523	Dexter	100% AD OT; 153K CWT
Willamette	4/15/13	Middle Fk, Willamette	2011	ChS	Willamette R. (22)	238,509	Dexter	100% AD OT; 84K CWT
Willamette	11/1/13	Middle Fk, Willamette	2012	ChS	Willamette R. (22)	299,319	Dexter	100% AD OT; 29K CWT
MFW Total						**1,983,740**		

Hatchery	Release Date	Release Location	BY	Species	Stock Name (code)	Release Number	#/Lb.	Lbs.	Marks
Willamette	4/15/14	Middle Fk, Willamette	2012	StS	Mid Willamette R. (22)	71,695	4.63	15,485.00	100% AD
						71,695		**15,485**	

Hatchery	Release Date	Release Location	BY	Species	Stock Name (code)	Release Number	#/Lb.	Lbs.	Marks
South Santiam	4/4/13	S. Santiam	2012	StS	S Santiam R. (24)	186,828	4.49	41,623.00	142K AD; 21K ADLM; 21K ADRM

Willamette	4/9/13	N. Santiam	2012	StS	S Santiam R. (24)	69,230	4.79	14,456.81	35K ADLM; 35K ADRM
Leaburg	4/10/13	McKenzie	2012	StS	S Santiam R. (24)	77,681	5.24	14,824.43	100% AD
Leaburg	4/13/13	McKenzie	2012	StS	S Santiam R. (24)	28,414	4.60	6,177.00	100% AD
						362,153		**77,081**	

Hatchery	Release Date	Release Location	BY	Species	Stock Name (code)	Release Number	#/Lb.	Lbs.	Marks
Marion Forks	3/18/13	N. Santiam	2011	ChS	N Santiam R. (21)	234,000	13.00	18,000.00	100% AD OT; 100K CWT
Marion Forks	3/19/13	N. Santiam	2011	ChS	N Santiam R. (21)	234,000	13.00	18,000.00	100% AD OT
Marion Forks	4/15/13	N. Santiam	2011	ChS	N Santiam R. (21)	343,494	11.20	30,669.00	100% AD OT 229K CWT
Marion Forks	6/11/13	N. Santiam	2011	ChS	N Santiam R. (21)	14,674	11.00	1,334.00	100% AD OT
Marion Forks	6/27/13	Detroit Res	2012	ChS	N Santiam R. (21)	66,543	120.00	554.53	100% AD OT PIT
Marion Forks	6/27/13	N. Santiam	2012	ChS	N Santiam R. (21)	33,270	120.00	277.25	100% AD OT PIT
MF Total						**925,981**		**68,834.78**	

Appendix 5: Accounting of hatchery-origin Chinook salmon passing Willamette Falls

Location	Description	02 Totals	03 Totals	04 Totals	05 Totals	06 Totals	07 Totals	08 Totals	09 Totals	10 Totals	11 Totals	12 Totals	Comment
Willamette Falls	H ChS over W Falls	83,100	87,700	96,700	36,600	37,000	23,100	14,700	28,500	67,100	45,100	37,200	Raw Count of clipped ChS over W Falls
Willamette Falls	Net H ChS over W Falls w 6% fallback	78,114	82,438	90,898	34,404	34,780	21,714	13,818	26,790	63,074	42,394	34,968	From Schroeder floy tagging '98-2000
Below Detroit		326	680	338	329	259	494	226	281	461	599	557	
Below Foster		955	630	377	530	528	483	209	483	799	545	443	From basin-specific survey summaries. Peak redd counts from spawning ground surveys.
Below Leaburg	Peak Redds	115	171	99	75	84	141	240	167	266	232	268	
Above Leaburg		807	1,016	1,038	1,072	709	1,346	629	531	1,013	1,168	666	
Below Dexter		64	14	9	9	111	9	134	36	22	99	76	
Below Detroit		0.87	0.96	0.85	0.70	0.69	0.75	0.27	0.49	0.76	0.63	0.75	From basin-specific survey summaries. pHOS estimates from counts of clipped and unclipped ChS carcasses, adjusted for otolith marks in unclipped fish.
Below Foster		0.86	0.87	0.82	0.80	0.84	0.82	0.50	0.38	0.96	0.79	0.84	
Below Leaburg	pHOS	0.80	0.93	0.94	0.50	0.58	0.78	0.83	0.73	0.91	0.59	0.83	
Above Leaburg		0.35	0.39	0.38	0.18	0.17	0.16	0.16	0.26	0.45	0.25	0.16	
Below Dexter		0.96	0.96	0.83	0.89	0.57	0.72	0.62	0.77	0.90	0.85	0.87	
Below Detroit		709	1,632	718	576	447	926	153	344	876	945	1,044	
Below Foster		2,058	1,375	772	1,056	1,111	984	261	460	1,916	1,076	930	
Below Leaburg	HOS	231	398	233	94	121	276	497	303	605	345	555	Assumes 2.5 spawners per redd: Peak Redds * 2.5 * pHOS
Above Leaburg		710	1,001	996	472	300	548	247	339	1,145	730	266	
Below Dexter		153	33	19	20	158	16	209	70	50	209	166	
Below Detroit		0.60	0.72	0.77	0.51	0.17	0.41	0.32	0.32	0.40	0.33	0.36	From basin-specific survey summaries. Prespawn mortality calculated from recovery of female carcasses. PSM rates of 1.0 were converted to 0.99 when redds were found but zero spawned-out females were sampled.
Below Foster		0.20	0.30	0.70	0.30	0.10	0.10	0.10	0.10	0.30	0.10	0.30	
Below Leaburg	PSM Rate	0.16	0.52	0.60	0.40	0.10	0.37	0.09	0.22	0.23	0.28	0.26	
Above Leaburg		0.05	0.16	0.11	0.16	0.02	0.05	0.01	0.01	0.10	0.05	0.01	
Below Dexter		0.84	0.99	0.99	0.94	0.29	0.95	0.17	0.99	0.99	0.60	0.57	
Below Detroit		1,064	4,197	2,405	599	92	644	72	162	584	465	587	
Below Foster		515	589	1,801	453	123	109	29	51	821	120	399	The number of hatchery-rorigin that died before spawning given that survival rate was (1 - PSM)
Below Leaburg	PSM Count	44	431	349	63	13	162	49	85	181	134	195	
Above Leaburg		37	191	123	90	6	29	2	3	127	38	3	
Below Dexter		777	3,313	1,406	290	66	324	44	6,887	9,198	317	221	
Below Detroit		1,773	5,829	3,123	1,175	538	1,570	224	506	1,460	1,410	1,632	
Below Foster		2,573	1,964	2,573	1,509	1,235	1,093	290	511	2,737	1,196	1,329	Basin-specific hatchery origin fish that spawned or died before spawning but were not harvested.
Below Leaburg		275	829	582	157	135	438	547	388	786	479	751	
Above Leaburg		748	1,191	1,120	562	306	577	249	342	1,272	768	269	
Below Dexter	HOS + PSM	930	3,346	1,424	310	224	340	253	6,957	9,248	526	387	
Other (unsurveyed) Basins		389	233	278	180	205	56	22	75	227	64	150	Uses weak positive relationship between HOS (+PSM) and harvest rate to predict run size of hatchery fish based on reported havest in unsurveyed streams. Formula is 0.9022 * reported harvest with r-squared = 0.30
Minto		4,362	4,032	3,559	1,427	3,148	1,619	768	2,068	4,274	NA	NA	
Foster		6,293	5,751	8,746	2,826	3,674	1,473	2,226	3,167	8,973	8,993	8230	
McKenzie	Capture/Removal of Hatchery Fish	5,939	5,635	6,132	3,019	2,770	2,197	2,501	3,304	6,251	5,490	3,665	
Leaburg H/Dam		0	0	0	0	0	330	137	136	126	65	78	
Dexter		NA	NA	NA	NA	5,664	3,728	2,168	4,322	6,116	6,884	8,277	
Basinwide	Returns to Hatchery	31,194	28,384	36,948	15,821	16,949	10,145	8,705	14,820	28,408	23,646	21,959	From Joint staff report
Basinwide	HOS + PSM	6,687	13,392	9,100	3,891	2,643	4,074	1,585	8,779	15,729	4,443	4,517	Summed from above
Basinwide	Total Harvest	12,587	11,026	13,256	4,564	5,738	2,184	295	3,161	9,732	4,928	5,068	From harvest summaries
Basinwide	HOS + PSM + Harvest + Hatchery	50,468	52,802	59,304	24,276	25,330	16,403	10,585	26,760	53,869	33,017	31,544	Total hatchery fish accounted for by spawners, PSM, harvest, and hatchery return.
Unaccounted hatchery-origin fish using Joint Staff Report		**27,646**	**29,636**	**31,594**	**10,128**	**9,450**	**5,311**	**3,233**	**30**	**9,205**	**9,377**	**3,424**	**Net ChS over W Falls minus accounted fish**
Percent of net Willamette Falls		**35%**	**36%**	**35%**	**29%**	**27%**	**24%**	**23%**	**0%**	**15%**	**22%**	**10%**	