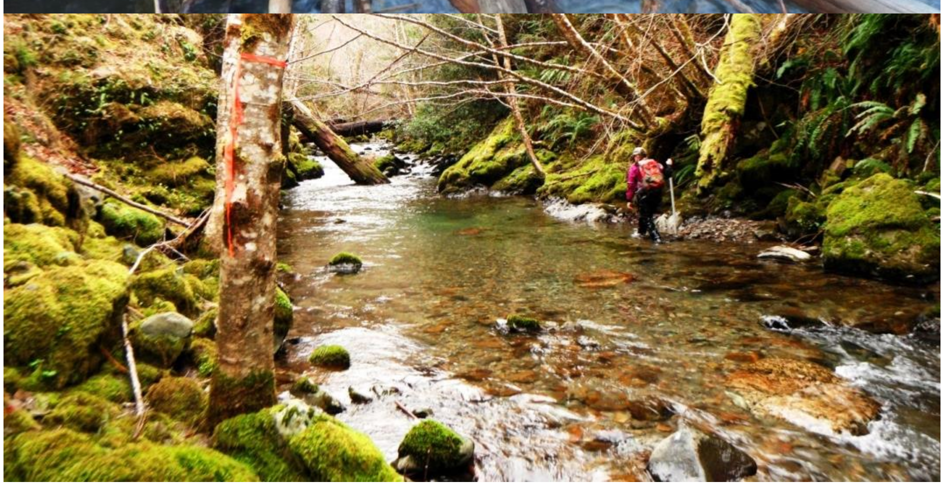
2014-2015 Salmonid Redd Abundance and Juvenile Salmonid Spatial Structure in the Smith River Basin, California and Oregon



DECEMBER 2015

ANNUAL PROGRESS REPORT TO THE CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
FISHERIES RESTORATION GRANTS PROGRAM
GRANTEE AGREEMENT: P1210524

ON BEHALF OF

THE SMITH RIVER ALLIANCE

AND

THE CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
ANADROMOUS FISHERIES RESOURCE AND MONITORING PROGRAM

2014-2015 Salmonid Redd Abundance and Juvenile Salmonid Spatial Structure in the Smith River Basin, California and Oregon

Annual Progress Report to the California Department of Fish and Wildlife
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Grantee agreement: P1210524

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Abstract

We continued to investigate two population viability metrics of salmonids in the Smith River basin (California and Oregon), with ESA listed coho salmon (*Oncorhynchus kisutch*) as the focal species. First, we monitored adult salmonid escapement and distribution for a fourth year during the winter of 2014-2015 using a combination of live fish, carcass, and redd counts as defined in California's Coastal Salmonid Monitoring Plan. The spawner survey sample frame includes 161.8 kilometers of potential spawning habitat divided into 68 reaches and 30 sub-reaches. We completed 414 spawning ground surveys in 30 main reaches and 11 sub-reaches throughout the Smith River basin during the 2014-2015 season. We made 216 live adult coho salmon observations. Most coho salmon observations occurred in Mill Creek with the exception of six individuals observed in Rowdy Creek. We recovered 15 coho salmon carcasses, all of which were observed in Mill Creek. Last, we were able to verify 39 individual coho salmon redds. As with previous years, all verified redds were found clustered in the upper Mill Creek sub-basin so we restricted the coho salmon redd population estimate to Mill Creek to avoid excessive error associated with between-reach sampling variation. We estimated total coho salmon redd abundance in the Mill Creek sub-basin as 149 (95% CI: 139 - 159) redds which equaled 31%, 66% and 57% of the estimated number of redds produced in the three previous seasons. Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) total redd abundance estimates were determined for the sample frame since these species were more evenly distributed throughout the Smith River basin. We estimated Chinook salmon redd abundance as 1715 (95% CI: 1092 - 2337) which equaled 45%, 96%, and 332% of the estimated number of redds produced in the three previous seasons. Steelhead redd abundance estimates are incomplete since we only surveyed approximately 60% of the season. However, we estimated a total of 914 steelhead redds (95% CI: 381 - 1446) equaling 87%, 132% and 257% of the estimated number of redds produced in the three previous incomplete survey seasons. Hatchery origin salmonids were observed spawning throughout sampling frame below the major river forks, with the mean hatchery proportion of Chinook salmon carcasses ranging from 0% to 42% and mean hatchery proportion of live steelhead ranging from 0% to 25%. Second, we monitored the summer spatial structure of juvenile salmonids and adult coastal cutthroat trout (*Oncorhynchus clarki clarki*) for a fourth year during the summer of 2015 using multiple-pass snorkel surveys in an occupancy modeling framework. We used multi-scaled occupancy models to estimate the probability of salmonid occupancy at the sample reach and at the sample unit (pools within a reach) simultaneously while accounting for species detection probabilities. The spatial structure sampling frame includes 298.1 kilometers of potential juvenile rearing habitat divided into 126 reaches and 40 sub-reaches. We detected juvenile coho salmon 21 out of 69 surveyed reaches in four portions of the watershed. Four forest fire complexes kept us from sampling five reaches including four reaches in the south fork and one reach in the north fork. Ten (48%) of the reaches with coho salmon were determined non-natal rearing areas. Estimated large-scale occupancy of juvenile coho salmon equaled 0.31 (SE=0.06) while estimated small-scale occupancy equaled 0.68 (SE=0.03) resulting in a proportion of total area occupied (PAO) of 0.21. Juvenile Chinook salmon had an estimated PAO of 0.35, over twice that of PAO estimates for 2014, but similar to those from 2012 and 2013.

Cover Photo's: *(1) Tagged Chinook salmon Carcass in Rowdy Creek on December 31, 2014.*
(2) Picture of Redd on Rock Creek taken during a spawning survey on February18, 2015.

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Acknowledgments

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Photograph of a coho salmon observed in South Fork Rowdy Creek on 14 December 2014; one of six live coho salmon observed during the winter of 2014/2015 in the Rowdy Creek sub-basin upstream of Rowdy Creek Fish Hatchery weir.

Introduction

This brief progress report summarizes the fourth year of data collection on salmonid populations in the Smith River basin based on the California Coastal Monitoring Program (CMP). We are conducting this effort for five years from 2011-2016 based on current secured funding. Extensive background on the context, development, methods, and implementation of this monitoring can be found in Garwood and Larson (2014) which summarizes the development and first two years of Smith River CMP monitoring from 2011 to 2013. This report is intended to summarize project operations and data collection for the 2014-2015 season, with a multi-year comparison five-year report to follow in 2016.

Monitoring Approach

We developed this coho salmon monitoring effort to assess two of the four viable salmonid population parameters: Abundance and Spatial Structure (McElhany et al. 2000). Each monitoring component requires well planned study designs, sampling protocols, analysis and reporting metrics, and data storage (Adams et al. 2011). Application of various monitoring components also needs to be standardized across multiple salmonid populations in order to assess population metrics at the ESU scale. Notwithstanding, the implementation of the CMP has only occurred in recent years for much of the monitoring area and methods are being refined as lessons from new monitoring programs and data sets are becoming available to program managers.

Population Abundance

Abundance is perhaps the most important population metric since it can generally be used to assess overall extinction risk without needing to understand all the species-specific factors influencing the population (McElhany et al. 2000). Spawning ground surveys are the primary monitoring method used for tracking salmonid population abundance trends in the northern monitoring area (Boydstun and McDonald 2005, Adams et al. 2011). Surveys are confined to an annual sample of stream reaches where redds, live fish, and carcasses are counted across multiple survey periods throughout a season (Gallagher et al. 2007). Total redd production is the primary abundance metric and is carried out using flag-based mark-recapture of individual redd features in a population model. The total number of redds are estimated for each survey reach and these totals are used to expand the estimate across the entire sample frame (Boydstun and McDonald 2005). Although this monitoring effort was designed for coho salmon, all salmonid species were incorporated into data collection and analysis based on the need to divide individual redds into separate species. Ultimately redds are converted to adult numbers based on adult to redd correction factors produced at local life cycle monitoring stations or from the scientific literature (Gallagher et al. 2010, Adams et al. 2011).

Spatial Structure

The spatial structure of a population refers both to the spatial distributions of individuals in the population and the processes that generate that distribution (McElhany et al. 2000). Spatial structure is important for assessing viability because understanding extinction risk for population abundance trends occurs at longer timescales than measured changes in the spatial arrangement of the population. Understanding patch use, patch size, patch connectivity, and patch colonization and extinction processes of the population will help managers define source patches while also protecting isolated patches that are much more vulnerable to extinction (Adams et al. 2011). For coho salmon, juvenile life stages are the most widely distributed across the riverscape with habitats being spatially and temporally dynamic (Wigington et al. 2006, Henning et al. 2006, Anderson et al. 2008, Koski 2009, Flitcroft et al. 2013). Two distinctive periods representing a high likelihood of contrasting stream habitat availability include the winter and summer. We suggest both periods are critical to understanding spatial structure dynamics and sampling strategies should be developed for each. For example, estuaries have been shown to be important temporal rearing locations for coho salmon during the winter (Koski 2009, Wallace and Allen 2009). Methods for monitoring juvenile salmonid spatial structure have not been formally developed by the CMP. However, Adams et al. (2011) suggested juvenile salmonid surveys be conducted during the summer on an annual basis in a sampled fraction of reaches throughout a population.

We adapted a snorkel survey protocol by Webster et al. (2005) to sample for juvenile coho salmon throughout a randomly selected set of reaches with pools defined as the primary sampling unit. We based our design on an occupancy modeling framework that incorporates both reach-level and pool-level occupancy while accounting for imperfect detection rates (Nichols et al. 2008, MacKenzie et al. 2006). By tracking occupancy at both scales, we were able to determine the overall proportion of area occupied during the summer rearing period. Results from each year can be directly compared to assess the relative change in annual spatial structure. Our study is the first attempt at formalizing sampling methods and a statistical framework specifically for measuring juvenile salmonid spatial structure in California so this work should be considered a pilot effort. As such, our methods have not been reviewed or endorsed by the CMP. We hope results from this study will offer critical empirical data to further the development of an accepted state-wide spatial structure monitoring component. Methods in the occupancy modeling construct are currently rapidly evolving suggesting opportunities to use new tools and methods in the near future.

Materials and Methods

Spawning Ground Survey Frame

Our sample frame consists of 68 primary reaches and 30 sub-reaches totaling 161.8 km within the coho salmon spawning ground survey sampling frame (Figure 1), (Garwood and Larson 2014). These reaches collectively represent 78% of the total estimated coho salmon spawning habitat in the Smith River basin. We eliminated the remaining 22% of potential habitat occurring in extreme remote areas within the Siskiyou Wilderness of the South Fork Smith River, the Oregon portion (Kalmiopsis Wilderness) of the North Fork Smith River, and the headwaters of the Siskiyou Fork. These areas are not accessible during the winter due to having locked US Forest Service gates preventing the spread of an invasive Port Orford cedar pathogen, persistent winter snowpack, or multiday remote treks requiring unsafe stream crossings and winter camping. Since these remote areas will never feasibly be sampled during the winter with the current protocol, we cannot consider the reaches when calculating adult coho salmon redd population estimates. This consideration eliminates any ill effects from non-response errors associated with failing to ever sample reaches having unique properties (e.g. high elevation, isolated) in the population. Notwithstanding, we included these remote reaches in the juvenile summer spatial structure sample frame.

Spatial Structure Survey Frame

Our sample frame consists of 126 primary reaches and 40 sub-reaches totaling 298.1 km within the coho salmon summer spatial structure sampling frame (Figure 1) (Garwood and Larson 2014). These reaches collectively represent 91% of the total estimated summer juvenile coho salmon rearing habitat in the Smith River basin. We eliminated the remaining 9% of potential habitat occurring in slough and stream channels in the lower Smith River estuary due to visual observation surveys likely suffering from poor underwater visibility. Other methods, such as minnow trapping or seining, are currently being employed by another study to generate occupancy patterns in these habitats. We intentionally included the Oregon portion of available coho salmon rearing habitat in the final sample frame. The North Fork represents a unique and isolated portion of the Smith River coho salmon population. With the help of biologists from the Oregon Department of Fish and Wildlife and the US Forest Service, we were able to implement our protocol in selected reaches occurring in Oregon.

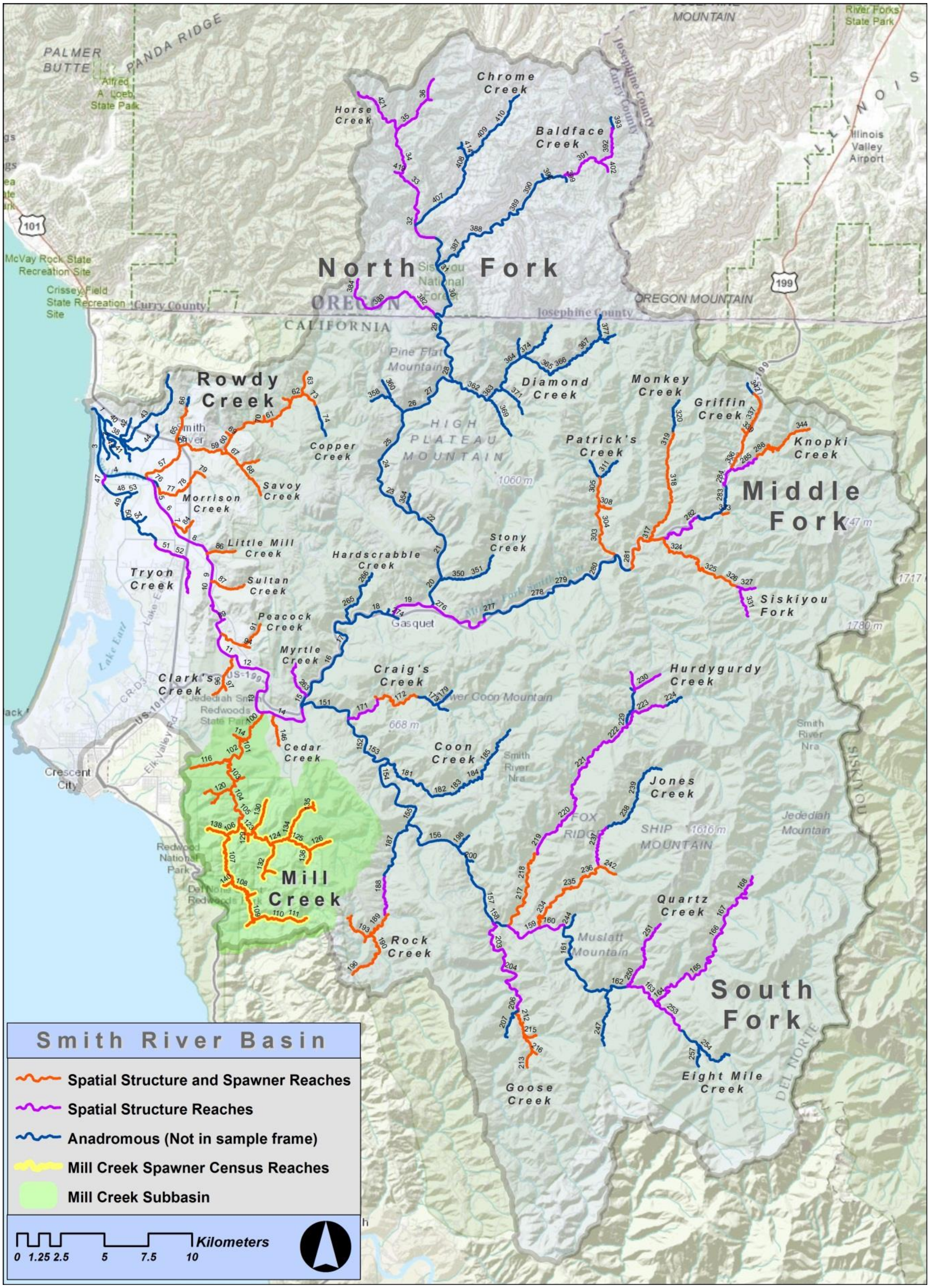

Figure 1. Map of the Smith River Basin, Del Norte County (California) and Curry County (Oregon). Stream lines indicate potential anadromous salmonid stream habitat based on this studies sample frame development process. Numbers represent 275 individual reach location codes used in generalized random tessellation sampling (GRTS).

Sample Draw Procedure and Sampling Rates

We used the generalized random tessellation stratified (GRTS) algorithm (Stevens and Olson 2004) to establish our annual adult spawning ground and juvenile spatial structure samples. We did not employ a rotational visitation scheme as suggested by Adams et al. (2011) since concurrent field efforts have been focused on refining sampling frames and collecting base-line data. However, an informed fixed rotating panel sampling strategy could be implemented in the near future once we determine optimal sampling rates for obtaining acceptable population estimate precision targets. Our GRTS sample draws included all available primary reaches. Oversampling ensured our anticipated survey effort could be maintained if landowner permissions could not be secured in individual reaches.

Spawning Ground Surveys

The optimal sample rate for determining population abundance trends from redd counts has not been completely assessed across northern California and proposed rates from available studies vary substantially from 10% (Jacobs 2002, Boydstun and McDonald 2005) to 50% (Ricker 2011). We sampled at a rate of 41%, 35% and 29% the first three seasons based on available resources and found our between-reach error represented 73% to 99% of the total estimate variance depending on species and year (Garwood and Larson 2014 and Garwood et al. 2014). For this study, we sampled at a rate of 29%, which was largely based on limited resources and available funding.

Spatial Structure Surveys

We set our initial within-reach sampling rate based on simulations performed by Webster et al. (2005) who used repeated snorkel survey counts of coho salmon in California. These authors determined a fixed sampling fraction of every second unit surveyed by two independent snorkel dives was optimal in detecting coho salmon in a low abundance scenario. Furthermore, we wanted to ensure our surveys had a high pool sampling fraction anticipating annual differences in spatial structure are likely more sensitive within reaches rather than between reaches. Our reach sample rate was largely based on available resources with the goal of maximizing the number of survey reaches each year. Previous occupancy estimates indicate variance between reaches greatly exceeds varience between pools suggesting the reach-level sampling rate is sensitive to how patchy the population is across the landscape (Garwood and Larson 2014 and Garwood et al. 2014). To properly assess sample rate as it applies to within-reach and between-reach variance requires a meta-analysis across multiple populations. Differences in relative coho salmon abundance, spatial representation, and spatial autocorrelation, can be incorporated into simulation routines for estimating optimal and cost efficient sampling rates throughout northern California. This study design and protocol has been implemented in four basins for three years and we plan to work with others to determine optimal sampling rates.

Field Methods

Spawning Ground Reach Survey Protocol

We used similar protocols defined by Gallagher et al. (2007) and recommended by (Adams et al. 2011) to survey for salmonid redds, live fish, and carcasses throughout our annual reach sample draw. Each year the project was staffed to ensure each reach in the sample draw could be surveyed every 10 to 14 days. Surveys were completed by a team of two walking the reach in an upstream direction. However, a few larger reaches were surveyed with kayaks in a downstream direction when stream discharge had increased but survey conditions were acceptable. A stream discharge threshold was determined for each survey reach using Smith River discharge estimates from the USGS Jed Smith gauging station in Hiouchi, CA. Our minimum water visibility for surveys ranged from 40 to 50 cm depending on stream size, with larger streams exceeding this threshold once safe flow conditions permitted surveys. When our survey return interval was interrupted by storm events, we returned to reaches as soon as they became available to maximize survey effort in each reach for the season.

Our survey protocol is designed to maximize the detection of redds during a given survey by having a primary observer searching for all redds and a dependent secondary observer searching redds the primary observer may have overlooked. We suggest this method maximizes redd detection rates by forcing each observer to identify all redds in contrast to a two person crew dividing the search effort. Overall redd observation probabilities of the primary observer equaled 97% in 2011-2012, 98% in 2012-2013 (Garwood and Larson 2014), 97% in 2013-2014, and 98% in 2014-2015 (This study). Given our secondary observer found only 2-3% more redds on average than the primary observer, this indicates a single observer was highly effective at finding most redds across all 4 sampling years. However, the field crew was exceptionally experienced over the first four-years of this study and we would expect detection probabilities to decrease among crews having less survey experience. For these reasons, we plan to continue using this double-dependent approach to maximize overall redd detection rates.

We only identified redds to species when identified salmonids were observed constructing or guarding the feature. Only redd features having distinct pot and tail spills were considered (i.e. test digs were not recorded). Redds observed without identified live fish were recorded as unknown species. All new redds were identified with flagging tied to available riparian vegetation. A unique redd record number, redd age, total redd length, distance, and compass bearing were transcribed on the flagging to identify the redd location and status on subsequent surveys. Spatial coordinates were collected for all individual redds using Garmin 60csx GPS with point averaging (minimum of 200 positions) employed to maximize location accuracy (Mean accuracy= 3.4 meters). Redd age categories included (1) new since last survey, (2) still visible and measurable, (3) still visible but not measurable, (4) no longer visible, (5) unknown due to poor visibility. During a survey, all newly observed redds were recorded as age=1 and all previously flagged redds were aged according to their current status (e.g. 2, 3, 4, or 5). When a redd was recorded as age four, the flag was tied into a knot and was no longer considered on subsequent surveys. Redd dimensions were not measured as used to classify redds using logistic regression as defined in Gallagher et al. (2007). We found a non-parametric K-nearest neighbor algorithm (kNN) (Cover and Hart 1967) outperformed redd measurements for redd classification in the Smith River basin (Ricker et al. 2014a).

Live salmonid information is important for identifying redd species, describing reach-level relative abundance, and identifying spatial distributions of species having cryptic spawning behaviors. We identified all observed live salmonids to species and gender whenever possible. We collected spatial coordinates for all salmonid locations using a Garmin 60csx GPS without point averaging. Fork lengths were estimated to the nearest five centimeters. Field staff would also inspect the body of each live fish for the presence or absence of clips that would indicate hatchery origin. Rowdy Creek Fish Hatchery has used an adipose fin clip for Chinook salmon and steelhead. However, a left-ventral fin clip was used by Rowdy Creek Fish Hatchery on Chinook salmon during the 2009 brood year (Garwood 2010). The observation of this clip was generally unreliable on live fish and was confounded by what side of the fish an observer was facing. Stray coho salmon could have an adipose (Oregon hatcheries) or a maxillary bone (Klamath/ Trinity hatcheries) clip with the maxillary also difficult to determine on live fish. Generally, we reserved the inspection of left-ventral and maxillary clips to salmonid carcasses. To minimize bias associated with clip inspections on live fish, we did not include observations in the hatchery vs. wild analysis if the immediate area around the adipose fin was obscured from view.

Carcasses are a source for biological samples including scales and genetic tissue and provide key information on demographic measurements including body size, sex ratios, age, and origin (hatchery or wild) (Crawford et al. 2007). All adult salmonid carcasses we encountered were identified to species and gender when possible. We collected spatial coordinates for each carcass location using a Garmin 60csx GPS without point averaging. Fork length was measured to the nearest centimeter and we examined the carcass for clip marks whenever possible. Potential clip observations included adipose fin (all species), left-ventral fin (Chinook salmon only), left or right maxillary (coho salmon only). We vouchered the heads of all Chinook salmon having adipose clips to retrieve the coded wire tag (CWT) for age and hatchery origin information. All carcasses encountered that had a complete lower jaw were marked with a uniquely numbered metal tag attached to the left lower jaw. We aged all carcasses based on stages of decomposition: (1) carcass fresh clear eye, (2) carcass cloudy eye low fungus, (3) carcass cloudy eye or no eye heavy fungus, (4) carcass skin and bones with head, (5) carcass skin and bones no head, (6) loose tag no fish. Last, we collected biological samples from carcasses on the first encounter only. Scales were collected from the left side of the carcass posterior to the dorsal fin and above the lateral line unless scales were no longer present. We collected tissue samples from numerous locations on the body concentrating upon fleshy areas with the least amount of decomposition. All scale and tissue samples were preserved by dehydration and submitted to the DFW scale and tissue archive in Arcata, CA.

Mill Creek Spawning Ground Census Protocol

We designed a spawning survey census in the Mill Creek sub-basin to incorporate coho salmon redd abundance into the Mill Creek Life Cycle Monitoring Station (LCS). By conducting a census of all available spawning habitat within a LCS we avoid excessive estimation error associated with between-reach redd abundance variation. The census area includes 14 primary reaches and seven sub-reaches totaling 33.5 stream kilometers within the West Branch Mill Creek and East Fork Mill Creek (Figure 1). Reaches in the LCS that were not selected during our annual GRTS draw were simply added to our survey effort.

Spatial Structure Field Survey Protocol

We designed this survey to incorporate both local (within reach) and landscape (between reach) scales. Our survey focused on stream pools as the sample unit since pools generally provide slow water habitats and are preferred for rearing by juvenile coho salmon (Bisson et al. 1988, Nickelson et al. 1992). For small and mid-sized streams, we used systematic sampling in every second pool throughout the entire length of each GRTS selected survey reach that met our maximum depth, size, temperature and visibility criteria (*see protocol:* Garwood and Ricker 2014). We based our pool sampling frequency on optimal sampling rates in a field protocol proposed by Webster et al. (2005). We conducted two independent surveys by separate divers for each selected sample unit during the first two years (2012-2013) of the project to calculate species detection probabilities (Garwood and Larson 2014). Based on these data, we found detection probabilities to be very high (p=0.94, 0.95) indicating not all sample units needed two independent passes. After sub-sampling the available data under various two-pass sample frequencies, we found changing the frequency of two-pass pools from every sampled pool to every fourth sampled pool had negligible influence (p=0.92, *see* Table 10 in results section) on detection probabilities. The primary advantage of reducing sampling effort was to allow for more surveys to be completed at less cost.

Sampling in large main stem Smith River reaches differed from smaller streams by restricting our sample units to slow water portions of edge, side channel, off-channel, and beaver characterized areas. Main stem pools were effectively difficult to survey based on size and depth (i.e. >5 m deep) and we did not expect juvenile coho salmon to occur in open pelagic waters during daytime hours. Based on preliminary field work, we decided to census all available main stem habitats in selected reaches because features were typically rare (i.e. usually less than 10 units per reach) and had unique qualities. Each sample unit was surveyed by two independent dive passes occurring on the same day. Large complex units (>5 meters wide) were surveyed by two divers using lanes (O'Neal 2007). After the first pass, individual divers discussed the dive approach, switched lanes and completed the second pass similar to the first.

Prior to each survey season, we completed intensive underwater training on fish identification and quantitative dive counts in at least three streams of various sizes hosting different assemblages of fish species. Underwater tests on species identification were given to each crew member to ensure coho salmon and other salmonids were confidently identified. Underwater flashlights were used at all times so shadowed and complex habitats could be inspected thoroughly. All fishes and amphibians observed in each sample unit were identified and enumerated independently by each diver using dive slates. Species and age classes of fish were divided into categories based on size and physical appearance. (*see* Garwood and

Ricker 2014). For example, juvenile trout were not identified to species, and coastal cutthroat trout were only identified when lacking parr marks indicating a sexually mature adult. All coho salmon observations found in unexpected locations or low numbers were documented using underwater photographs or video and stored in the projects media archive.

Spawning Ground Survey Statistical Methods

Redd Speciation

We used a non-parametric K-nearest neighbor algorithm (kNN) (Cover and Hart 1967) to classify all unidentified redds to a unique species. Spawning date and the XY spatial coordinates of known-species redds and live fish are equally scaled in dimensional space and are then used to predict the nearest unknown redds through the majority vote of the three known nearest neighbors in Euclidean distance (Ricker et al. 2014a). This approach takes advantage of the spatial and temporal clustering of salmonid spawning runs and only requires accurate GPS coordinates to be taken at individual redds and live fish. The primary reason for including live fish observations was to maximize the use of known species spatial and temporal distributions. We found that mean live fish dates were similar to mean known redd dates (*see* Garwood and Larson [2014] *and* Table 3 in results section), so the kNN date vectors are comparable between fish and redds. Most importantly, we discovered the proportion of known species redds ranged from 43% in the early season to only 9% in the late season (Garwood and Larson 2014). This range is likely due to differences in species-specific spawning behaviors between salmon and steelhead. Steelhead spawn later in the season and are observed on redds far less often than Chinook salmon or coho salmon, resulting in a lower percentage of known-species redds later in the season. By including live fish, we are able to incorporate more known-species observations at times when few fish were observed constructing redds but were observed nearby.

We used UTME, UTMN, and date as spatial and temporal dimensions to calculate Euclidean distance (d_{ij}) between redd x_i and redd or fish x_j as:

$$d_{ij} = \sum_{l=1}^{n} \sqrt{(x_{il} - x_{jl})^2}$$

Where:
l = redd and fish attributes (UTME, UTMN, JDate); and
n = 3 when UTMs and JDate are used, and n = 1 when JDate only is used

We only used live fish observations that were not associated with a known-species redd to avoid pseudo-replication of l neighbors. That is, known-species redds were only counted once, and the fish associated with those redds were not used in the kNN classification of unknown redds. kNN selects classes based on the shortest Euclidean distance in time (date) and space (UTMs). These attributes are on two distinctly different scales resulting in uneven weighting of attributes, so we standardized attribute data into z-scores:

$$z_i = \frac{x_i - \mu}{\sigma}$$

where the value of z represents the distance between the raw score and the population mean (μ) in units of standard deviation (σ). We classified each unidentified redd by the majority vote of the three nearest known individual fish or redd neighbors (l=3) in time and space as recommended in previous work by Ricker and Stewart (2011) and Ricker et al. (2014a), who found a l of 3 produced the highest accuracy of classification with the fewest ties. Cross validation was used to evaluate the performance of the kNN model (Ricker et al. 2014a). Cross validation is an iterative process in which a single observation is removed from the data set, the model is fit to the remaining data, and the removed observation is then predicted. Overall, model accuracy is assessed as the total percentage of correctly classified known-species redds. All analysis were performed using program R (R Core Team 2013) and associated packages defined in Ricker et al. (2014a).

Estimation of Within-Reach Redd Abundance

Schwarz et al. (1993) developed a theoretical foundation for the problem of estimating a total from repeatedly sampling, marking, and releasing salmon returning to the Chase River, British Columbia, Canada. The estimator developed by these authors extends the Jolly-Seber capture-mark-recapture model to allow for the estimation of the population total by making assumptions about the recruitment process, estimating survival of fish between sampling occasions via capture-mark-recapture, then using these parameters to adjust counts for animals that enter the population and die between survey occasions. We apply this general approach to periodic redd surveys, assuming that all newly deposited redds are recruited at the mid-point of each survey interval, and estimate redd survival between occasions by inspecting the number of individually fagged redds that remain visible between each subsequent survey occasion. The estimation of total redd construction within a survey reach can be described as an age-based open population mark-recapture experiment in which redds are either marked and/or recaptured on each survey occasion, and redds are individually identified and marked with unique redd IDs applied to flagging. The population of redds is considered open because new redds are recruited into the population when they are constructed, and 'die' when they become obscured from view. In the context of repeated spawning ground surveys we estimate total redd abundance within a sample stream reach as:

$$\hat{\tau}_J = B_0 + \frac{\sum_{i=2}^{k} B_i - 1}{\sqrt{\hat{S}_p}}$$

where $\hat{\tau}_J$ is the estimate of the total number of redds within a sample reach *j*; B_i is the number of new redds on the *i*th survey occasion; *k* is the total number of survey occasions; and B_0 is the number of redds observed on the first survey of the season. The numerator of the second term is then the sum of all new redds observed from the second occasion to the last occasion, divided by survival of flagged redds pooled across all survey occasions for which at least one new redd of the target species was observed following the advice and methods of Ricker et al. (2014):

$$\hat{S}_p = \frac{\sum_{i=1}^{k-1} R_{i+1}}{\sum_{i=1}^{k-1} M_i}$$

where $\hat{S}_p$ is the pooled survival rate of flagged redds when *i* denotes the survey occasion and *k* is the total number of survey occasions. The numerator is then the sum of recaptured redds from the second survey occasion to the last survey occasion, and the denominator is the sum of marked redds and recaptured redds that were still visible from the first occasion to the second to last occasion.

This age-based mark recapture model has the following assumptions based on Ricker et al. (2014b):

(1) Field surveyors correctly identify all redds as redds, and no redds are missed during each survey occasion.

(2) Redds do not become detectable again after they have been classified as obscured from view.

(3) All redd flags are seen, individually identifiable, and recorded properly.

(4) All flagged redds survive with the same probability, regardless of species (homogeneity of survival between redds), and in our pooled case all flagged redds survive with the same probability across all occasions (homogeneity of survival between occasions).

(5) Recruitment of new redds from occasion *i* to *i* +1 occurs at midpoint of the interval between survey occasions, starting with the second survey during which redds are observed.

(6) Redds are considered obscured in the interval between occasion *i* and *i* + 1 if the flag (and redd) are not observed after occasion *i*.

Estimation of Total Redd Abundance Within the Sample Frame

Total redd abundance within the Smith River adult coho spawning ground survey frame is estimated using a Simple Random Sample estimator for total (Adams et al. 2011):

$$\hat{T} = N\left(\frac{\sum_{j=1}^{n} \hat{\tau}_j}{n}\right)$$

where N is the number of reaches within the Smith River spawning ground survey sample frame, n is the number of reaches surveyed, and $\hat{\tau}_j$ the estimate of the total number of redds present in sample reach j. The standard error of $\hat{T}$ was calculated using within-reach and between-reach variance derived from bootstrap resampling, and applying the finite population correction factor as in Adams et al. (2011):

$$se(\hat{T}) = N\sqrt{\left(1-\frac{n}{N}\right)\hat{\theta}_b + \frac{1}{N_n}\left(\sum_{i=1}^{n}\hat{\theta}_w\right)}$$

where $\hat{\theta}_b$ is the between-reach variance of bootstrapped replicates, and $\hat{\theta}_w$ is the within-reach variance of bootstrap replicates. The bootstrap resampling process is described in detail in Ricker et al. (2014b). N is the total number of reaches in the Smith River spawning ground survey sample frame, n is the number of sample reaches.

Spatial Structure Statistical Methods

Occupancy Models

We applied multi-scaled occupancy models (Nichols et al. 2008) to estimate the probability of salmonid occupancy simultaneously at two spatial scales while accounting for detection probabilities. The larger scale corresponds to the probability of occupancy at the sample reach(ψ), whereas the smaller scale corresponds to the probability of occupancy at the sample pool (θ), given the species was present in the sample reach. Detection probability (p) is modeled at the smaller pool scale based on individual snorkel passes in every fourth sampling unit. The advantage to modeling occupancy at two spatial scales is both landscape and local spatial distributions of a given species can be calculated while accounting for individual survey detection probabilities in a single framework. The primary assumption of this approach is the target animal's occupancy status cannot change over the course of the study season (MacKenzie et al. 2006, Nichols et al. 2008). We fixed our sampling season to the summer period after river flows stabilized and the coho salmon smolt migration period was largely complete.

Model parameter definitions:

p_t^s = Pr (detection at occasion t at pool s given the reach is occupied and the species is present in the immediate pool).
ψ = Pr (sample reach occupied);
θ_t = Pr (species present at the immediate sample pool given the reach is occupied)

We used using the single-season multi-method approach in program PRESENCE (USGS 2015) to calculate estimates of occupancy (ψ), estimates of conditional occupancy (θ), and detection probability (p) of each species and age class category. We assumed p was constant in pools between the two snorkel passes. The proportion of area occupied was determined by simply multiplying the two occupancy parameters ($\psi * \theta$). We collected habitat covariates but their effect on occupancy and detection were not explored in this analysis since a more thorough meta-analysis including multiple basins is forthcoming.

Database and Data Storage

We collected spawning ground survey data using field computers (PDA's) operating the DFW Coastal Monitoring Program Aquatic Survey Program database (current version: 0.9.3.) (Burch et al. 2014). We collected the spatial structure data using paper entered into a Microsoft Access program due to the Aquatic Survey Program database lacking specific data elements at the time of surveys. We fixed data fields in all PDA forms within specific ranges to minimize data entry error. Standard QAQC queries were run each day after PDA's were downloaded to correct any data errors directly after surveys were completed. Databases were backed up once a week and uploaded to the regional central data server after the QAQC was complete.

2014-2015 Spawning Ground Survey Results and Discussion

Spawning Ground Survey Conditions and Effort

We completed 414 surveys in 30 main reaches and 11 sub-reaches during the 2014-2015 survey period which extended from November 3, 2014 through March 5, 2015 (Table 1). GRTS sampling represented 29% of the total frame with 20 reaches and 7 sub-reaches. One original GRTS drawn reach and its associated sub-reach were not surveyed due to private landowners denying access to portions of the reaches. An additional 10 reaches and 4 sub-reaches were surveyed to complete a census of the Mill Creek LCS (Table 1). The precipitation regime for the first half of the 2014-2015 spawning survey period was comprised of multiple, frequently occurring lower magnitude storms while that of the second half was characterized by fewer, widely spaced higher magnitude storms (Figure 2). Rainfall at the Gasquet Ranger Station totaled 80% of average during the survey period; however, rainfall from November through December totaled 95% of average and rainfall from January through March 5 totaled 67% of average (CDEC 2015).

Four major storm events elevated discharge and turbidity beyond our maximum survey threshold of 16,000 cubic feet per second at the USGS Jed Smith gaging station (Figure 2). On average, conditions were favorable for surveying reaches 82% (SD= 8%) of days within the spawning survey period. We surveyed 73 days out of a possible 114 available days resulting in an effort of 64%. On average, we surveyed each reach 10 times (range 2-15) with an overall reach return interval of 14 days (Table 1, Figure 2). Survey revisit intervals were consistent for most reaches from November through early December despite multiple storms that maintained daily average mainstem flows above 1000 cfs at the USGS Jed Smith gauge site in Hiouchi (Figure 1). Storm events, particularly in December, inhibited return visits to some reaches because either minimum visibility thresholds were not met – reaches 57, 104 and 303 for example – or conditions were unsafe for surveying – reaches 172 and 190.

GRTS Spawning Ground Surveys

Live Fish Observations

We made 2,379 observations of live anadromous salmonids within the GRTS surveyed portion of the Smith River during the winter of 2014-2015 (Table 2, Figure 3). These live salmonid totals do not represent unique individual observations because live individuals could be observed over multiple survey periods. Live anadromous fish observations in GRTS reaches included 1362 Chinook salmon, 94 coho salmon, 616 steelhead and 307 unidentified salmonids (Table 2, Figure 3). Live Chinook salmon dominated the first half of the survey season's observations (Table 3, Figure 3). Mean observation date for Chinook salmon was November 29 and ranged from November 3 to January 21. Early storms in October and a series of storms during November and December enabled Chinook salmon to access most GRTS reaches and they were detected in 18 of 20 main reaches surveyed, but not were not detected in any of the 7 GRTS sub-reaches (Table 2, Figure 5). Live coho salmon were observed from December 4 through February 11 with a mean observation date of January 16 (Table 3, Figure 5). Of the 94 live coho salmon observed in GRTS reaches, 88 were detected in Mill Creek and six were detected in Rowdy Creek (Table 2, Figure 5). Steelhead dominated live salmonid observations throughout the latter half of the survey season (Figure 3). Steelhead observations occurred from January 6 through the end of spawning surveys on March 5, with a mean observation date of February 9 (Table 3). Thus, we only captured a portion of the steelhead spawning season during our survey. Similar to Chinook salmon, steelhead were widely distributed across the geographic extent of the sampling frame and were observed in 18 of 20 main GRTS reaches and 1 of 7 GRTS sub-reaches (Table 2).

Carcass Observations

We recovered 239 anadromous salmonid carcasses in the GRTS survey reaches during the winter of 2014-2015. Chinook salmon carcasses were the most abundant, with 219 individual carcasses recovered (Table 2, Figure 7). Next most abundant were unidentified salmonid carcasses, 9 individuals, and coho salmon, 8 individuals. All coho salmon carcasses were recovered in Mill Creek between January 8 and February 19 (Table 2, Table 3). It is likely that two storms, one in late January and another in early February flushed or dispersed coho salmon carcasses and thus decreased our ability to detect them on subsequent surveys. No tagged coho salmon carcasses were recaptured in GRTS sampling reaches.

Hatchery Origin Salmonid Observations

Hatchery origin salmonids were observed below the confluence of the Middle Fork and South Fork of the Smith River during the winter of 2014-2015. (Table 4, Figure 8). The proportion of hatchery origin salmonids varied by species and watershed area (above the confluence of the Middle and South Forks, below the confluence of the Middle and South Forks excluding Rowdy Creek, and Rowdy Creek) (Table 4). Hatchery origin fish constituted 7.3% (range: 0% to 23.4%) of all live Chinook salmon observations where the presence or absence of an adipose fin could be determined, and 11.9% (range: 0% to 23%) of all Chinook salmon carcasses recovered. No Chinook salmon were identified as having a left ventral fin clip. The Rowdy Creek Fish Hatchery (RCH) used a left-ventral fin clip for the 2009 brood year and individuals with this clip have been detected in previous years. Hatchery origin steelhead constituted 20.3% (range: 0% to 70.6%) of all live observations where the presence or absence of an adipose fin could be determined (Table 4). It should be noted that detecting adipose fin clips on live steelhead was difficult, especially during higher flows and when turbidity was even moderately elevated. Our only steelhead carcasses were recovered in Rowdy Creek (N=3) and all had adipose fin clips. No hatchery origin live coho salmon or coho salmon carcasses were encountered during the winter of 2014-2015. Coho salmon are not produced by Rowdy Creek Fish Hatchery.

Redd Observations

We identified 717 anadromous salmonid redds within the GRTS surveyed portion of the Smith River during the winter of 2014-2015 (Table 5, Figure 9). Live fish were observed constructing and/or guarding

256 of the 717 redds. Of these occupied redds, 215 were identified as chinook salmon redds, 18 as coho salmon redds and 23 as steelhead redds. A total of 461 redds were not occupied and thus remained unidentified. The average total reach-level redd density within the GRTS surveyed reaches equaled 17.6 redds per kilometer, with the highest observed densities occurring in the Rowdy and Mill Creek watersheds and the upper Middle Fork Smith River mainstem (Table 5). Cumulatively, 36 percent of redds observed in the GRTS sampled reaches were identified to species, however, this proportion fluctuated across the season. During November and December – when chinook salmon were abundant and frequent storms occurred – roughly 50 percent of observed redds had fish occupying them. After January – when observations of coho salmon and steelhead in the river increased and precipitation was in the form of larger, well-spaced storms – the percentage of occupied redds ranged from 6 to 32 percent (Figure 9). All verified coho salmon redds were observed in the Mill Creek LCS above the confluence of the East Fork and West Branch (Table 5, Figure 5). In contrast, verified Chinook salmon and steelhead redds were distributed in the sub-basins across the survey area (Table 5, Figure 4, Figure 6). The first verified coho salmon redd was observed on December 4 and the last was observed on February 11 (Table 3). Overall, mean observation dates of known species redds were consistently within a few days of mean live fish dates for all three species.

Redd Prediction Performance

The kNN classifier performed well in the 2014-2015 survey season, correctly predicting 375 of 388 (96.6%) redds verified to species from GRTS and Mill Creek census reaches (Table 6). Unlike 2013-2014, known species redd abundance was more similar between Steelhead and coho salmon. The kNN classifier correctly predicted 99.1% of Chinook salmon redds followed by 85.4% of steelhead redds and 84.6% of coho salmon redds. One unknown redd outside of Mill Creek was predicted to be a coho salmon redd by the KNN classifier. This redd was located in Reach 59 on Rowdy Creek, one of only two reaches outside of Mill Creek where adult coho salmon were observed.

Total Redd Abundance

Total redd abundance estimates of Chinook salmon and steelhead for the Smith River GRTS sample frame in 2014-2015 were 1715 (1092 - 2337) and 914 (381 - 1446), respectively (Table 7). We did not detect a verified coho salmon redd outside of the Mill Creek LCS, however, we did predict one coho salmon redd in reach 59 of Rowdy Creek. Based on this single prediction coupled with the small number of coho salmon detected outside the Mill Creek LCS, we did not calculate a coho salmon population estimate for the GRTS sample frame. Similar to previous years, we only report the Mill Creek LCS coho salmon estimate.

The estimated number of Chinook salmon redds increased from the previous year (2013-2014) by 332%, but was similar to the 2012-2013 estimate (96%) and less than half of the 2011-2013 estimate (45%) (Figure 10). We also observed an increase in the estimated number of steelhead redds, however, with much less magnitude. The estimated number of steelhead redds equaled 257% of the 2013-2014 estimate, 132% of the 2012-2013 estimate and 87% of the 2011-2012 estimate (Figure 10).

Mill Creek Spawner Survey Census

Live Fish Observations

During the winter of 2014-2015 we had 1441 observations of live anadromous salmonids in Mill Creek LCS census reaches. These observations included 972 Chinook salmon, 210 coho salmon, 92 steelhead and 167 unknown species (Table 2). Chinook salmon were observed in most portions of the mainstem reaches of the East Fork and West Branch Mill Creek, but not in the upper extents of their tributaries (Figure 4). Relatively few observations of live coho salmon were made in the lower East Fork and West Branch of Mill Creek; however, coho salmon were present in the upper portions of many tributaries (Figure 5).

Carcass Observations

During the winter of 2014-2015 we observed 140 Chinook salmon, 13 coho salmon, zero steelhead and 13 unknown anadromous salmonid carcasses in the Mill Creek LCS (Table 2). Twenty-one Chinook salmon carcasses and one tagged coho salmon carcass were recaptured on subsequent surveys indicating poor recapture success.

Redd Observations and Abundance

Verified coho salmon redds were observed throughout most of the Mill Creek LCS (Figure 11). During the 2014-2015 spawning survey season we observed 165 Chinook salmon redds, 39 coho salmon redds, 7 steelhead redds, and 402 unknown species redds (Table 5). The known species redds plus the kNN predicted species redds (i.e. total number of observed redds) resulted in 117 coho salmon, 395 Chinook salmon, and 114 steelhead redds. We estimated total redd abundance in the Mill Creek LCS sub-basin for 2014-2015 as 149 coho salmon redds (139 - 159), 467 Chinook salmon redds (454 - 480), and 131 steelhead redds (124 - 137) (Table 8). The estimated number of coho salmon redds in Mill Creek in 2014-2015 represented 31% of the 2011-2012 estimate, and 66% of the 2012-2013 estimate and 57% of the 2013-2014 estimate (Figure 10).

Coastal Cutthroat Trout and Pacific Lamprey

During the winter of 2014-2015 we made incidental observations of coastal cutthroat trout (*Oncorhynchus clarki clarki*) and Pacific lamprey (*Lampetra tridentata*) while conducting our anadromous salmonid spawning surveys. We observed 20 coastal cutthroat trout redds in four reaches and three sub-reaches within the Mill Creek LCS (Table 5). One additional coastal cutthroat redd was observed in Peacock Creek. Coastal cutthroat trout redds were observed from December 10 to February 23, with a mean observation date of January 9. In comparison, during 2013-2014, 83 coastal cutthroat redds were observed in the Mill Creek LCM and their mean observation date was January 27 (Garwood et al. 2014). We also observed 11 Pacific Lamprey redds. The first Pacific lamprey redd was observed on February 18 and the last was observed on March 4, with a mean observation date of February 28. Our observations of these two species likely do not reflect their actual redd abundance or distribution patterns. Coastal cutthroat trout exhibit diverse life-histories in the Smith River which result in a prolonged spawning season (Moyle 2002). Additionally, numerous Pacific lamprey have been observed constructing redds as late as mid-May in main-stem Mill Creek (Jolyon Walkley, personal observation).

Table 1. Summary statistics of spawning ground reach survey effort and reach survey availability based on flow conditions for the winter of 2014-2015, Smith River basin, Del Norte County, CA. Surveys occurred from November 3, 2014 to March 5, 2015. Location codes with shaded cells were not GRTS drawn for the annual survey but indicate they were surveyed to complete the annual upper Mill Creek census. Reach lengths were extracted from the USGS National Hydrological Dataset, 24K routed hydrography.

Subbasin	Location Code[a]	Reach length (m)	# of surveys	Mean # of days between surveys	Std Dev.	Max	Proportion of season available to survey
Rowdy	57	3215	8	16	6	30	0.66
Rowdy	59	1227	12	11	4	20	0.70
Rowdy	62	2276	10	12	2	14	0.74
Rowdy	67	2492	9	14	5	23	0.77
Rowdy	72	579	9	14	6	28	0.74
Morrison	79	1407	11	11	4	20	0.85
Peacock	91	3296	8	14	2	17	0.89
Peacock	94	402	3	35	19	54	0.89
Mill	104	1416	14	10	5	22	0.72
WB Mill	106	2111	13	10	3	15	0.76
WB Mill	**107**	2675	12	11	2	14	0.83
WB Mill	108	2030	13	10	2	14	0.84
WB Mill	**109**	1802	13	10	2	14	0.85
WB Mill	**110**	2582	13	10	2	13	0.93
WB Mill	**111**	1314	2	65	0	65	0.93
EF Mill	**123**	2149	11	12	4	22	0.74
EF Mill	**124**	2298	12	11	3	14	0.76
EF Mill	**125**	1589	15	9	2	14	0.92
EF Mill	**126**	1444	11	11	2	15	0.93
EF Mill	**129**	436	5	18	10	35	0.93
First Gulch	**130**	2506	11	10	2	15	0.89
Kelly	132	2481	14	9	3	14	0.90
Kelly	133	593	13	8	3	14	0.91
Bummer	134	2996	12	11	2	14	0.77
Bummer	135	300	8	14	8	33	0.77
Low Divide	**136**	863	13	9	3	17	0.89
WB Mill	**138**	125	15	9	3	15	0.93
WB Mill	**140**	741	11	12	6	25	0.93
WB Mill	141	442	12	9	2	13	0.93
WB Mill	**143**	834	10	11	2	14	0.93
Craig's	172	3310	8	14	4	21	0.67
Rock	190	1447	8	14	5	23	0.70
Middle Fork	286	1823	9	13	4	22	0.78
Patrick	303	2250	8	14	7	27	0.71
Monkey	319	2674	8	15	6	28	0.80
Siskiyou	324	2511	8	14	4	19	0.76
Siskiyou	326	1187	8	15	3	20	0.77
Idlewild	333	542	7	15	5	26	0.79
Griffin	336	2601	10	12	4	23	0.81
Griffin	337	2336	10	12	2	17	0.81
Griffin	339	357	7	14	9	34	0.81
	Total	-	414	14	-	-	0.82[b]

[a]*Bold indicates Mill Creek Census reach,* [b]*Mean value.*

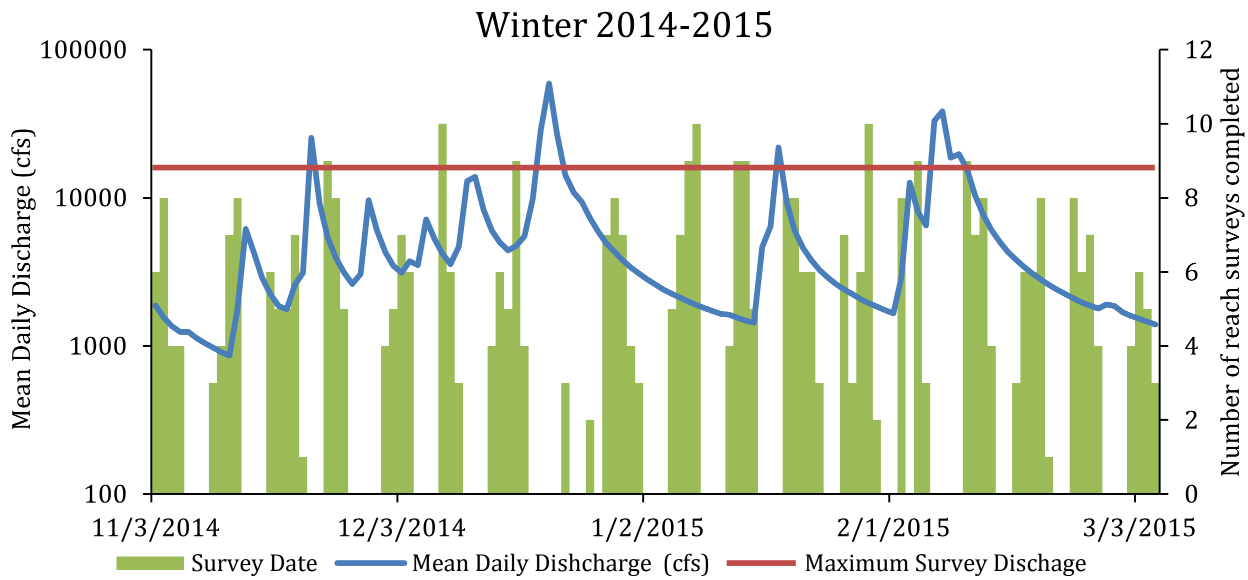

Figure 2. Spawning ground survey effort and timing during the 2014-2015 survey year in the Smith River basin (Del Norte County, CA) as it relates to mean daily river discharge. The dashed red line represents the maximum discharge (16,000 cubic feet per second) where spawner surveys could be safely completed in smaller streams without being impaired by decreased water clarity.

Table 2. Summary of live adult and salmonid carcasses observed by species and reach from November 3, 2014 to March 5, 2015, Smith River basin, Del Norte County, CA. Live salmonid totals do not represent individual fish observations since live individuals could be observed over multiple survey periods. All observed salmonid carcasses were uniquely tagged with numbered jaw tags so totals represent the number of tagged carcasses. Location codes with shaded cells were not GRTS drawn for the annual survey but indicate they were surveyed to complete the annual upper Mill Creek census.

		Live salmonids				Salmonid carcasses			
Subbasin	Location Code[a]	Chinook Salmon	Coho Salmon	Steelhead	Unknown species	Chinook Salmon	Coho Salmon	Steelhead	Unknown species
Rowdy	57	94	-	196	101	23	-	-	-
Rowdy	59	163	5	270	81	41	-	3	5
Rowdy	62	185	-	46	13	7	-	-	-
Rowdy	67	182	1	29	26	33	-	-	-
Rowdy	72	-	-	4	1	-	-	-	-
Morrison	79	12	-	-	-	3	-	-	-
Peacock	91	3	-	8	1	-	-		-
Peacock	94	-	-	-	-	-	-	-	-
Mill	104	45	-	3	16	25	2		1
WB Mill	106	142	2	4	15	30	1	-	1
WB Mill	**107**	244	26	26	28	37	1	-	7
WB Mill	108	124	37	6	22	14	2	-	2
WB Mill	**109**	60	6	14	14	10	-	-	1
WB Mill	**110**	35	10	9	2	2	1	-	-
WB Mill	**111**	-	-	-	-	-	-	-	-
EF Mill	**123**	25	2	2	10	12	2	-	1
EF Mill	**124**	111	19	15	31	11	-	-	-
EF Mill	**125**	105	26	7	11	12	1	-	-
EF Mill	**126**	15	1	2	6	3	-	-	-
EF Mill	**129**	-	-	-	-	-	-	-	-
First Gulch	**130**	4	21	4	14	-	2	-	1
Kelly	132	22	25	1	5	3	1	-	-
Kelly	133	-	3	-	-	-	-	-	-
Bummer	134	78	8	2	4	4	2	-	-
Bummer	135	-	8	-	-	-	-	-	-
Low Divide	**136**	2	-	-	-	-	-	-	-
WB Mill	**138**	-	-	-	-	-	-	-	-
WB Mill	**140**	4	6	-	2	-	-	-	-
WB Mill	141	-	4	-	1	-	-	-	-
WB Mill	**143**	1	6	-	2	2	-	-	-
Craig's	172	63	-	11	8	8	-	-	-
Rock	190	39	-	4	1	2	-	-	-
Middle	286	88	-	-	2	6	-	-	-
Patrick	303	15	-	1	-	8	-	-	-
Monkey	319	10	-	4	-	-	-	-	-
Siskiyou	324	50	-	2	5	7	-	-	-
Siskiyou	326	14	-	1	2	2	-	-	-
Idlewild	333	-	-	-	-	-	-	-	-
Griffin	336	33	-	11	3	3	-	-	-
	Total	1968	216	695	427	308	15	3	19

[a]*Bold indicates Mill Creek Census reach*

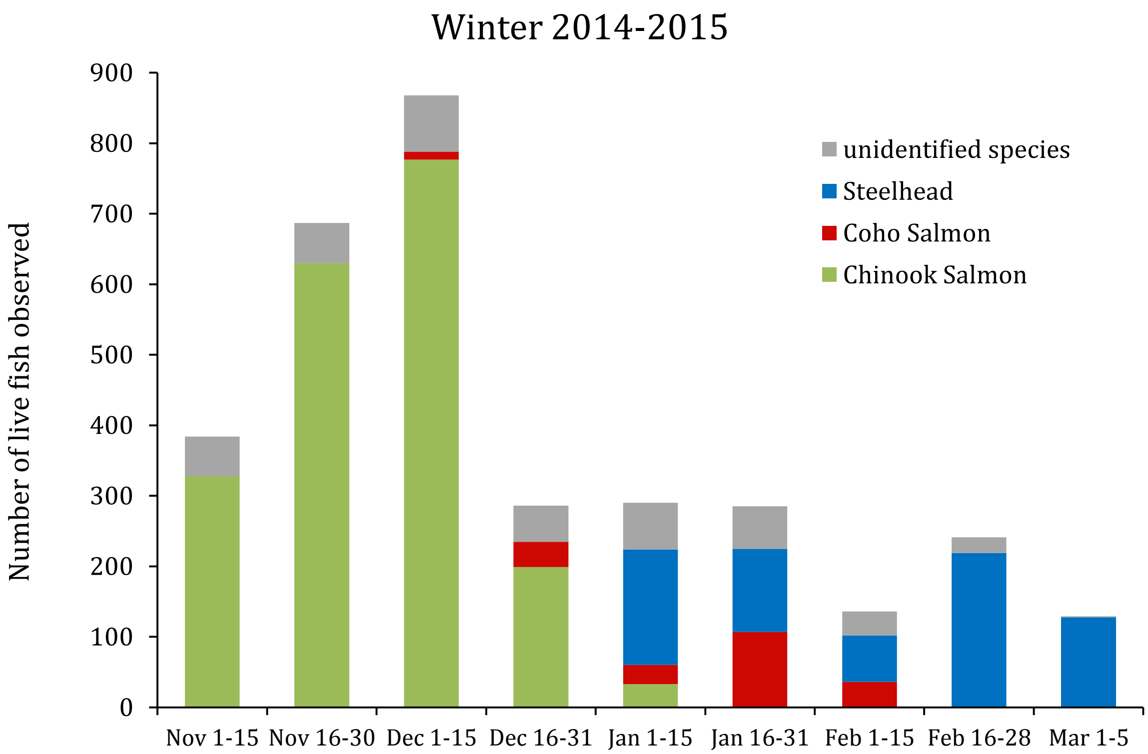

Figure 3. Number of identified live salmonids, by species and survey period, observed during spawner surveys occurring from November 3, 2014 to March 5, 2015 in the Smith River basin, Del Norte County, CA.

Table 3. Descriptive statistics for observation date of live fish, observation date of known species redds, observation date of carcasses, and carcass fork lengths for the 2014-2015 spawning ground survey season in the Smith River basin, Del Norte County, CA. Totals include data from GRTS drawn reaches and the Mill Creek Lifecycle Monitoring Station census.

		Chinook Salmon	Coho Salmon	Steelhead
Live fish observations:	N	1914[a]	217	696
	Mean	29-Nov-14	16-Jan-15	9-Feb-15
	SD	14.24	16.35	19.28
	Min	3-Nov-2014	4-Dec-2014	06-Jan-2015
	Max	21-Jan-15	11-Feb-15	5-Mar-15
Live fish sex ratio:	F / M	1 / 1.25	1 / 1.57	1 / 1.55
Known species redd:	N	321	39	28
	Mean	29-Nov-2014	20-Jan-2015	7-Feb-2015
	SD	14.5	18.1	17.4
	Min	3-Nov-2014	4-Dec-2014	8-Jan-2015
	Max	5-Jan-2015	11-Feb-2015	5-Mar-2015
Carcass observations:	N	308	15	3
	Mean	21-Dec-14	30-Jan-15	22-Feb-15
	SD	16.4	11.2	4.2
	Min	5-Nov-2015	8-Jan-2015	16-Feb-2015
	Max	28-Jan-2015	19-Feb-2015	25-Feb-2015
Carcass sex ratio:	F / M	1 / 0.97	1 / 0.50	-
Carcass fork length (cm)	N	243	13	3
	Mean	84	68	79
	SD	13.2	9.1	2.2
	Min	51	45	77
	Max	120	82	82

[a] *Live salmonid totals do not represent individual fish observations since live individuals could be observed over multiple survey periods.*

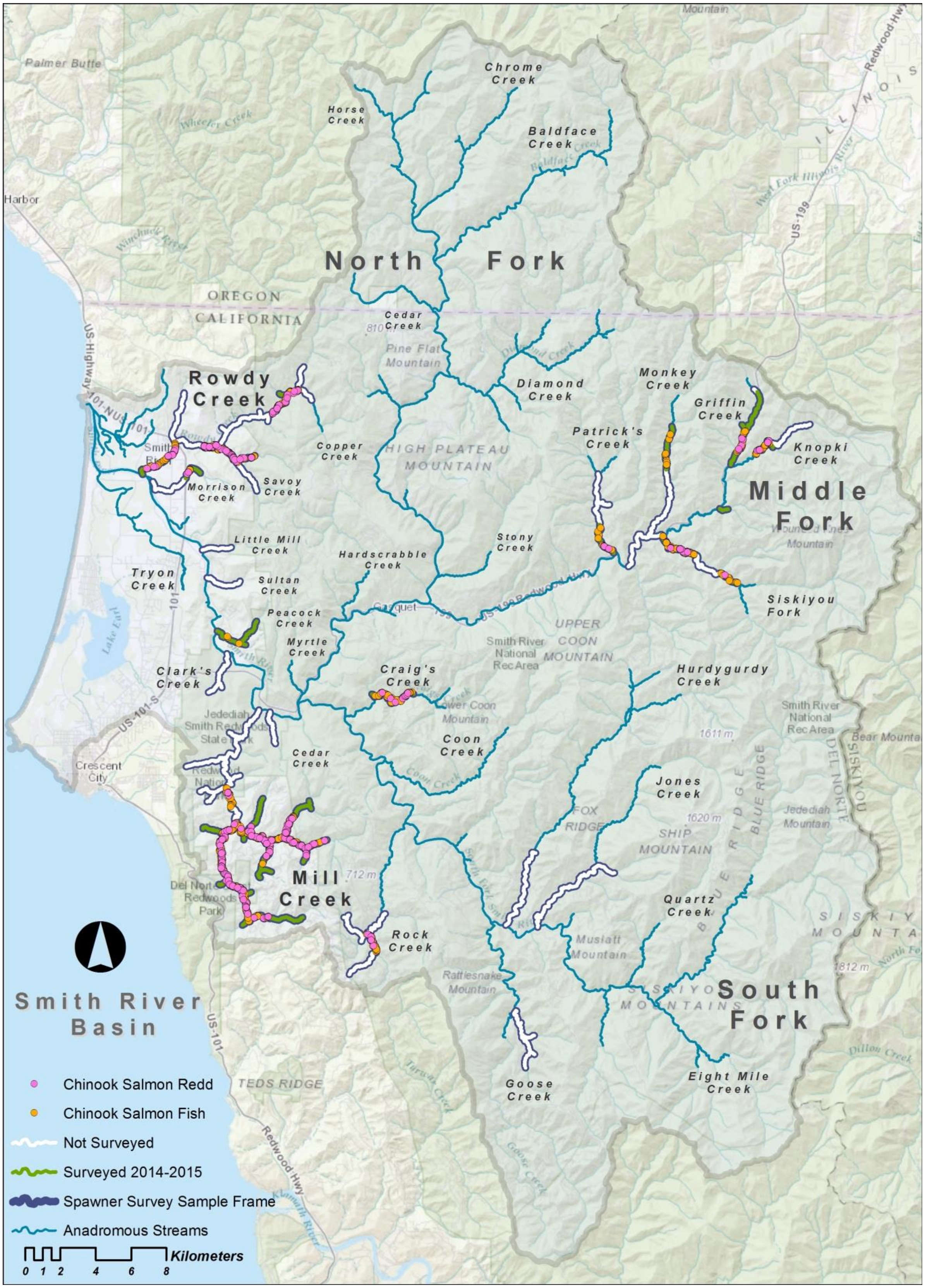

Figure 4. Map showing annual survey reaches, distribution of observed adult Chinook salmon, and verified Chinook salmon redds, Smith River Basin, Del Norte County, CA. Note: redd location symbols are displayed above fish observation symbols and may obscure fish observations in reaches with numerous verified Chinook salmon redds.

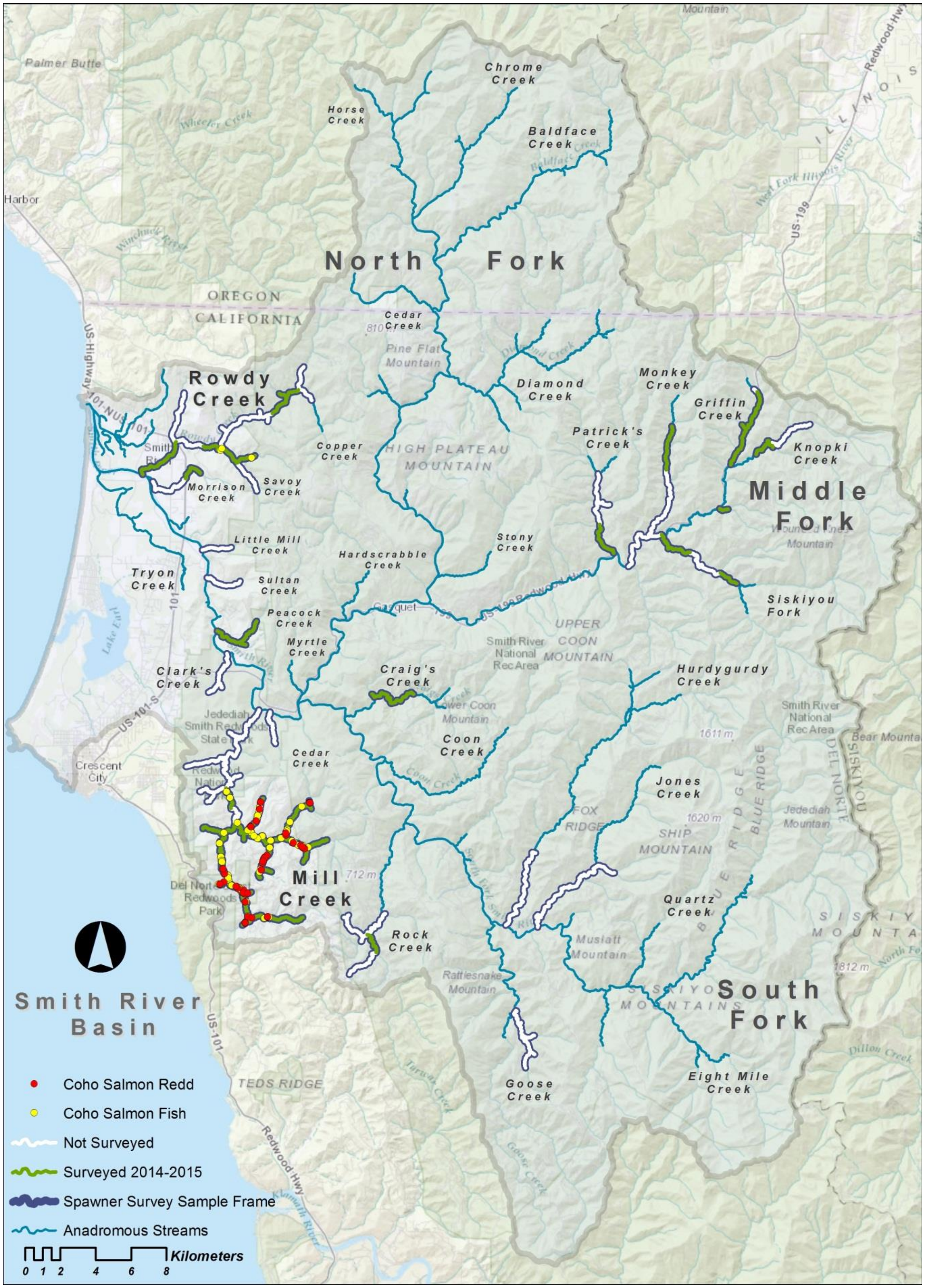

Figure 5. Map showing annual survey reaches, distribution of observed adult coho salmon, and verified coho salmon redds, Smith River Basin, Del Norte County, CA. Note: redd location symbols are displayed above fish observation symbols and may obscure fish observations in reaches containing high densities of verified coho salmon redds.

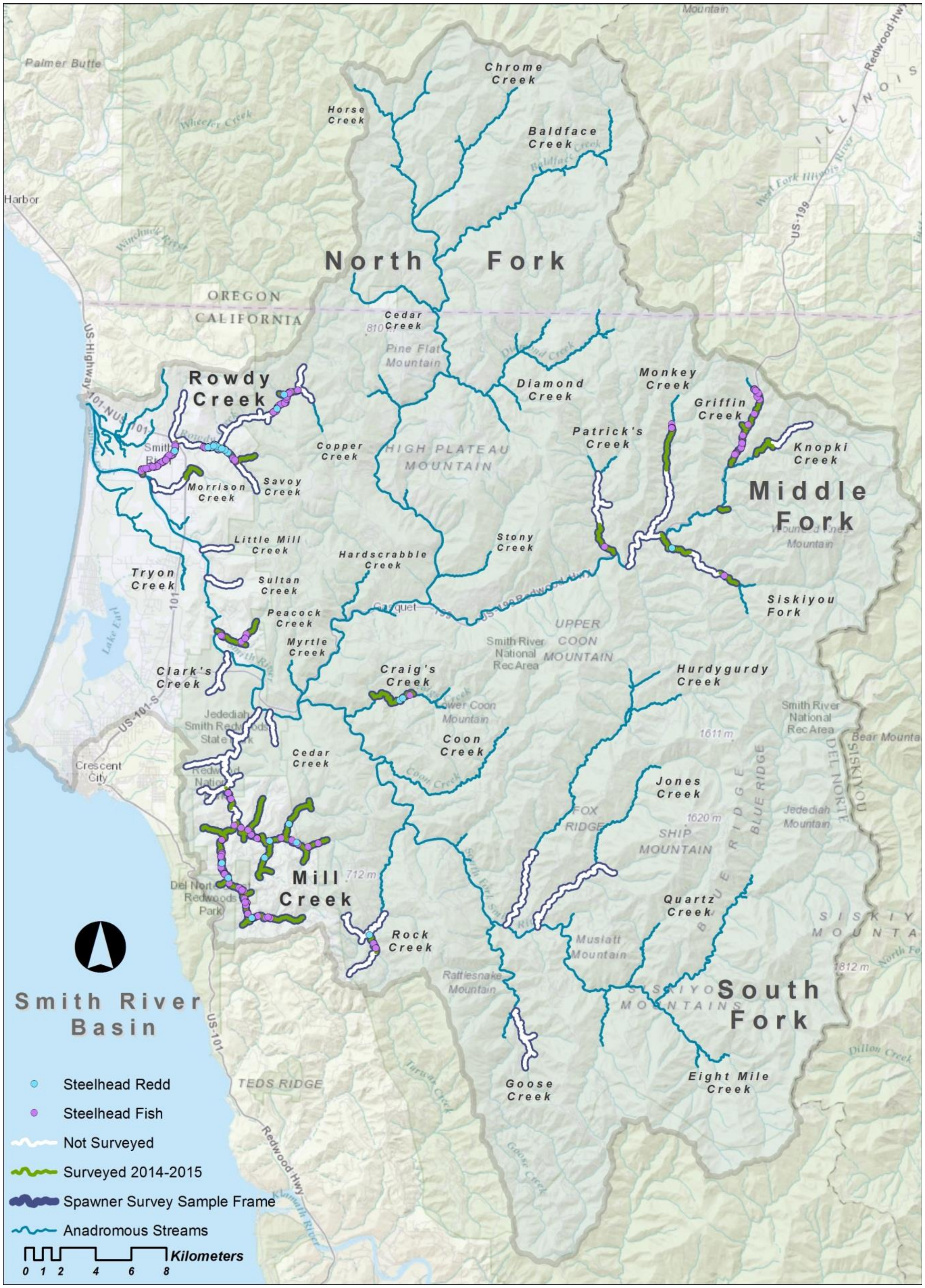

Figure 6. Map showing annual survey reaches, distribution of observed adult steelhead, and verified steelhead redds, Smith River Basin, Del Norte County, CA. Note: redd location symbols are displayed above fish observation symbols and may obscure fish observations in reaches containing high densities of verified steelhead redds.

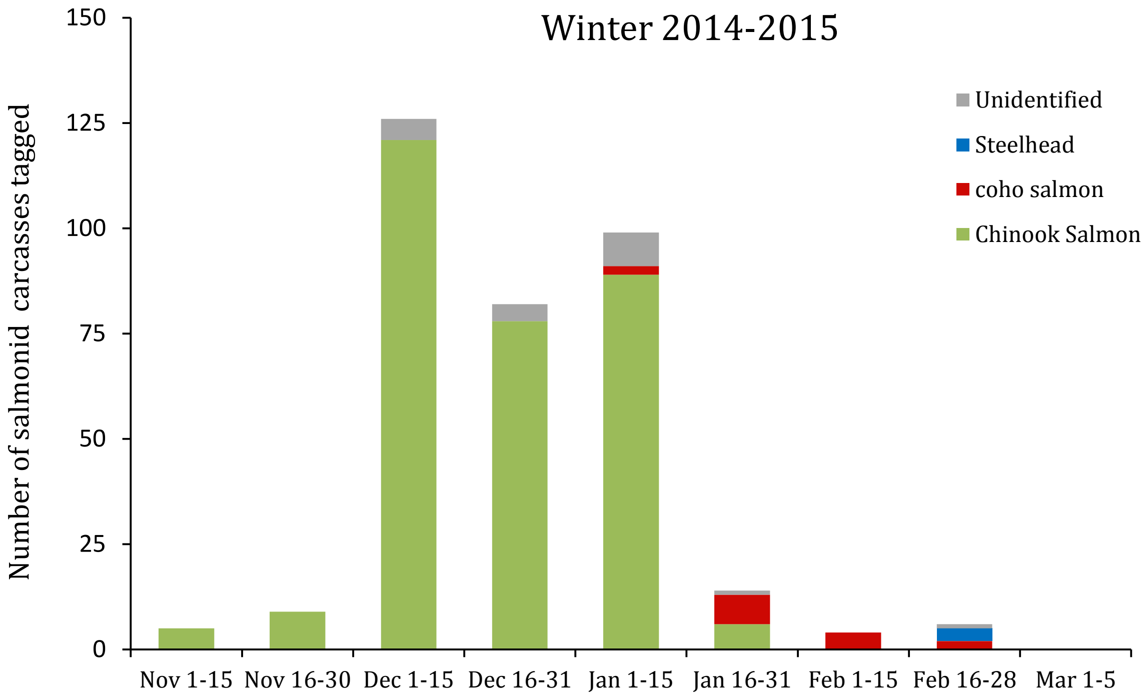

Figure 7. Number of uniquely tagged salmonid carcasses identified by species and survey period during the 2014-2015 spawner survey season, Smith River basin, Del Norte County, CA.

Table 4. Proportion of observed hatchery-origin salmonids summarized by species, observation type, and major sub-basin, during the winter 2014-2015 spawning ground surveys conducted throughout the Smith River basin, Del Norte County, CA. Sub-basins include Rowdy Creek (all reaches sampled in the sub-basin with fish hatchery), Below forks (all reaches sampled in tributaries [excluding Rowdy Creek] below the confluence of the Middle and South forks of the Smith River), and Above forks (all sampled reaches occurring above the confluence of the Middle and South forks of the Smith River). Mill Census (all reaches sampled in the Mill Creek LCS and a component within the Below Forks sub-basin) is also given for comparison, Note that live fish and carcass observation totals represent occasions only where an inspection of the individual fish allowed the observer to identify if a fin (adipose or left ventral) or maxillary bone (left or right) were present or absent. Many occasions did not allow for us to inspect the animal for marks based on visual obstructions, distance, water clarity, partial carcass scavenging or carcass decay. Data are from GRTS drawn reaches and the Mill Creek Life Cycle Monitoring Station census reaches.

Live fish observations 2014-2015									
	Coho Salmon			Chinook Salmon			Steelhead		
Sub-basin	No Clip	Clip	% Hatchery	No Clip	Clip	% Hatchery	No Clip	Clip	% Hatchery
Rowdy Cr	0	0	-	98	30	23.4	5	12	70.6
Below Forks	17	0	0	351	16	4.4	25	0	0
Above Forks	0	0	-	135	0	0	17	0	0
Total	**17**	**0**	**0**	**584**	**46**	**7.3**	**47**	**12**	**20.3**
Mill Census	17	0	0	334	15	4.3	22	0	0
Carcass observations 2014-2015									
	Coho Salmon			Chinook Salmon			Steelhead		
Sub-basin	No Clip	Clip	% Hatchery	No Clip	Clip	% Hatchery	No Clip	Clip	% Hatchery
Rowdy Cr	0	0	-	27	54	23.0	0	3	100
Below Forks	11	0	0	111	3	2.6	0	0	-
Above Forks	0	0	-	28	0	0	0	0	-
Total	**11**	**0**	**0**	**193**	**26**	**11.9**	**0**	**3**	**100**
Mill Census	11	0	0	110	3	2.7	0	0	-

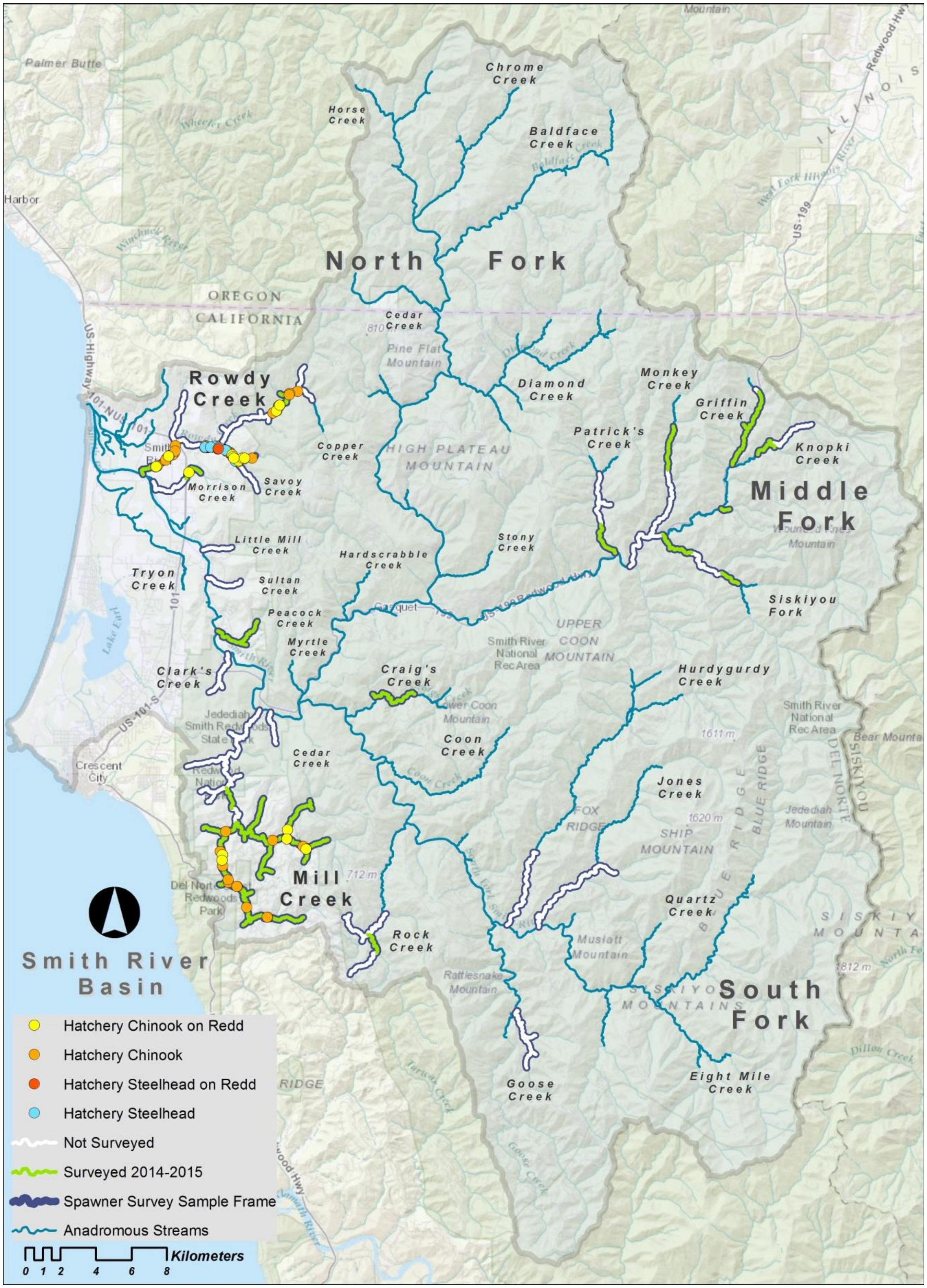

Figure 8. Map showing annual survey reaches and the distribution of observed adipose fin clipped adult hatchery Steelhead, hatchery Steelhead constructing redds, adipose fin clipped adult Chinook salmon and hatchery Chinook salmon constructing redds observed in the Smith River Basin, Del Norte County, CA.

Table 5. Summary of total observed redds separated by reach and species for the winter of 2014-2015, Smith River basin, Del Norte County, CA. Surveys occurred from November 3, 2014 to March 5, 2015. Location codes with shaded cells were not GRTS drawn for the annual survey but indicate they were surveyed to complete the annual upper Mill Creek Life Cycle Monitoring Station census. The number of observed redds per kilometer was calculated by dividing the total number of unique observed redds by the reach length obtained from the USGS National Hydrological Dataset, 24K routed hydrography.

Subbasin	Location Code[a]	Number of observed redds by species						# of redds per KM[b]
		Chinook Salmon	Coho Salmon	Steelhead	Unknown Species	Coastal Cutthroat Trout	Pacific Lamprey	
Rowdy	57	14	-	2	46	-	-	19.3
Rowdy	59	31	-	10	80	-	-	98.6
Rowdy	62	19	-	1	28	-	-	21.1
Rowdy	67	34	-	2	56	-	-	36.9
Rowdy	72	-	-	1	5	-	-	10.4
Morrison	79	2	-	-	6	-	-	5.7
Peacock	91	-	-	-	7	1	-	2.1
Peacock	94	-	-	-	-	-	-	-
Mill	104	5	-	-	8	-	-	9.2
WB Mill	106	17	-	-	56	-	1	34.6
WB Mill	**107**	35	2	2	79	-	-	44.1
WB Mill	108	16	4	-	41	-	2	30.0
WB Mill	**109**	9	2	-	28	-	4	21.6
WB Mill	**110**	7	3	1	17	-	1	10.8
WB Mill	**111**	-	-	-	-	-	-	0.0
EF Mill	**123**	4	-	-	21	-	1	11.6
EF Mill	**124**	14	-	1	39	-	1	23.5
EF Mill	**125**	24	5	1	38	-	-	42.8
EF Mill	**126**	8	-	-	21	2	-	20.1
EF Mill	**129**		-	-	-	-	-	-
First Gulch	**130**	1	5	-	12	6	-	7.2
Kelly	132	6	8	1	10	6	-	10.1
Kelly	133	-	1	-	1	2	-	3.4
Bummer Lake	134	20	2	1	25	1	1	16.0
Bummer Lake	135	-	1	-	-	2	-	3.3
Low Divide	**136**	2	-	-	2	-	-	4.6
WB Mill	**138**	-	-	-	1	-	-	8.0
WB Mill	**140**	1	2	-	5	-	-	10.8
WB Mill	141	-	2	-	4	1	-	13.6
WB Mill	**143**	1	2	-	2	-	-	6.0
Craig's	172	11	-	3	14	-	-	8.5
Rock	190	6	-	1	16	-	-	15.9
Middle Fork	286	14	-	-	19	-	-	18.1
Patrick	303	2	-	-	4	-	-	2.7
Monkey	319	-	-	-	7	-	-	2.6
Siskiyou	324	11	-	1	10	-	-	8.8
Siskiyou	326	1	-	-	7	-	-	6.7
Idlewild	333	-	-	-	2	-	-	3.7
Griffin	336	6	-	-	6	-	-	4.6
Griffin	337	-	-	-	3	-	-	1.3
Griffin	339	-	-	-	-	-	-	0.0
Total		321	39	28	726	21	11	15.3[c]

[a]Bold indicates Mill Creek Census reach, [b]Excludes Coastal Cutthroat Trout redds, [c]Mean value.

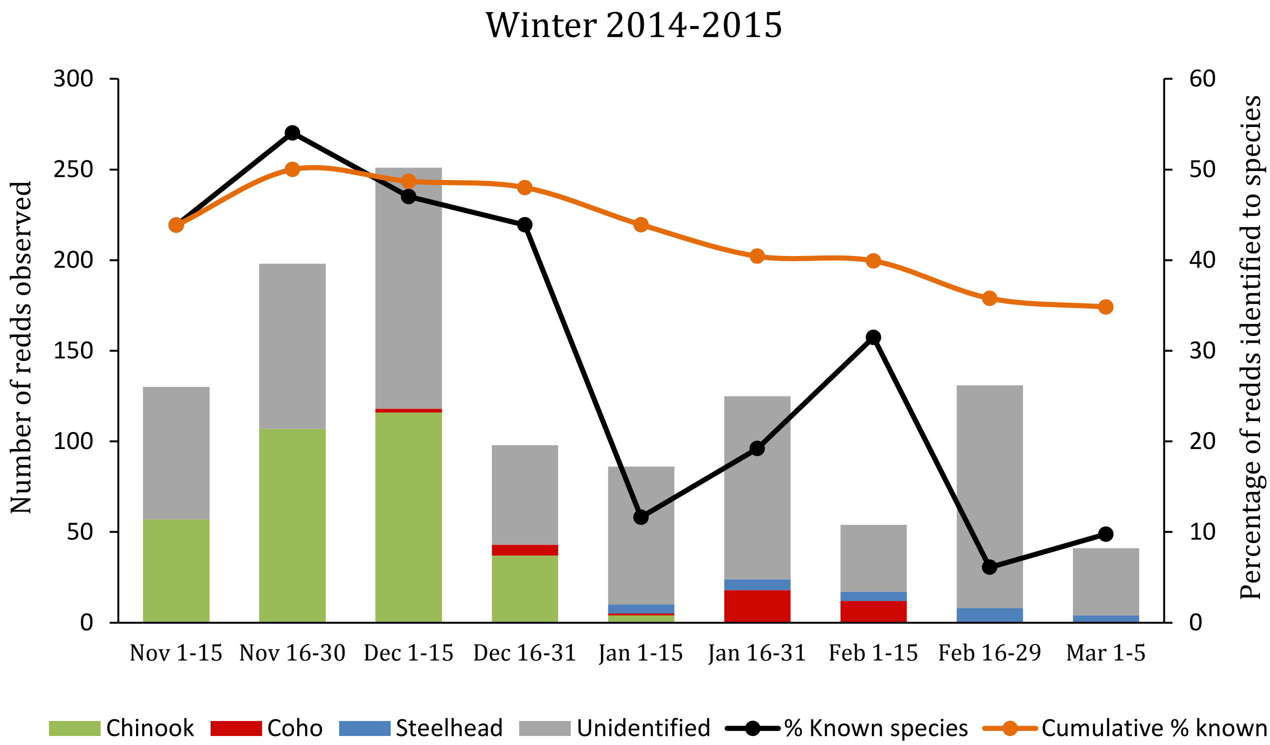

Figure 9. Number of individual salmonid redds observed by survey period during the 2014-2015 spawner survey season in the Smith River basin, Del Norte County, CA. Line plots represent percentages of redds identified to species by survey period through direct observations of live fish actively building or guarding individual redds.

Table 6. Confusion matrix, statistics, and number of redds by species for the 2014-2015 spawning ground survey seasons in the Smith River basin, Del Norte County, CA. Redds were predicted with the kNN algorithm using known species redds and live fish locations as a training dataset. Model performance was assessed using a leave one out cross validation. Data are from GRTS drawn reaches and the additional Mill Creek Life Cycle Monitoring Station census reaches. The number of correctly predicted redds, by species, are identified in bold text. Sensitivity indicates 1- the probability of type II error. Specificity indicates 1- probability of a type 1 error.

Winter 2014-2015		Reference		
		Coho Salmon	Chinook Salmon	Steelhead
Prediction	Coho Salmon	**33**	3	2
	Chinook Salmon	3	**318**	2
	Steelhead	3	0	**24**
	Sensitivity	0.846	0.991	0.857
	Specificity	0.986	0.925	0.992
	Accuracy (95% CI)		0.97 (0.94 - 0.98)	
Number of Redds	Known Species	39	321	28
	kNN Predicted	79	370	277
	Total	118	691	305

Table 7. Estimated total number of redds by species in the Smith River GRTS spawner survey sample frame for the winter of 2014-2015. Components of estimated variance are broken down to the estimation of the number of redds within the reach and estimation of redds by expanding the sample reaches to the entire frame (sample error).

	GRTS reaches		
	Coho Salmon[a]	Chinook Salmon	Steelhead
Redd estimate	NA	1715	914
SE	NA	298.4	255.2
Total within reach variance	NA	140.4	57.5
Total between reach variance	NA	703.2	426.7
% Within reach variance	NA	16.6	11.9
% Between reach variance	NA	83.4	88.1
95% CI	NA	(1092, 2337)	(381, 1446)

[a]*No known or predicted coho salmon redds were observed outside of the Mill Creek life cycle monitoring station.*

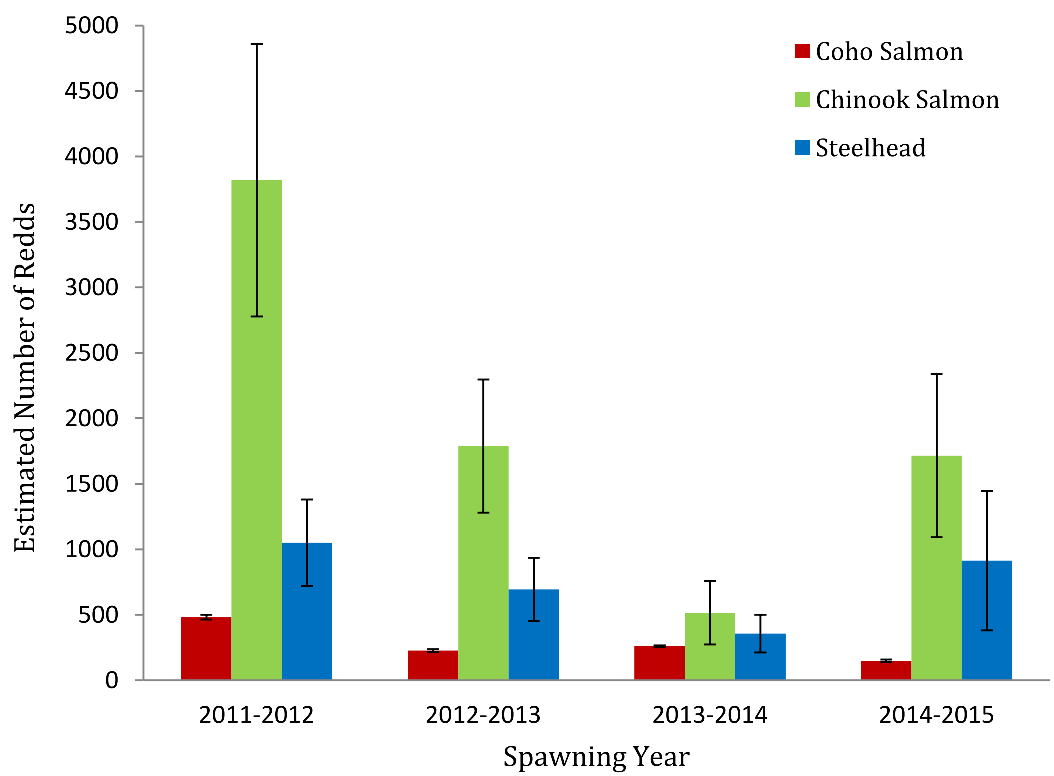

Figure 10. Estimated total number of redds produced in the Smith River GRTS spawner survey sample frame by species and spawning year, Smith River basin, Del Norte County, CA. Error bars represent 95% confidence intervals around point estimates. Coho salmon redd estimates are restricted to the Mill Creek spawner census area and thus have no between-reach variance as indicated by small 95% confidence intervals around estimates. Steelhead estimates do not represent the entire steelhead spawning season since surveys ended in March of each year.

Table 8. Estimated total number of redds by species within the Mill Creek Life Cycle Monitoring Station for the winter of 2014-2013. Components of estimated variance are broken down into the estimation of the number of redds within the reach. There is no between-reach variation since all reaches were surveyed.

	Mill LCS		
	Coho Salmon	Chinook Salmon	Steelhead
Redd estimate	149	467	131
SE	4.6	6.1	3.1
Total within reach variance	21.0	37.4	9.6
95% CI	(139,159)	(454,480)	(124,137)

2015 Spatial Structure Survey Results and Discussion

Sampling Effort and Coho Salmon Occupancy

We surveyed a total of 53 reaches and 15 sub-reaches during the summer of 2015 representing 41.9 percent of the total sampling frame in stream kilometers (Table 9). One pool in an additional remote South Fork Smith River reach (Reach 167) was surveyed to determine whether Coho Salmon were present in the reach (Table 9). Surveys extended from June 17th to August 11th with 34 work days and 160 person days. Each survey reach required an average of 1.1 crew days to complete. Juvenile coho salmon were detected in four portions of the basin including the lower main stem Smith River and proximal tributaries, Rowdy Creek, Mill Creek, and the upper South Fork Smith River (Table 9, Figure 11). No Coho Salmon were detected in the North Fork Smith River. Unfortunately major lightning-induced forest fires in the North Fork Smith River, Middle Fork Smith River and the South Fork Smith River prevented us from sampling 5 GRTS reaches (Figure 11). We documented coho salmon occurring in 21 out of 69 surveyed reaches and within 220 of 1,324 sampled pools. The median number of coho salmon observed per pool equaled 10; range: 1 to 246 (Table 9). We determined 10 out of the 21 reaches (48%) with coho salmon were non-natal rearing areas (Table 9). However, only 10% of the total fish counted were observed in non-natal reaches. Individual surveyors performed well at detecting juvenile coho salmon in pools. The overall detection probability (p) equaled 0.87 (SE= 0.03). Estimated large-scale probability of occupancy (ψ) equaled 0.31 (SE= 0.06), (Table 10). The estimate of conditional pool-level occupancy, given present in a reach($\theta|\psi$), equaled 0.68 (SE 0.03) (Table 10). We estimated the overall proportion of area occupied ($\theta * \psi$) as 0.21. We detected coho salmon juveniles in Jones Creek, tributary to the South Fork Smith River, for the first time under this monitoring program (Table 9, Figure 11). Last, we incidentally detected juvenile coho salmon in four additional reaches (Location codes: 11, 57,109 and 125) that were not part of the GRTS sample draw but were briefly inspected during field reconnaissance (Figure 11).

Occupancy of Other Salmonid Species

Reach-level occupancy (ψ) estimates and pool densities for individual salmonid species other than coho salmon (i.e. Chinook salmon, age 0 and 1+ juvenile trout spp., adult coastal cutthroat trout) are reported in Table 10. All groups were widely distributed throughout the basin during the summer of 2015 (Table 11, Figures 12 [Chinook salmon], 13 [trout spp.], and 14 [adult coastal cutthroat trout]) with ψ ranging from 0.75 (Chinook salmon) to 1.00 (YOY trout spp.) (Table 10). The estimate of conditional pool-level occupancy (θ), given present in a reach($\theta|\psi$), was similar to previous years for most groups except Chinook salmon from the summer of 2014 (Table 10). Juvenile Chinook salmon had an estimated proportion of area occupied (PAO) of 0.35 in 2015, equaling 233% of their 2014 PAO. The 2014 Chinook distribution was likely truncated due to extended drought conditions that prevailed during the 2013-2014 adult spawning migration (Garwood et al. 2014).

Table 9. Summary statistics of coho salmon occupancy and relative abundance based on snorkel surveys occurring in 69 GRTS drawn reaches during the summer of 2015, Smith River Basin, California and Oregon.

Subbasin	Location code	Reach length (m)	Number of units surveyed	Number of units occupied	Mean pool count	Total number observed	Rearing Type
Lower Smith River	5	2044	8	0	-	0	Non-natal
Lower Smith River	6	798	4	4	1.5	6	Non-natal
Lower Smith River	8	1419	9	3	2.7	8	Non-natal
Lower Smith River	10	2520	13	5	8.8	44	Non-natal
North Fork Smith River	34	2845	36	0	-	0	-
Rowdy Creek	58	1860	14	0	-	0	-
Rowdy Creek	59	1228	17	0	-	0	-
Rowdy Creek	61	2320	15	0	-	0	-
Rowdy Creek	62	2278	18	0	-	0	-
South Fork Rowdy Creek	67	2492	45	0	-	0	-
Rowdy Creek Trib.	70	355	3	0	-	0	-
Rowdy Creek Trib.	72	579	9	0	-	0	-
Copper Creek	73	1098	18	0	-	0	-
Little Mill Creek	86	1737	21	0	-	0	-
Peacock Creek	91	3296	58	0	-	0	-
Peacock Creek Trib.	94	402	2	0	-	0	-
Clarks Creek	96	2277	32	0	NA	1	Non-natal
Clarks Creek Trib.	97	367	11	0	-	0	-
Clarks Creek Trib.	98	968	26	0	-	0	-
Mill Creek	100	1805	10	2	1.5	3	Non-natal
Mill Creek	101	1944	14	6	4.0	24	Non-natal
Mill Creek	102	2329	14	9	7.6	68	Non-natal
Mill Creek	104	1416	7	7	44.9	314	Non-natal
Mill Creek	105	1412	6	6	11.8	71	Non-natal
West Branch Mill Creek	106	2111	21	19	29.2	555	Natal
West Branch Mill Creek	108	2031	26	24	38.6	927	Natal
West Branch Mill Creek	110	2382	38	28	31.8	889	Natal
Mill Creek Trib.	114	603	5	1	NA	1	Natal
East Fork Mill Creek	124	2298	22	22	60.2	1325	Natal
East Fork Mill Creek	126	1452	26	15	8.3	124	Natal
Bummer Lake Creek	134	2997	39	34	9.4	321	Natal
Bummer Lake Creek Trib.	135	300	4	3	8.7	26	Natal
Hamilton Creek	138	1427	37	0	-	0	-
West Branch Mill Creek Trib.	141	442	11	4	11.5	46	Natal
Cedar Creek	146	2351	41	0	-	0	-
South Fork Smith River	159	2461	11	0	-	0	-
South Fork Smith River	166	3582	38	23	2.9	66	Unknown
South Fork Smith River	167	2445	1	1	NA	1	Unknown
Craigs Creek	171	2473	37	0	-	0	-
Craigs Creek Trib.	175	230	6	0	-	0	-
Rock Creek	188	2714	38	0	-	0	-
Rock Creek	189	2075	29	0	-	0	-
Rock Creek Trib.	192	151	5	0	-	0	-
Rock Creek Trib.	193	2280	28	0	-	0	-
Rock Creek Trib.	194	296	2	0	-	0	-
Goose Creek	204	2809	16	0	-	0	-
Goose Creek	205	1704	11	0	-	0	-
Goose Creek Trib.	211	92	1	0	-	0	-
Hurdygurdy Creek	218	2696	16	0	-	0	-
Hurdygurdy Creek	220	3155	26	0	-	0	-
Hurdygurdy Creek	223	2984	37	0	-	0	-
HurdyGurdy Creek Trib.	232	1046	20	0	-	0	-
Jones Creek	234	2445	16	4	2.5	10	Natal
Jones Creek	236	2232	8	0	-	0	-
Quartz Creek	251	1944	14	0	-	0	-
Middle Fork Smith River	276	3987	10	0	-	0	-
Middle Fork Smith River	284	1291	8	0	-	0	-
Middle Fork Smith River	285	1944	17	0	-	0	-
Middle Fork Smith River	286	1823	15	0	-	0	-
Patrick Creek	305	1666	15	0	-	0	-
Monkey Creek	317	2229	18	0	-	0	-
Monkey Creek	318	2513	31	0	-	0	-
Siskiyou Fork	324	2511	16	0	-	0	-
Siskiyou Fork	325	2937	17	0	-	0	-
Siskiyou Fork	327	1102	11	0	-	0	-
Idlewild Creek	333	542	13	0	-	0	-
Cedar Creek	382	2548	39	0	-	0	-
Cedar Creek	383	2397	38	0	-	0	-
Horse Creek	420	1956	37	0	-	0	-
Totals			1325	220	22.0	4830	

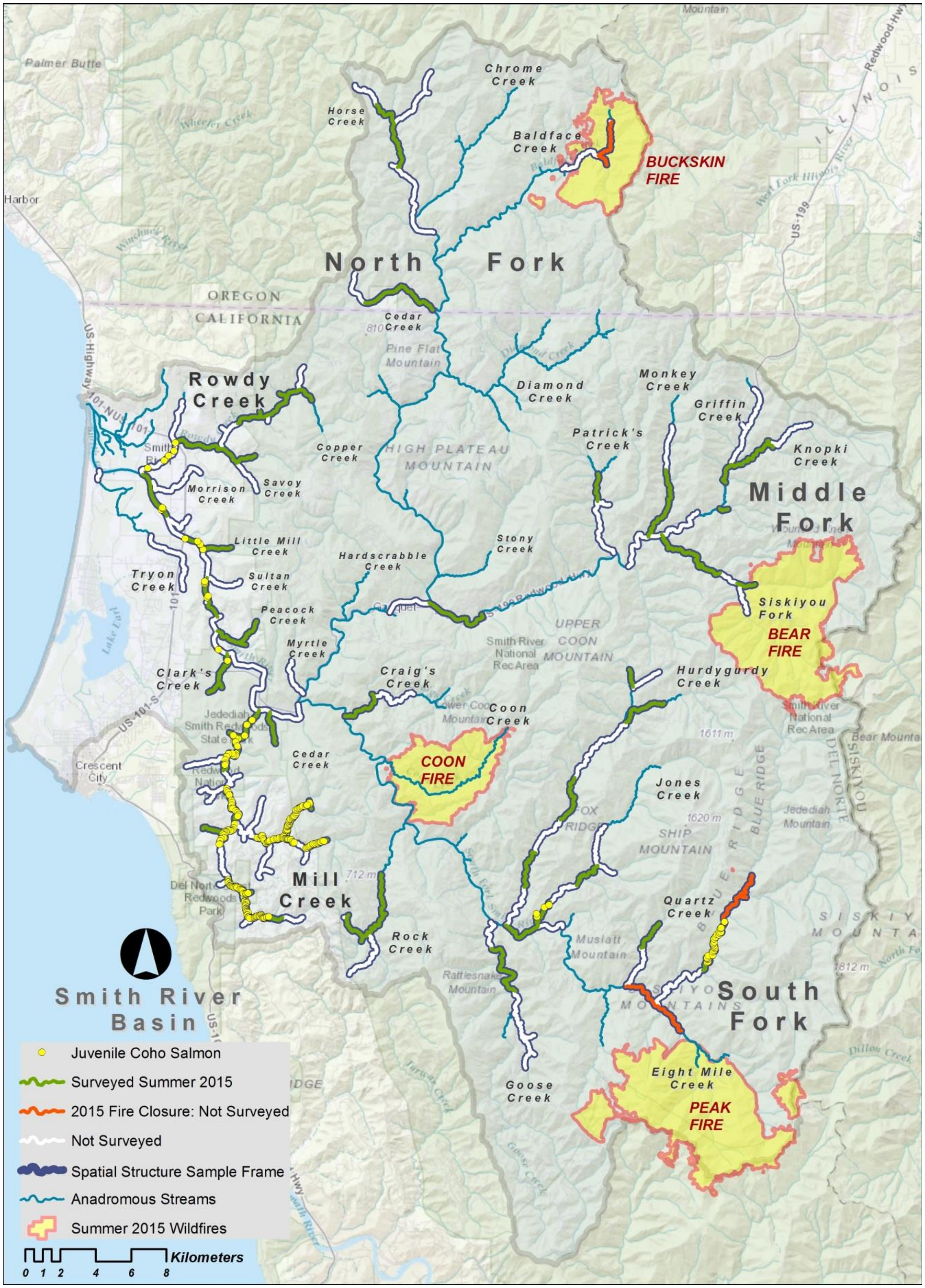

Figure 11. Map showing annual spatial structure survey reaches and the spatial distribution of pools containing juvenile coho salmon from summer 2015, Smith River Basin, California and Oregon. Note: some minimal incidental observations are included on the map in areas outside of the GRTS sampled portion.

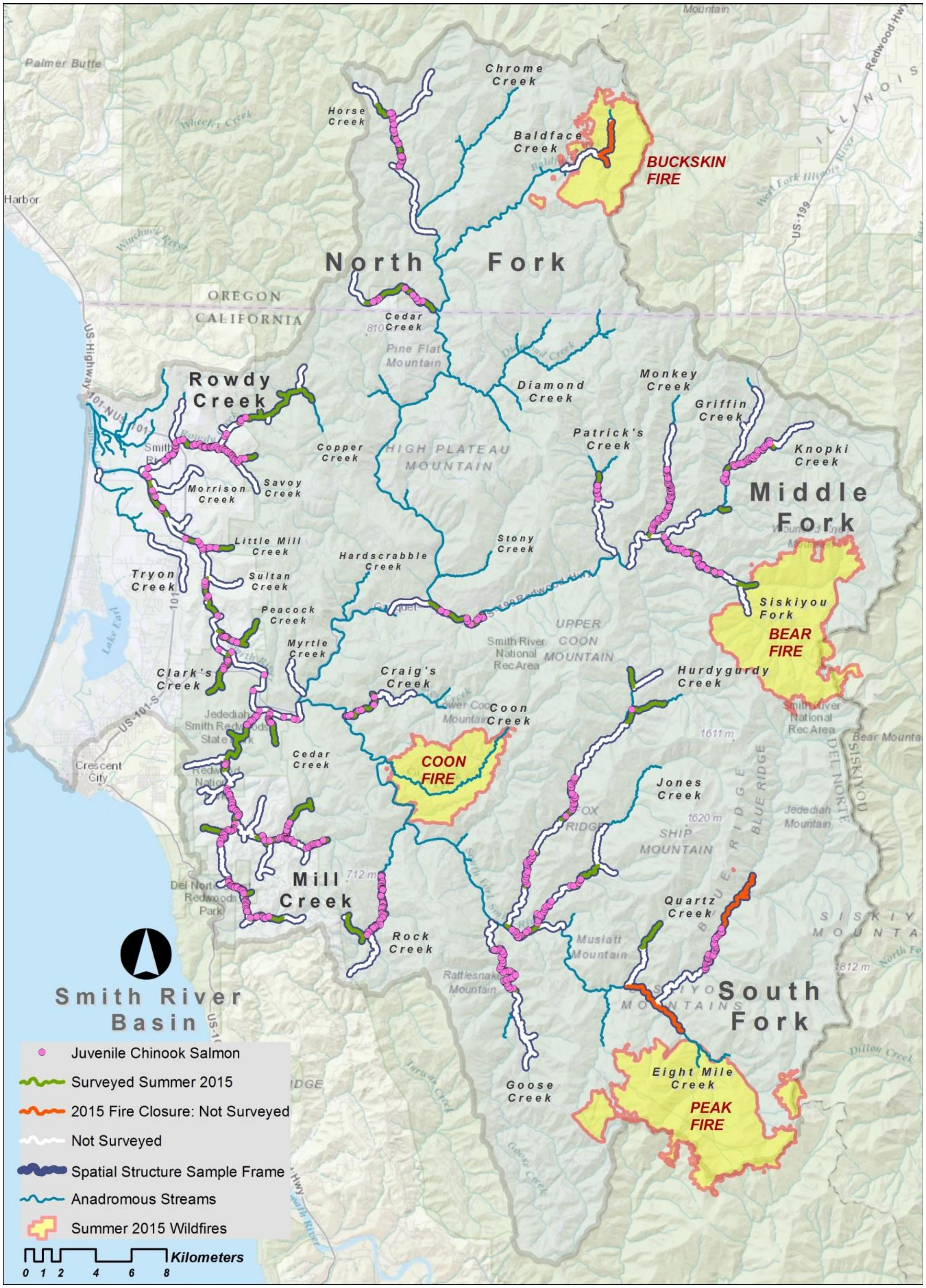

Figure 12. Map showing annual spatial structure survey reaches and the spatial distribution of pools containing juvenile Chinook salmon from summer 2015, Smith River Basin, California and Oregon. Note: some minimal incidental observations are included on the map in areas outside of the GRTS sampled portion.

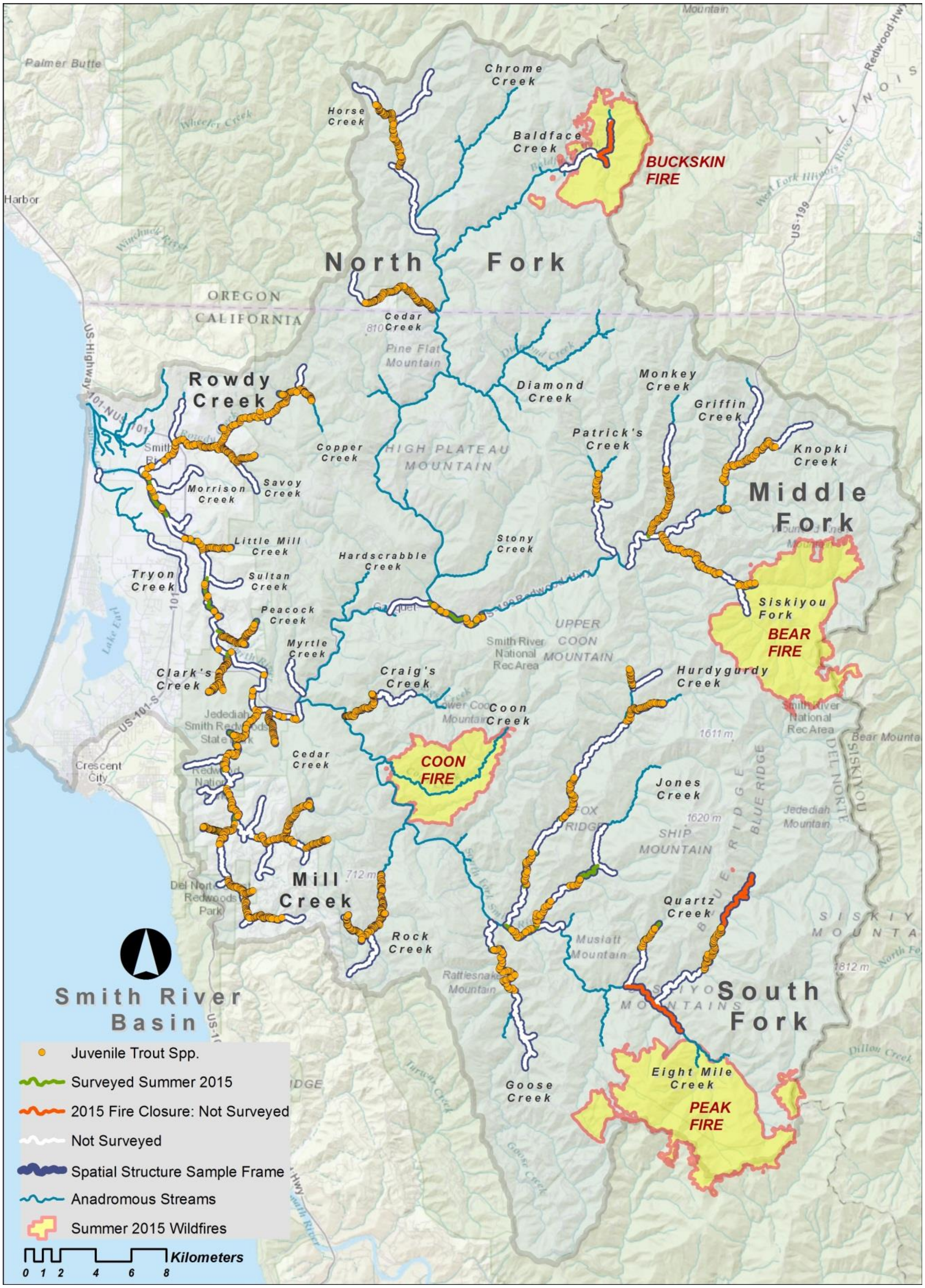

Figure 13. Map showing annual spatial structure survey reaches and the spatial distribution of pools containing juvenile trout (spp.) from summer 2015, Smith River Basin, California and Oregon. Note: some minimal incidental observations are included on the map in areas outside of the GRTS sampled portion.

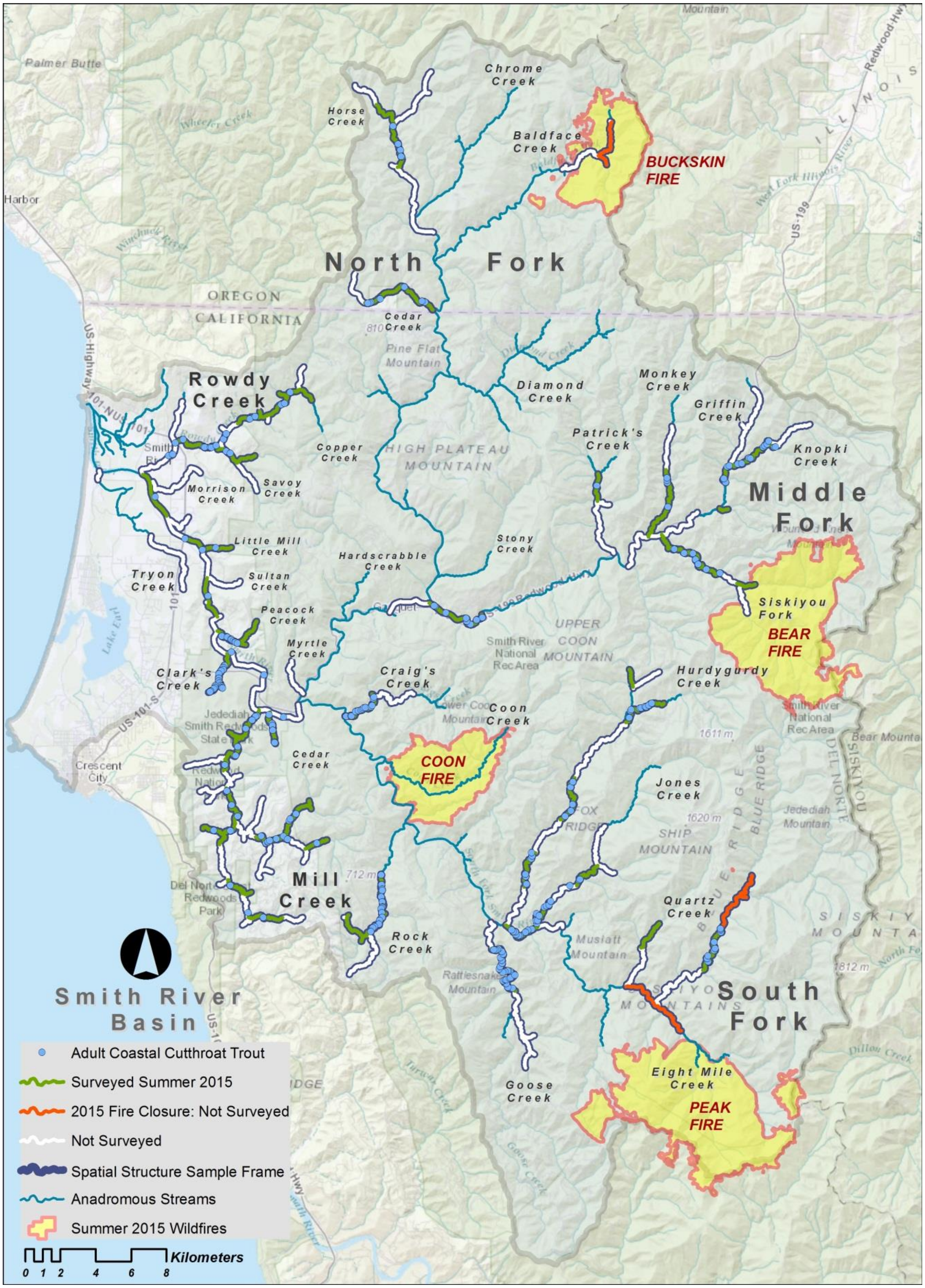

Figure 14. Map showing annual spatial structure survey reaches and the spatial distribution of pools containing adult coastal cutthroat trout from summer 2015, Smith River Basin, California and Oregon. Note: some minimal incidental observations are included on the map in areas outside of the GRTS sampled portion.

Table 10. Annual occupancy estimates, proportion of area occupied, and relative count densities if salmonids for the summer spatial structure survey 2012 to 2015, Smith River basin, California and Oregon.

Species	PSI	SE	95% CI	Theta	SE	95% CI	*p*	SE	95% CI	PAO	# of Reaches present	Mean pool count	Median pool count[1]
Summer 2012													
Coho Salmon	0.42	0.08	0.28 - 0.57	0.68	0.02	0.63 - 0.72	0.94	0.01	0.92 - 0.96	0.29	17 of 41	27.2	17
Chinook Salmon	0.71	0.07	0.55 - 0.83	0.38	0.02	0.35 - 0.42	0.86	0.02	0.83 - 0.89	0.27	28 of 41	14.8	4
Trout (YOY)	0.98	0.02	0.85 - 1.00	0.93	<0.01	0.91 - 0.94	0.96	<0.01	0.95 - 0.96	0.91	40 of 41	23.0	14
Trout (1+)	1.00	–	–	0.82	0.01	0.80 - 0.85	0.81	0.01	0.79 - 0.83	0.82	40 of 41	3.3	2
Adult Cutthroat Trout	0.92	0.05	0.74 - 0.98	0.38	0.02	0.34 - 0.42	0.63	0.03	0.57 - 0.68	0.35	35 of 41	1.5	1
Summer 2013													
Coho Salmon	0.39	0.06	0.27 - 0.51	0.60	0.02	0.56 - 0.63	0.95	<0.01	0.93 - 0.97	0.23	24 of 60	24.7	12
Chinook Salmon	0.77	0.06	0.64 - 0.86	0.47	0.01	0.44 - 0.50	0.90	0.01	0.88 - 0.92	0.36	45 of 60	12.2	4
Trout (YOY)	0.98	0.02	0.89 - 1.00	0.98	<0.01	0.97 - 0.99	1.00	–	–	0.96	59 of 60	34.5	18
Trout (1+)	1.00	–	–	0.82	0.01	0.80 - 0.84	0.86	<0.01	0.84 - 0.87	0.82	60 of 60	4.4	3
Adult Cutthroat Trout	0.91	0.05	0.75 - 0.97	0.22	0.01	0.20 - 0.25	0.61	0.03	0.55 - 0.66	0.20	46 of 60	1.3	1
Summer 2014													
Coho Salmon	0.35	0.06	0.24 - 0.47	0.67	0.02	0.62 - 0.71	0.92	0.02	0.87 - 0.95	0.23	23 of 67	20.8	12
Chinook Salmon	0.45	0.06	0.33 - 0.64	0.33	0.03	0.28 - 0.38	0.80	0.04	0.71 - 0.87	0.15	28 of 67	6.7	3
Trout (YOY)	1.00	–	–	0.96	<0.01	0.94 - 0.97	0.96	<0.01	0.95 - 0.97	0.96	67 of 67	31.1	14
Trout (1+)	1.00	–	–	0.96	0.01	0.92 - 0.98	0.81	0.01	0.78 - 0.83	0.96	66 of 67	6.5	3
Adult Cutthroat Trout	0.90	0.05	0.73 - 0.96	0.20	0.02	0.17 - 0.24	0.70	0.05	0.59 - 0.79	0.18	48 of 67	1.5	1
Summer 2015													
Coho Salmon	0.31	0.06	0.21 - 0.43	0.68	0.03	0.62 - 0.74	0.87	0.03	0.80 - 0.92	0.21	21 of 69	22.0	10
Chinook Salmon	0.75	0.06	0.62 - 0.84	0.46	0.02	0.41 - 0.48	0.87	0.02	0.83 - 0.91	0.35	48 of 68	10.0	4
Trout (YOY)	1.00	–	–	0.96	<0.01	0.94 - 0.97	0.97	<0.01	0.95 - 0.98	0.96	68 of 68	33.3	19
Trout (1+)	0.98	0.02	0.90 - 1.00	0.83	0.02	0.80 - 0.86	0.87	0.01	0.84 - 0.90	0.81	66 of 68	6.2	3
Adult Cutthroat Trout	0.84	0.06	0.70 - 0.92	0.26	0.02	0.22 - 0.30	0.71	0.04	0.61 - 0.78	0.22	49 of 68	1.7	1

PSI - The probability a species is detected in a given reach for the survey year; **Theta**-The probability a species is detected in a given sample pool conditional to the species being present in the reach for the survey year; ***p***-Individual species detection probability if present in a given sample pool; **PAO**-Proportion of area occupied. (PSI * Theta) Overall occupancy value; incorporates reach-level- and pool-level occupancy for the entire sample frame in a given year

Table 11. Number of pools occupied and density of Chinook Salmon, Unidentified juvenile trout (not identified to species), and adult Coastal Cutthroat Trout for all GRTS drawn reaches surveyed during spatial structure sampling in the Smith River, June - September 2014.

Subbasin	Location Code	Reach length (m)	Number of units Surveyed	Chinook Salmon		0+ Unidentified Trout		1+ Unidentified Trout		Coastal Cutthroat Trout	
				Pools occupied	Mean density	Pools occupied	Mean density	Pools occupied	Mean density	Pools occupied	Mean density
Lower Smith River	5	2044	8	6	3.8	6	8.7	6	2.7	1	1.0
Lower Smith River	6	798	4	3	101.0	3	4.0	3	5.0	-	-
Lower Smith River	8	1419	9	5	38.0	8	16.0	4	9.5	2	1.5
Lower Smith River	10	2520	13	6	34.7	6	5.8	5	2.8	1	1.0
North Fork Smith River	34	2845	36	13	3.1	35	33.7	29	4.3	4	1.3
Rowdy Creek	58	1860	14	9	14.8	14	200.3	13	13.5	1	1.0
Rowdy Creek	59	1228	17	15	13.5	17	203.9	15	19.1	5	3.0
Rowdy Creek	61	2320	15	3	3.7	15	59.3	12	6.3	2	1.0
Rowdy Creek	62	2278	18	-	-	18	68.1	16	3.8	3	1.0
South Fork Rowdy Creek	67	2492	45	18	3.8	45	61.7	31	4.4	2	1.5
Rowdy Creek Trib.	70	355	3	-	-	3	2.7	3	1.3	-	-
Rowdy Creek Trib.	72	579	9	-	-	9	11.6	3	1.0	-	-
Copper Creek	73	1098	18	-	-	18	37.4	12	2.3	-	-
Little Mill Creek	86	1737	21	5	1.6	21	47.5	20	5.1	1	1.0
Peacock Creek	91	3296	58	7	5.4	49	6.3	45	4.7	8	2.5
Peacock Creek Trib.	94	402	2	-	-	1	1.0	2	3.5	-	-
Clarks Creek	96	2277	32	6	2.3	25	3.1	20	2.2	7	1.1
Clarks Creek Trib.	97	367	11	-	-	4	1.3	8	1.3	5	1.0
Clarks Creek Trib.	98	968	26	-	-	12	1.9	20	2.7	6	1.2
Mill Creek	100	1805	10	6	12.8	9	25.9	6	6.0	4	1.3
Mill Creek	101	1944	14	-	-	12	5.4	3	2.3	1	1.0
Mill Creek	102	2329	14	2	12.5	13	8.6	6	4.7	2	3.5
Mill Creek	104	1416	7	7	35.1	7	71.1	6	9.5	2	2.0
Mill Creek	105	1412	6	6	10.0	6	63.7	5	3.6	1	1.0
West Branch Mill Creek	106	2111	21	16	11.0	21	58.9	17	5.6	2	1.0
West Branch Mill Creek	108	2031	26	20	7.8	25	88.6	21	4.8	1	1.0
West Branch Mill Creek	110	2382	38	6	1.3	35	36.2	28	2.9	1	1.0
Mill Creek Trib.	114	603	5	-	-	5	1.6	1	1.0	-	-
East Fork Mill Creek	124	2298	22	8	1.4	22	82.7	21	7.4	7	1.3
East Fork Mill Creek	126	1452	26	10	5.2	26	22.3	24	4.0	1	1.0
Bummer Lake Creek	134	2997	39	4	3.8	36	15.4	32	3.4	3	1.0
Bummer Lake Creek Trib.	135	300	4	-	-	3	4.3	3	2.3	-	-
Hamilton Creek	138	1427	37	-	-	31	3.4	34	3.6	1	1.0
West Branch Mill Creek Trib.	141	442	11	-	-	11	9.4	9	1.9	-	-
Cedar Creek	146	2351	41	8	2.8	40	7.4	18	2.3	6	1.0
South Fork Smith River	159	2461	11	9	29.8	11	32.3	9	30.0	9	4.6
South Fork Smith River	166	3582	38	24	5.2	38	33.5	37	14.6	9	1.4
Craigs Creek	171	2473	37	8	4.3	37	32.5	31	5.0	15	1.5
Craigs Creek Trib.	175	230	6	-	-	6	5.7	5	1.2	-	-
Rock Creek	188	2714	38	18	3.4	37	36.1	34	6.4	10	1.1
Rock Creek	189	2075	29	10	8.9	29	41.1	25	7.7	6	1.3
Rock Creek Trib.	192	151	5	-	-	5	8.2	2	3.5	-	-
Rock Creek Trib.	193	2280	28	1	1.0	28	27.5	19	8.4	-	-

Continued on next page…

Table 11. Continued...

Rock Creek Trib.	194	296	2	-	-	2	14.0	1	3.0	-	-
Goose Creek	204	2809	16	15	13.3	16	34.8	16	19.8	16	2.4
Goose Creek	205	1704	11	10	15.0	11	54.3	11	16.6	9	3.2
Goose Creek Trib.	211	92	1	-	-	1	17.0	-	-	-	-
Hurdygurdy Creek	218	2696	16	14	20.8	16	49.9	15	15.2	8	1.3
Hurdygurdy Creek	220	3155	26	16	4.3	26	32.8	23	9.6	5	1.4
Hurdygurdy Creek	223	2984	37	1	2.0	37	27.6	31	2.5	9	1.3
HurdyGurdy Creek Trib.	232	1046	20	-	-	17	4.6	15	2.7	-	-
Jones Creek	234	2445	16	11	22.3	16	63.9	13	10.9	9	2.2
Jones Creek	236	2232	8	5	10.4	7	57.3	7	16.0	3	2.3
Quartz Creek	251	1944	14	-	-	14	6.5	14	6.4	-	-
Middle Fork Smith River	276	3987	10	8	23.0	10	16.5	9	20.4	8	2.6
Middle Fork Smith River	284	1291	8	5	12.2	8	33.9	7	3.6	4	1.3
Middle Fork Smith River	285	1944	17	15	9.9	17	15.4	15	5.1	4	1.3
Middle Fork Smith River	286	1823	15	9	9.6	15	28.8	15	7.3	7	1.0
Patrick Creek	305	1666	15	5	3.4	15	12.6	14	6.6	1	1.0
Monkey Creek	317	2229	18	14	3.9	18	19.0	8	1.3	-	-
Monkey Creek	318	2513	31	24	4.1	30	10.7	25	3.0	4	1.0
Siskiyou Fork	324	2511	16	8	3.3	16	54.1	9	2.7	2	1.5
Siskiyou Fork	325	2937	17	10	3.9	17	44.1	10	4.0	5	1.0
Siskiyou Fork	327	1102	11	-	-	8	4.0	-	-	-	-
Idlewild Creek	333	542	13	-	-	12	6.0	9	2.0	-	-
Cedar Creek	382	2548	39	5	1.4	38	18.8	19	2.3	3	1.0
Cedar Creek	383	2397	38	4	2.0	37	11.6	24	3.9	4	1.0
Horse Creek	420	1956	37	5	1.6	36	11.1	13	1.6	-	-

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