2013-2014 Salmonid Redd Abundance and Juvenile Salmonid Spatial Structure in the Smith River Basin, California and Oregon

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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

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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 third year during the winter of 2013-2014 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 343 spawning ground surveys in 36 main reaches and 13 sub-reaches throughout the Smith River basin during the 2013-2014 season. We made 494 live adult coho salmon observations. Most coho salmon observations occurred in Mill Creek except one individual observed in Rowdy Creek and one individual observed in Hurdygurdy Creek. We recovered 54 coho salmon carcasses. All coho salmon carcasses were observed in Mill Creek except four individuals in Rowdy Creek. We were able to verify 108 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 260 (95% CI: 253 - 266) redds which equaled 54% and 115% of the estimated number of redds produced in the two 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 516 (95% CI: 284 - 770) which equaled only 14% and 29% of the estimated number of redds produced in the two previous seasons. Steelhead redd abundance estimates are incomplete since we only surveyed approximately 60% of the season. However, we estimated a total of 356 steelhead redds (95% CI: 212 - 502) equaling 34% and 51% of the estimated number of redds produced in the two 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 third year during the summer of 2014 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 (within 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 in 23 out of 67 surveyed reaches in five portions of the watershed. Eight (35%) of the reaches with coho salmon were determined non-natal rearing areas. Estimated large-scale occupancy of juvenile coho salmon equaled 0.35 (SE=0.06) while estimated small-scale occupancy equaled 0.67 (SE=0.02) resulting in a proportion of total area occupied (PAO) of 0.23. Juvenile Chinook salmon had an estimated PAO of 0.15, equaling only 56% and 42% of previous years. This large reduction of Chinook salmon space use could be related to early smolt migration timing, but was likely more influenced by the small adult return in the previous winter coupled with an extended drought period observed during the previous winter limiting spawning distributions.

Cover Photo's: *(1) Three male coho salmon spawning in West Branch Mill Creek on January 30, 2014. (2) Dry stream channel in West Branch Mill Creek on December 30, 2013 from exceptional drought conditions observed over the majority of the 2013-2014 spawning season.*

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Acknowledgments

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Photograph of a male coho salmon carcass observed in Rowdy Creek on 27 January 2014; one of four coho salmon carcasses recovered during the winter of 2014 in the Rowdy Creek sub-basin upstream of Rowdy Creek Fish Hatchery weir.

Introduction

This brief progress report summarizes the third 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 2013-2014 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.

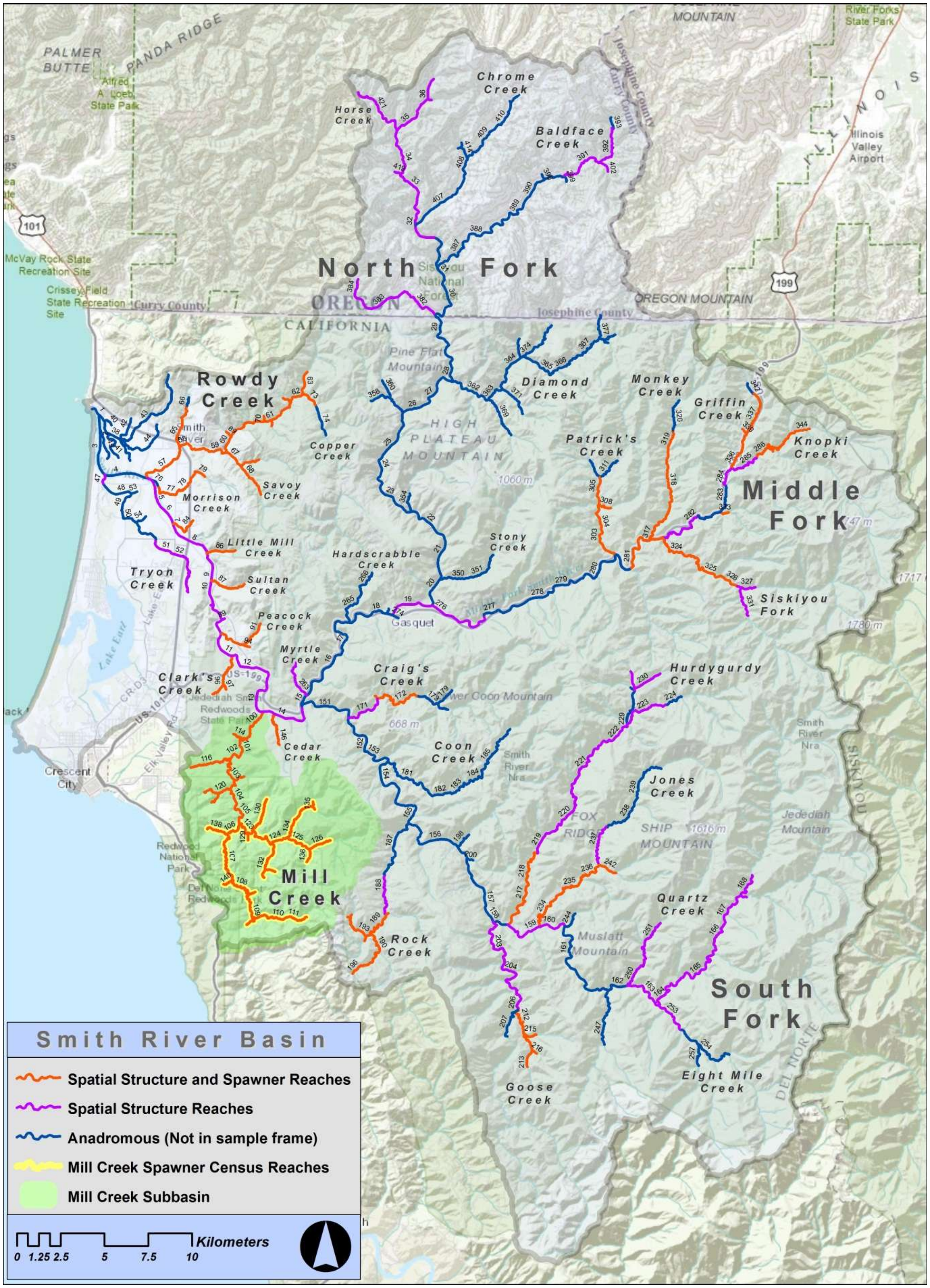

Figure 1. Map of the Smith River Basin, Del Norte County (California) and Curry County (Oregon). Stream lines indicate potential anadromous salmonid stream habitat based on this studies sample frame development process. Numbers represent 275 individual reach location codes used in generalized random 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% and 35% the first two seasons based on available resources and found our between-reach error represented 73% to 94% of the total estimate variance depending on species and year (Garwood and Larson 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. 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 one year 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), and 97% in 2013-2014 (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. However, the field crew was exceptionally experienced over the first three-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 2013) 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.

2013-2014 Spawning Ground Survey Results and Discussion

Spawning Ground Survey Conditions and Effort

We completed 343 surveys in 27 main reaches and 12 sub-reaches during the 2013-2014 survey period which extended from November 6, 2013 to March 8, 2014 (Table 1). GRTS sampling represented 29% of the total frame with 19 reaches and 8 sub-reaches. Two original GRTS drawn reaches were not surveyed due to private landowners denying access to portions of reaches. An additional 8 reaches and 4 sub-reaches were surveyed to complete a census of the Mill Creek LCS (Table 1). The precipitation regime for the 2013-2014 survey period was marked by exceptionally dry conditions resulting in extremely low stream discharge. Rainfall at the Gasquet Ranger Station totaled 59% of average during the survey period, however, rainfall from November through the end of January was just 24% of average (CDEC 2014). Three storms increased discharge and turbidity enough to delay our reach return interval (Figure 2). Overall, 91% of the days within the survey period had favorable conditions where the daily average river discharge was below our maximum survey threshold (16,000 cubic feet per second at the USGS Jed Smith gaging station). On average, the availability of reaches with favorable survey conditions equaled 86% (SD= 3%) of days within the survey period (Table 1). We surveyed on 65 of 112 available days resulting in an effort of 58%. On average, we surveyed each reach 8.8 times (range 1-17) with an overall average reach return interval equaling 16 days (Table 1, Figure 2). However, we did not survey all reaches during extended dry periods since extremely low stream flows prevented anadromous fish migrations in some small tributaries.

GRTS Spawning Ground Surveys

Live Fish Observations

We made 2181 observations of live anadromous salmonids within the GRTS surveyed portion of the Smith River during the winter of 2013-2014 (Table 2, Figure 3). Live salmonid totals do not represent individual fish observations since live individuals could be observed over multiple survey periods. Observations included 262 coho salmon, 1460 Chinook salmon, 258 steelhead, and 201 unidentified salmonids (Table 2, Figure 3). As expected, the first half of the season was dominated by live Chinook salmon observations with the mean observation date equaling December 16 (Table 3, Figure 3). Exceptionally low stream flows prevented Chinook salmon from accessing many streams (Figure 4) and they were only detected in 12 of the 27 GRTS surveyed reaches (Table 2, Figure 5). Live coho salmon observations ranged from December 3 through March 8 with a mean observation date of February 4 (Table 3, Figure 3). Live coho salmon were narrowly distributed with 260 of the 262 observations occurring in nine GRTS reaches in Mill Creek (Table 2, Figure 5). We observed one female coho salmon in Rowdy Creek and one male coho salmon in Hurdygurdy Creek (Figure 5). Live steelhead observations increased steadily during the last portion of the survey period with a mean observation date of February 22 (Table 3, Figure 3). Thus, our observations represent only a portion of the steelhead spawning season since our effort ended March 8. We found our steelhead observations were moderately distributed with detections in 21 of 27 GRTS surveyed reaches (Table 2, Figure 6).

Carcass Observations

We recovered 239 anadromous salmonid carcasses in GRTS survey reaches during the winter of 2013-2014. Carcass totals were dominated by Chinook salmon with 200 individuals, followed by 28 coho salmon, and 11 unidentified salmonids (Table 2, Figure 7). Four of the 28 coho salmon carcasses in the GRTS survey were recovered in Rowdy Creek (Table 2). We encountered the first coho salmon carcass on December 16 and the last on March 5. The mean coho salmon carcass date was February 15 (Table 3). Of the 28 tagged coho salmon carcasses in the GRTS survey, we recaptured 4 on subsequent surveys indicating poor recapture success.

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 2013-2014 (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 6.9% (range: 0% to 21.7%) of all live Chinook salmon observations where the presence or absence of an adipose fin could be determined, and 28.6% (range: 0% to 42.3%) of all Chinook salmon carcasses recovered. The difference in the percentages between live and dead Chinook salmon may be due to Rowdy Creek Fish Hatchery (RCH) using a left-ventral fin clip for the 2009 brood year. Determining the absence of an adipose or left ventral fin on live fish is difficult so carcasses likely better represent the actual proportion of hatchery origin Chinook salmon. Hatchery origin steelhead constituted 4.7% (range: 0% to 25%) of all live observations where the presence or absence of an adipose fin could be determined (Table 4). We did not encounter any steelhead carcasses. No hatchery origin live coho salmon were encountered during the winter of 2013-2014. We did however encounter two hatchery origin coho salmon carcasses in Rowdy Creek (Figure 8). One fish was produced at the Trinity River hatchery (right maxillary clip) and the other was produced at the Iron Gate Hatchery (left maxillary clip) on the Klamath River. Coho salmon are not produced by Rowdy Creek Fish Hatchery.

Redd Observations

We identified 403 anadromous salmonid redds within the GRTS surveyed portion of the Smith River during the winter of 2013-2014 including 58 coho salmon, 56 Chinook salmon, 17 steelhead, and 271 unidentified species (Table 5, Figure 9). The average total reach-level redd density equaled 11.9 redds per kilometer, with the highest observed densities occurring in Rowdy Creek and Mill Creek watersheds (Table 5). Thirty-three percent of the overall observed redds were identified to species, though this proportion varied greatly over the spawning season. Immediately after each of the first three rain events we observed fish spawning on nearly 50% of redds we encountered. After flows receded fish were observed spawning on less than 30% of redds encountered (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 sub-basins throughout the surveyed area (Table 5, Figure 4, Figure 6). The first verified coho salmon redd was observed on January 13 and the last was observed on February 27 (Table 3). Overall, mean observation dates of known species redds were consistently within a few days of mean live fish dates for all species (Table 3).

Redd Prediction Performance

The kNN classifier performed well in the 2013-2014 survey season, correctly predicting 186 of 206 (90.3%) redds verified to species from GRTS and Mill Creek census reaches (Table 6). Unlike previous years, known species redd abundance was more similar between Chinook and coho salmon. The kNN classifier correctly predicted 100% of Chinook salmon redds followed by 91.7% of coho salmon redds and 60.7% of steelhead redds. No coho salmon redds were predicted outside of Mill Creek.

Total Redd Abundance

Total redd abundance estimates of Chinook salmon and steelhead for the Smith River sample frame in 2013-2014 are 516 (284 - 770) and 356 (212 - 502), respectively (Table 7). Because we did not detect or predict any coho salmon redds outside of the Mill Creek LCS, a coho salmon redd abundance estimate was not calculated for the Smith River GRTS sample frame. The estimated number of Chinook salmon redds was far lower than the two previous years, representing only 14% of the 2011-2012 estimate, and only 29% of the 2012-2013 estimate (Figure 10). We also observed a decline in the estimated number of steelhead redds, however, with much less magnitude. The estimated number of steelhead redds equaled 34% of the 2011-2012 estimate and 51% of the 2012-2013 estimate (Figure 10).

Mill Creek Spawner Survey Census

Live Fish Observations

Live coho salmon were observed throughout most of the Mill Creek LCS census area in both years (Figure 11). However, very few observations occurred in the two lowest reaches (106 and 123). During the winter of 2013-2014 we had 1169 observations of live anadromous salmonids in Mill Creek LCS census reaches. These observations included 449 coho salmon, 437 Chinook salmon, 142 steelhead, and 141 unknown species (Table 2).

Carcass Observations

During the winter of 2013-2014 we encountered 49 coho salmon, 54 Chinook salmon, and 2 unknown species carcasses in the Mill Creek LCS (Table 2). Of the 49 coho salmon carcasses we encountered, four 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 2013-2014 spawning survey season we observed 108 coho salmon redds, 25 Chinook salmon redds, 17 steelhead redds, and 245 unknown species redds (Table 5). The known species redds plus the kNN predicted species redds (i.e. total number of observed redds) resulted in 229 coho salmon, 111 Chinook salmon, and 56 steelhead redds. We estimated total redd abundance in the Mill Creek LCS sub-basin for 2013-2014 as 260 coho salmon redds (253 - 266), 110 Chinook salmon redds (109 - 111), and 63 steelhead redds (59 - 66) (Table 8). The estimated number of coho salmon redds in Mill Creek represented 54% of the 2011-2012 estimate, and 115% of the 2012-2013 estimate (Figure 10).

Coastal Cutthroat Trout

During the winter of 2013-2014 we observed 83 coastal cutthroat trout (*Oncorhynchus clarki clarki*) redds in 8 reaches and 4 sub-reaches (Table 5). The first cutthroat trout redd was observed January 8 and the last was observed on February 21 with a mean observation date of January 27. These observations are incidental and likely do not reflect actual redd abundance or distribution patterns. Coastal cutthroat trout exhibit diverse life-histories in the Smith River resulting in a prolonged spawning season (Moyle 2002) likely extending well beyond our survey period.

Table 1. Summary statistics of spawning ground reach survey effort and reach survey availability based on flow conditions for the winter of 2013-2014, Smith River basin, Del Norte County, CA. Surveys occurred from November 6, 2013 to March 8, 2014. 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	59	1227	14	8	5	23	0.81
Rowdy	62	2276	14	8	5	22	0.83
Rowdy	72	579	1	-	-	-	0.83
Rowdy	73	1167	4	32	18	55	0.83
Mill	103	1314	14	9	4	22	0.83
Mill	105	1412	15	8	4	22	0.83
WB Mill	**106**	2111	16	8	3	16	0.84
WB Mill	**107**	2675	17	8	2	13	0.86
WB Mill	108	2030	16	8	2	13	0.86
WB Mill	109	1802	16	7	2	14	0.89
WB Mill	**110**	2582	10	12	7	26	0.91
WB Mill	**111**	1314	2	63	0	63	0.91
EF Mill	**123**	2149	13	9	5	22	0.84
EF Mill	124	2298	13	9	4	22	0.84
EF Mill	125	1559	16	8	2	13	0.89
EF Mill	**126**	1444	9	13	9	35	0.89
EF Mill	**129**	436	2	77	0	77	0.84
First Gulch	**130**	2506	9	14	7	28	0.89
Kelly	**132**	2481	9	14	7	28	0.89
Kelly	**133**	593	4	16	3	20	0.89
Bummer	134	2996	10	12	4	19	0.85
Bummer	135	300	2	14	-	14	0.85
Low Divide	136	863	5	11	5	19	0.89
WB Mill	**138**	125	9	13	10	35	0.90
WB Mill	**140**	741	2	7	0	7	0.90
WB Mill	141	442	3	49	34	83	0.90
WB Mill	143	834	7	15	6	27	0.91
Cedar	146	2351	4	30	14	44	0.91
Rock	189	2075	12	10	5	22	0.83
Rock	193	2280	11	10	5	22	0.83
Rock	194	296	2	9	0	9	0.83
Rock	195	171	2	9	0	9	0.83
Hurdygurdy	217	2989	13	9	3	14	0.83
Middle Fork	281	3888	13	9	3	15	0.81
Patrick	305	1668	12	10	3	15	0.83
Monkey	318	2515	8	16	6	29	0.83
Griffin	336	2601	7	18	6	29	0.83
Griffin	339	357	1	-	-	0	0.83
Knopki	344	3225	7	21	12	41	0.83
	Total	-	343	16.3[b]	-	-	0.86[b]

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

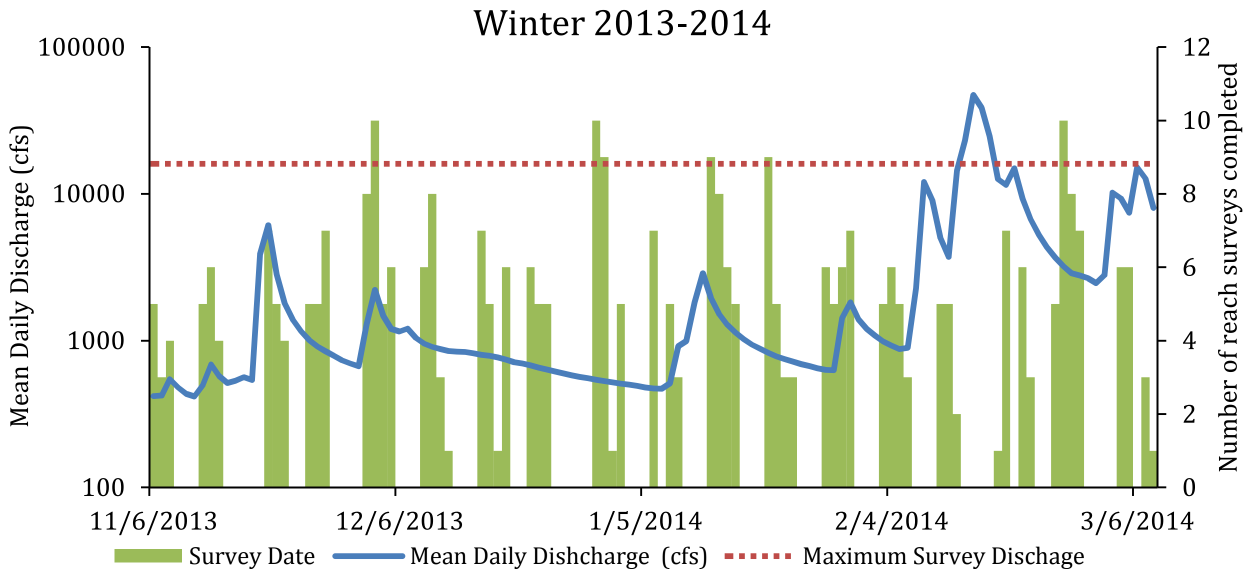

Figure 2. Spawning ground survey effort and timing during the 2013-2014 survey year in the Smith River basin (Del Norte County, CA) as it relates to mean daily river discharge. The dashed red line represents the maximum discharge (16,000 cubic feet per second) where spawner surveys could be safely completed 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 6, 2013 to March 8, 2014, 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	59	621	1	63	15	129	4	-	7
Rowdy	62	136	-	12	2	3	-	-	-
Rowdy	72	-	-	-	-	-	-	-	-
Rowdy	73	-	-	-	-	-	-	-	-
Mill	103	73	9	1	35	14	-	-	1
Mill	105	179	5	3	55	22	1	-	2
WB Mill	**106**	111	13	5	23	14	2	-	1
WB Mill	**107**	171	110	39	61	16	9	-	1
WB Mill	108	44	76	31	19	4	4	-	-
WB Mill	109	3	55	20	10	-	13	-	-
WB Mill	**110**	-	31	10	15	-	6	-	-
WB Mill	**111**	-	-	-	-	-	-	-	-
EF Mill	**123**	87	4	1	18	9	5	-	-
EF Mill	124	141	15	3	7	9	3	-	-
EF Mill	125	4	83	13	8	2	2	-	-
EF Mill	**126**	-	19	10	-	-	-	-	-
EF Mill	**129**	-	-	-	-	-	-	-	-
First Gulch	**130**	-	17	-	2	-	2	-	-
Kelly	**132**	-	21	2	3	-	2	-	-
Kelly	**133**	-	6	-	-	-	-	-	-
Bummer	134	-	11	2	3	-	-	-	-
Bummer	135	-	-	-	1	-	-	-	-
Low Divide	136	-	4	2	1	-	-	-	-
WB Mill	**138**	-	11	-	-	-	-	-	-
WB Mill	**140**	-	-	-	-	-	-	-	-
WB Mill	141	-	-	2	-		-	-	-
WB Mill	143	-	2	5	2	-	1	-	-
Cedar	146	-	-	1	1	-	-	-	-
Rock	189	66	-	22	7	1	-	-	-
Rock	193	-	-	16	1	-	-	-	-
Rock	194	-	-	-	-	-	-	-	-
Rock	195	-	-	-	-	-	-	-	-
Hurdygurdy	217	132	1	32	25	13	-	-	1
Middle Fork	281	49	-	6	5	3	-	-	-
Patrick	305	12	-	2	1	-	-	-	-
Monkey	318	-	-	6	2	-	-	-	-
Griffin	336	-	-	13	1	-	-	-	-
Griffin	339	-	-	-	-	-	-	-	-
Knopki	344	-	-	3	-	-	-	-	-
	Total	1815	494	336	323	239	54	0	13

[a]*Bold indicates Mill Creek Census reach*

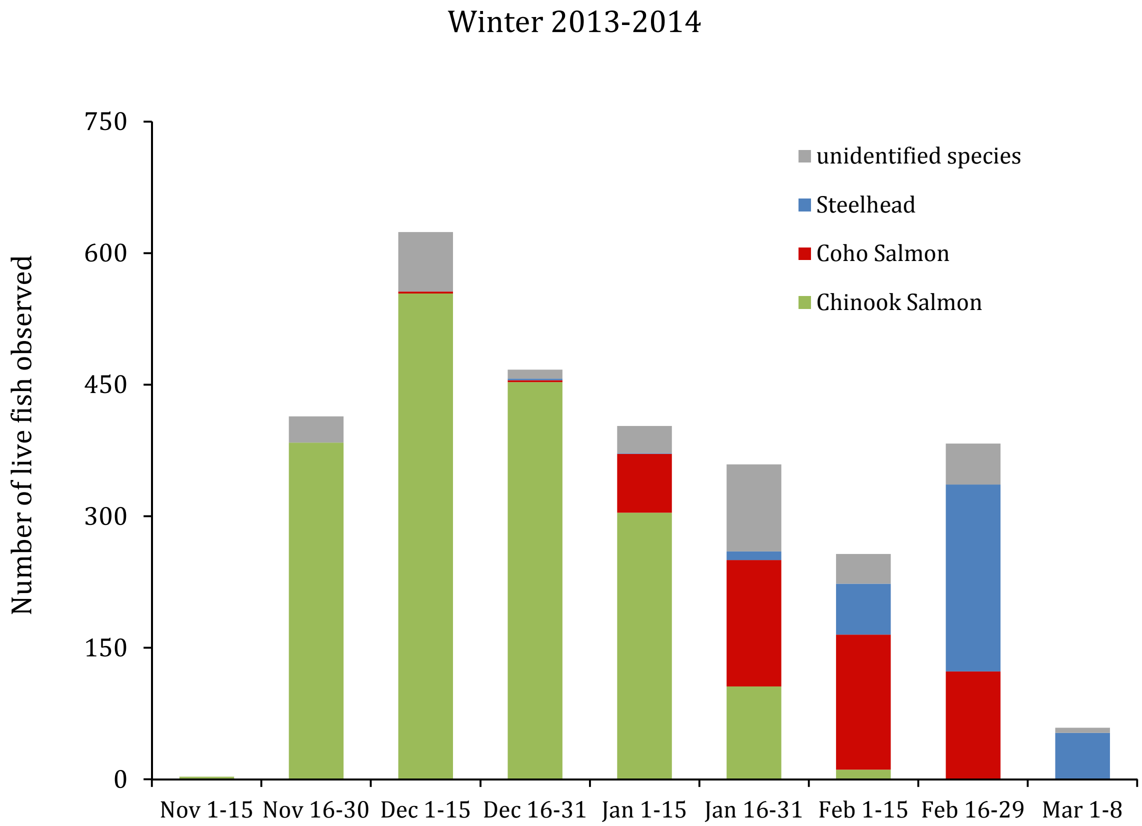

Figure 3. Number live salmonids, identified to species and survey period, observed during spawner surveys occurring over two winters in the Smith River basin, Del Norte County, CA.

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 2013-2014 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	1813[a]	494[a]	228[a]
	Mean	16-Dec-2013	4-Feb-2014	22-Feb-2014
	SD	18.0	13.6	10.3
	Min	6-Nov-2013	3-Dec-2013	23-Dec-2013
	Max	11-Feb-2014	8-Mar-2014	8-Mar-2014
Live fish sex ratio:	F / M	1 / 2.10	1 / 1.21	1 / 1.70
Known species redd:	N	70	108	28
	Mean	5-Dec-2013	4-Feb-2014	24-Feb-2014
	SD	11.8	13.8	7.5
	Min	14-Nov-2013	13-Jan-2014	30-Jan-2014
	Max	13-Jan-2014	27-Feb-2014	8-Mar-2014
Carcass observations:	N	243	53	-
	Mean	4-Jan-2014	15-Feb-2014	-
	SD	16.1	16.4	-
	Min	8-Nov-2013	16-Dec-2013	-
	Max	5-Feb-2014	5-Mar-2014	-
Carcass sex ratio:	F / M	1 / 0.73	1 / 0.90	-
Carcass fork length (cm)	N	215	44	-
	Mean	74	70	-
	SD	16.2	6.5	-
	Min	45	53	-
	Max	112	80	-

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

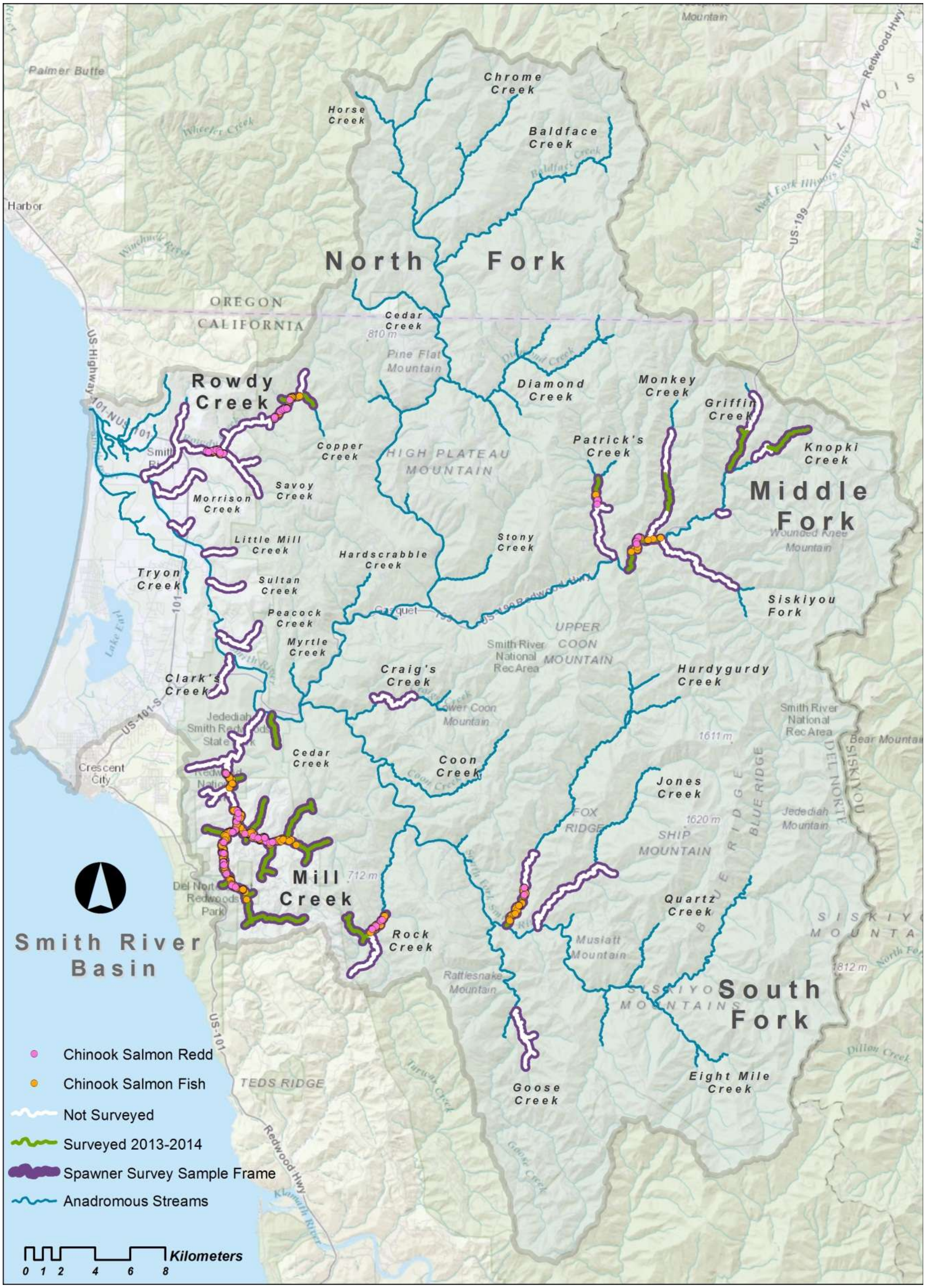

Figure 4. Map showing annual survey reaches, distribution of observed adult Chinook salmon, and verified Chinook salmon redds, Smith River Basin, Del Norte County, CA. Note: redd location symbols are displayed above fish observation symbols and may obscure fish observations in reaches with numerous verified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

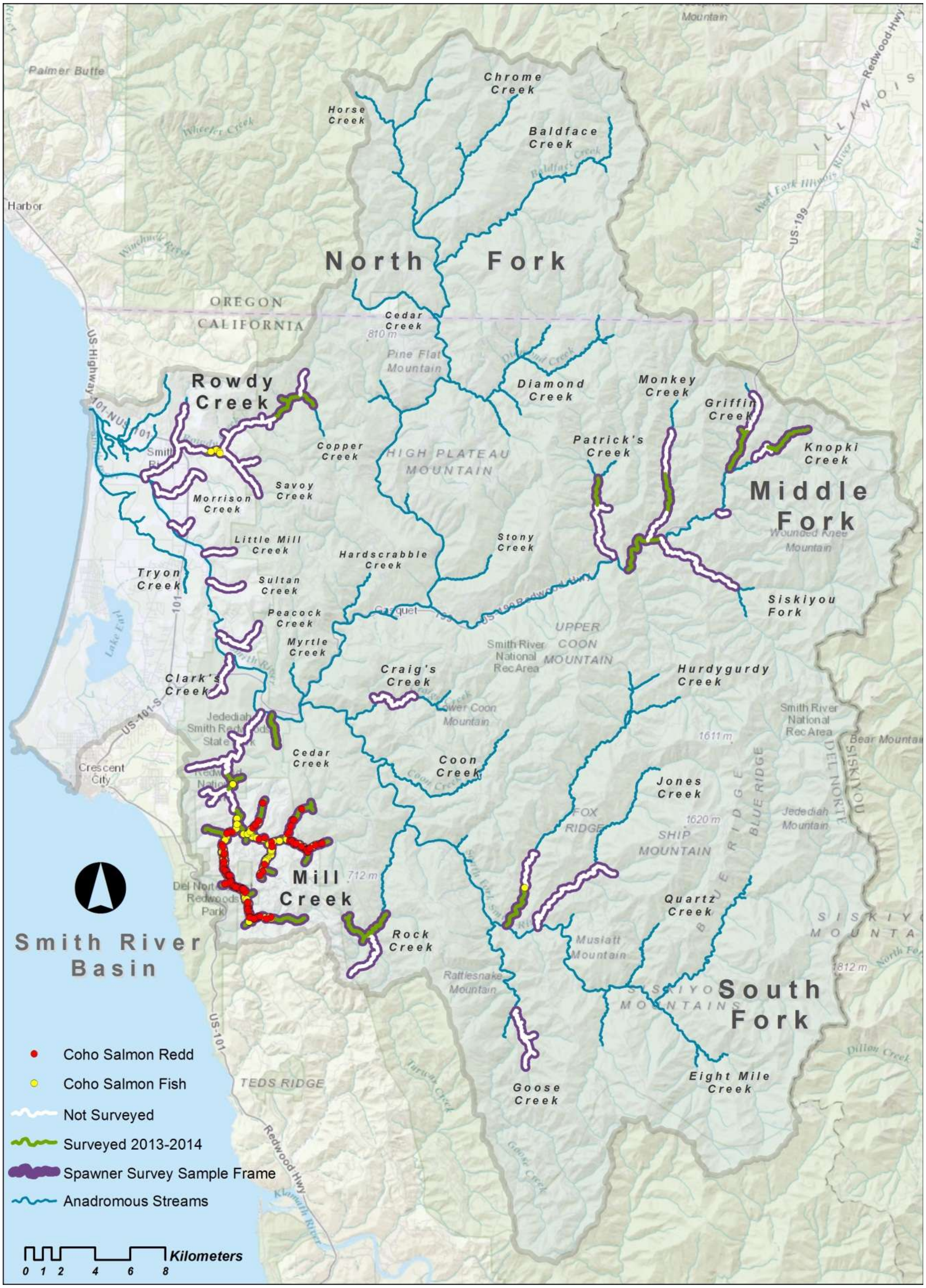

Figure 5. Map showing annual survey reaches, distribution of observed adult coho salmon, and verified coho salmon redds, Smith River Basin, Del Norte County, CA. Note: redd location symbols are displayed above fish observation symbols and may obscure fish observations in reaches containing high densities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

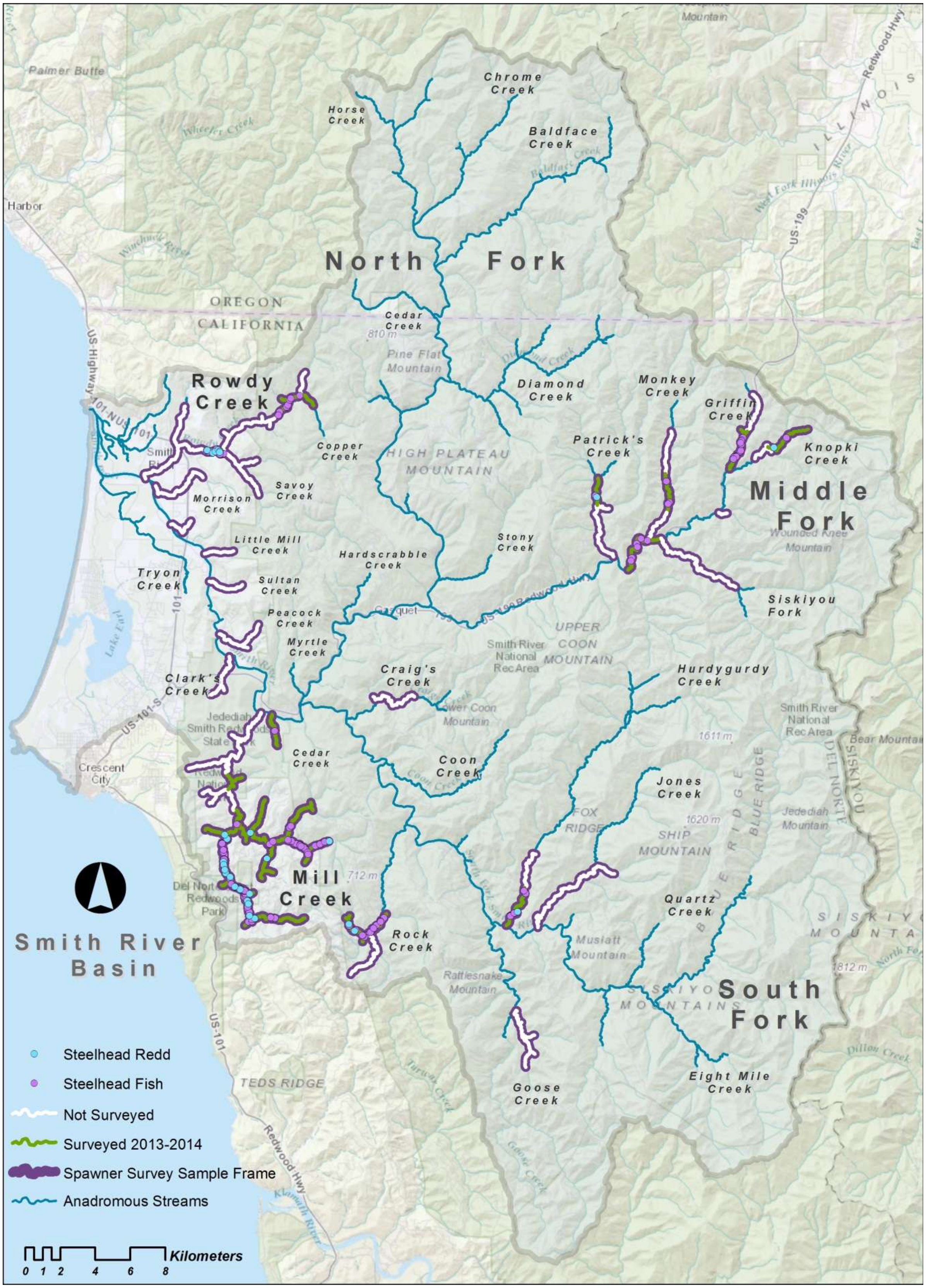

Figure 6. Map showing annual survey reaches, distribution of observed adult steelhead, and verified steelhead redds, Smith River Basin, Del Norte County, CA. Note: redd location symbols are displayed above fish observation symbols and may obscure fish observations in reaches containing high densities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

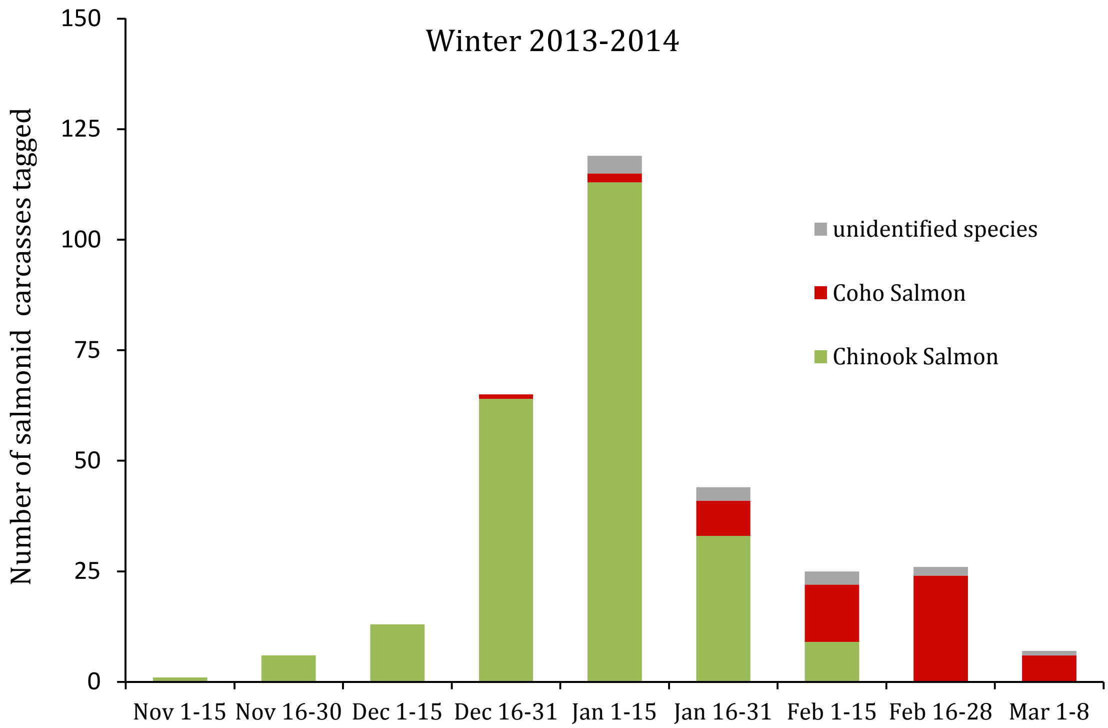

Figure 7. Number of uniquely tagged salmonid carcasses identified by species and survey period during the 2013-2014 spawner survey season, Smith River basin, Del Norte County, CA.

Table 4. Proportion of observed hatchery-origin salmonids summarized by species, observation type, and major sub-basin, during the winter 2013-2014 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). 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 2013-2014									
	Coho Salmon			Chinook Salmon			Steelhead		
Sub-basin	No Clip	Clip	% Hatchery	No Clip	Clip	% Hatchery	No Clip	Clip	% Hatchery
Rowdy Cr	1	0	0	72	20	21.7	21	1	4.5
Below Forks	83	0	0	343	18	5.0	3	1	25.0
Above Forks	1	0	0	101	0	0	17	0	0
Carcass observations 2013-2014									
	Coho Salmon			Chinook Salmon			Steelhead		
Sub-basin	No Clip	Clip	% Hatchery	No Clip	Clip	% Hatchery	No Clip	Clip	% Hatchery
Rowdy Cr	2	2	50	60	44	42.3	0	0	-
Below Forks	40	0	0	63	10	13.7	0	0	-
Above Forks	0	0	-	12	0	0	0	0	-

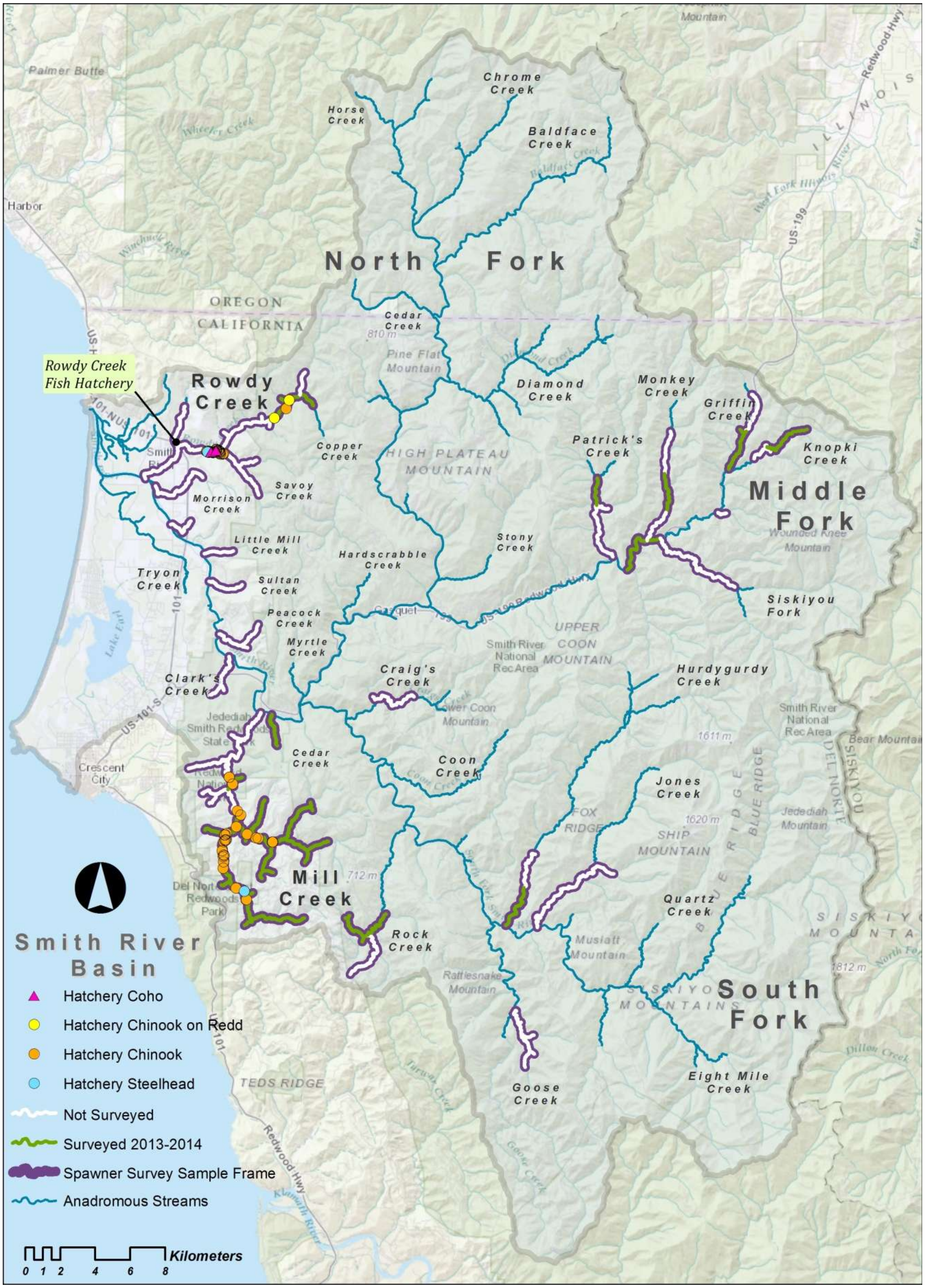

Figure 8. Map showing annual survey reaches and the distribution of observed adipose fin clipped adult hatchery Steelhead, adipose fin clipped adult Chinook salmon, hatchery Chinook salmon constructing redds, and two maxillary clipped coho salmon from the Trinity and Klamath River fish hatcheries; observed 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 2013-2014, Smith River basin, Del Norte County, CA. Surveys occurred from November 6, 2013 to March 8, 2014. 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	
Rowdy	59	19	-	6	18	-	35.0
Rowdy	62	7	-	-	15	-	9.6
Rowdy	72	-	-	-	-	-	-
Rowdy	73	-	-	-	-	-	-
Mill	103	1	-	-	21	-	16.7
Mill	105	7	-	-	13	-	14.2
WB Mill	**106**	5	4	2	25	2	17.0
WB Mill	**107**	7	19	5	59	-	33.7
WB Mill	108	2	21	2	20	1	22.2
WB Mill	109	-	12	3	22	5	20.5
WB Mill	**110**	-	8	1	11	6	8.4
WB Mill	**111**	-	-	-	-	-	-
EF Mill	**123**	2	-	1	17	-	9.3
EF Mill	124	9	3	-	20	1	13.9
EF Mill	125		15	-	25	-	25.2
EF Mill	**126**	-	6	1	7	12	9.6
EF Mill	**129**		-	-	-	-	-
First Gulch	**130**	-	5	-	6	22	4.4
Kelly	**132**	-	2	1	13	27	6.4
Kelly	**133**	-	2	-	-	3	3.4
Bummer	134	-	6	-	7	-	4.3
Bummer	135	-	-	-	-	-	-
Low Divide	136	-	1	-	5	2	7.0
WB Mill	**138**	-	-	-	1	1	6.7
WB Mill	**140**	-	4	-	2	-	8.1
WB Mill	141	-	-	1	3	-	9.0
WB Mill	143	-	-	-	2	1	2.4
Cedar	146	-	-	-	-	-	-
Rock	189	4	-	-	26	-	14.5
Rock	193	-	-	2	10	-	5.3
Rock	194	-	-	-	-	-	-
Rock	195	-	-	-	-	-	-
Hurdygurdy	217	2	-	1	27	-	10.0
Middle Fork	281	3	-	-	11	-	3.6
Patrick	305	2	-	1	6	-	5.4
Monkey	318	-	-	-	3	-	1.2
Griffin	336	-	-	-	8	-	3.1
Griffin	339	-	-	-	1	-	2.8
Knopki	344	-	-	1	8	-	2.8
Total		70	108	28	412	83	10.8[c]

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

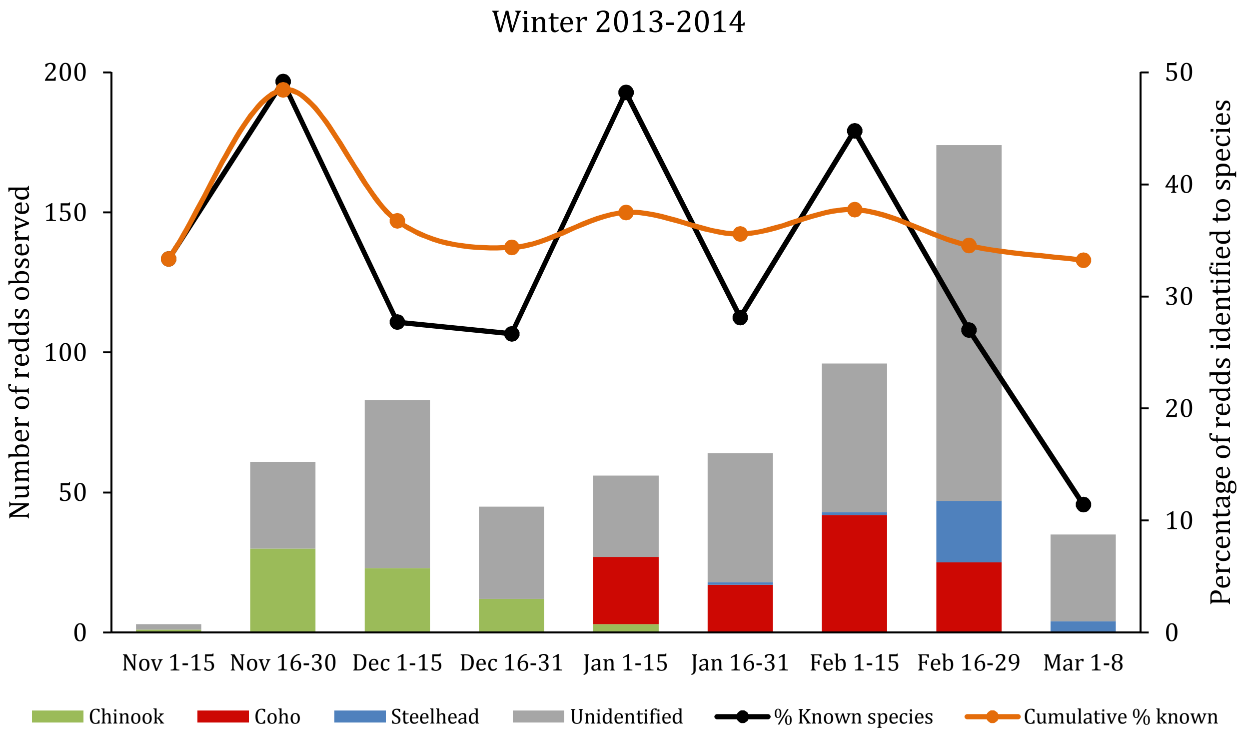

Figure 9. Number of individual salmonid redds observed by survey period during the 2013-2014 spawner survey season in the Smith River basin, Del Norte County, CA. Line plots represent percentages of redds identified to species by survey period through direct observations of live fish actively building or guarding individual redds.

Table 6. Confusion matrix, statistics, and number of redds by species for the 2013-2014 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 2013-2014		Reference		
		Coho Salmon	Chinook Salmon	Steelhead
Prediction	Coho Salmon	**99**	0	10
	Chinook Salmon	6	**70**	1
	Steelhead	3	0	**17**
	Sensitivity	0.917	1.00	0.607
	Specificity	0.898	0.949	0.983
	Accuracy (95% CI)		0.90 (0.85 - 0.94)	
Number of Redds	Known Species	108	70	28
	kNN Predicted	123	177	113
	Total	231	247	141

Table 7. Estimated total number of redds by species in the Smith River GRTS spawner survey sample frame for the winter of 2013-2014. 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	516	356
SE	NA	116.4	69.5
Total within reach variance	NA	0.8	0.1
Total between reach variance	NA	107.6	31.7
% Within reach variance	NA	0.7	0.2
% Between reach variance	NA	99.3	99.8
95% CI	NA	(284, 770)	(212, 502)

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

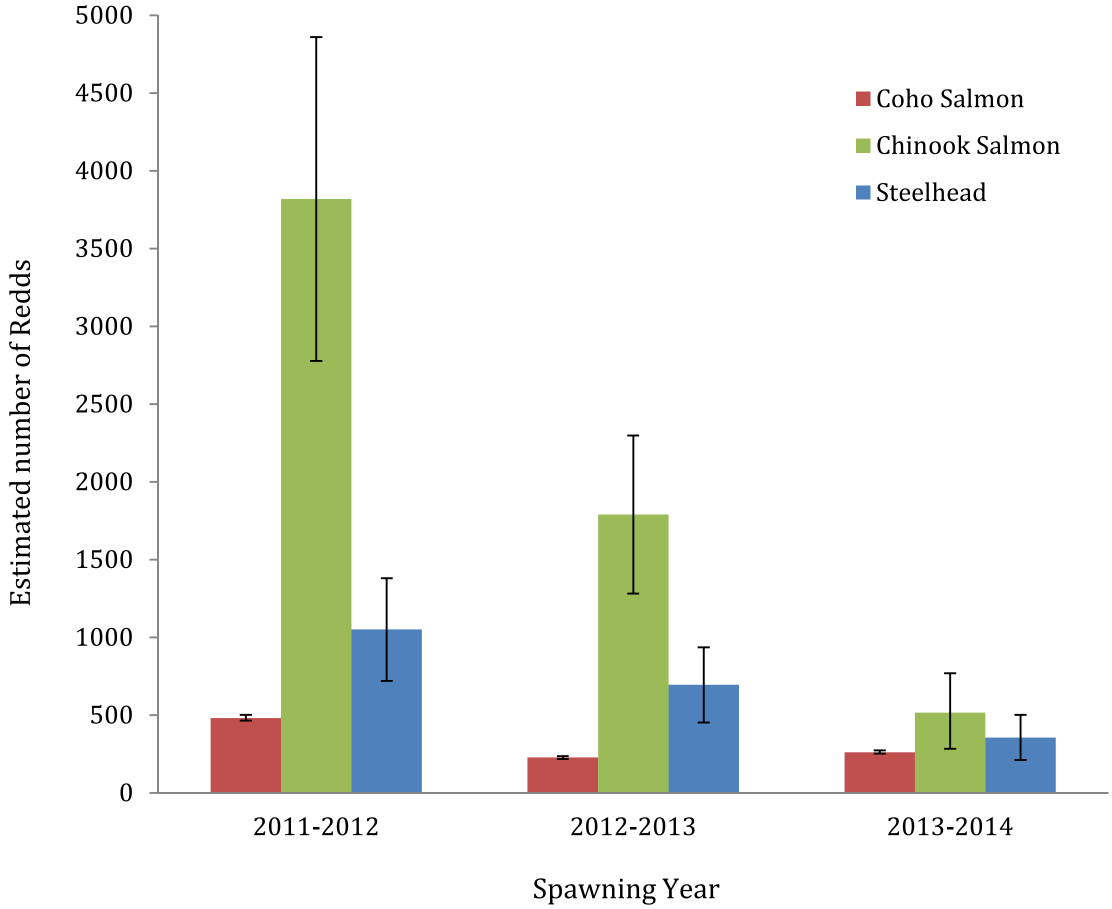

Figure 10. Estimated total number of redds produced in the Smith River GRTS spawner survey sample frame by species and spawning year, Smith River basin, Del Norte County, CA. Error bars represent 95% confidence intervals around point estimates. Coho salmon redd estimates are restricted to the Mill Creek 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.

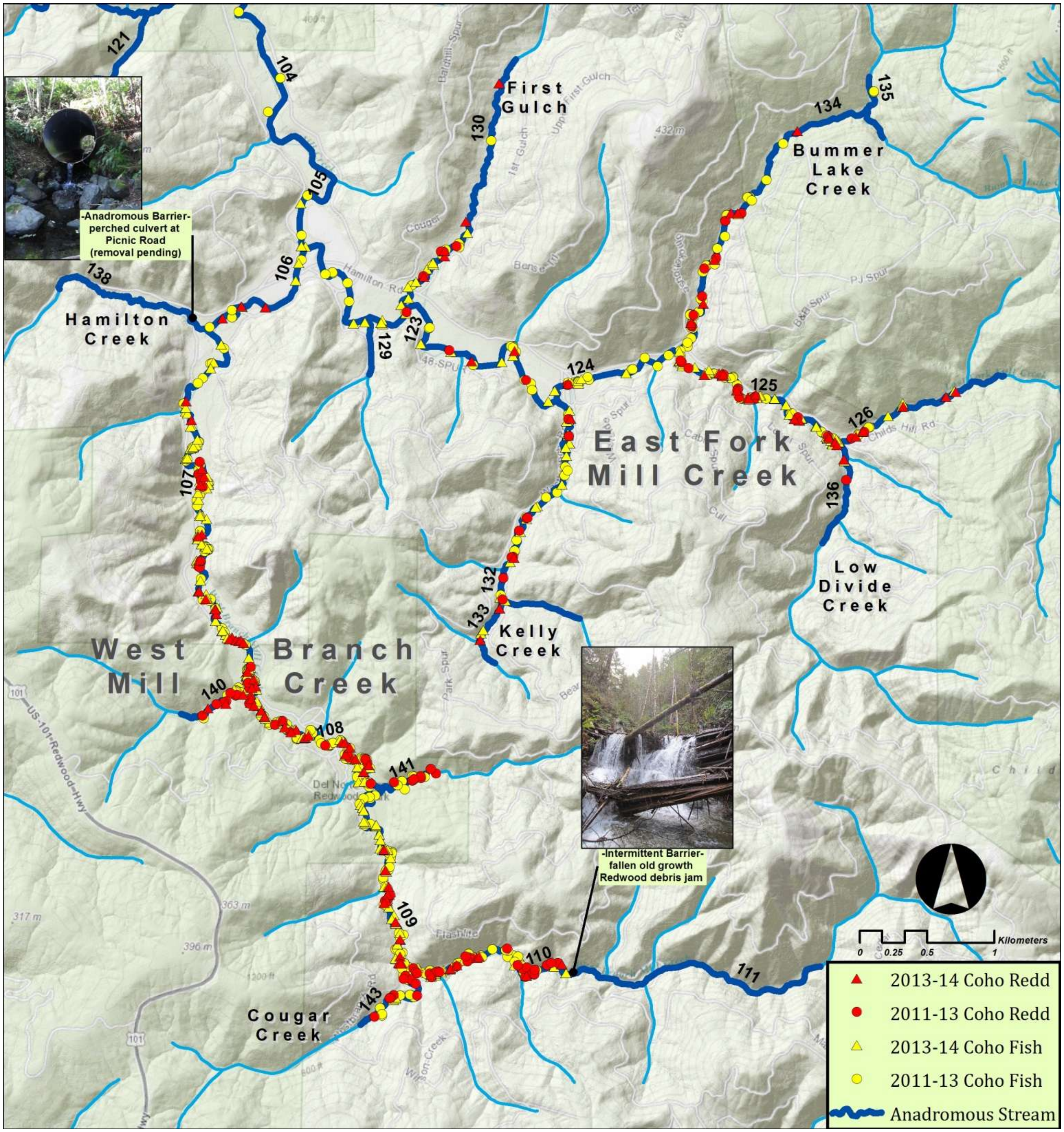

Figure 11. Distribution of observed adult coho salmon and verified coho salmon redds in the Mill Creek spawning ground census (Life Cycle Monitoring Station) area during the winters of 2011-2012, 2012-2013, and 2013-2014 Smith River Basin, Del Norte County, CA. Note: redd location symbols are displayed above fish observation symbols and may obscure fish observations in reaches containing high densities of verified redds. Although live coho salmon were observed holding in pools outside of the census region in the lower main stem Mill Creek, no coho salmon redds have been confirmed below the confluence of the East Fork and West Branch. Two current barriers blocking access to significant anadromous fish habitat are identified.

Table 8. Estimated total number of redds by species within the Mill Creek Life Cycle Monitoring Station for the winter of 2013-2014. 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	260	110	63
SE	3.2	0.4	1.7
Total within reach variance	10.1	0.1	3.0
95% CI	(253, 266)	(109, 111)	(59, 66)

2014 Spatial Structure Survey Results and Discussion

Sampling Effort and Coho Salmon Occupancy

We surveyed a total of 49 reaches and 18 sub-reaches during the summer of 2014 representing 38.5 percent of the total sampling frame in stream kilometers (Table 9). Surveys extended from June 18th to September 8th with 39 work days and 129 person days. Each survey reach required an average of 1.2 crew days to complete. Juvenile coho salmon were detected in five portions of the basin including the lower main stem Smith River and proximal tributaries, Rowdy Creek, Mill Creek, upper North Fork Smith River and the upper South Fork Smith River (Table 9, Figure 12). We documented coho salmon occurring in 23 out of 67 surveyed reaches and within 361 of 1525 sampled pools. The median number of coho salmon observed per pool equaled 12; range: 1 to 306 (Table 9). We determined 8 out of the 23 reaches (35%) with coho salmon were non-natal rearing areas (Table 9). However, only 3% 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 0.92 (SE= <0.02). Estimated large-scale probability of occupancy (ψ) equaled 0.35 (SE= 0.06), (Table 10). The estimate of conditional pool-level occupancy, given present in a reach($\theta|\psi$), equaled 0.67 (SE 0.02) (Table 10). We estimated the overall proportion of area occupied ($\theta * \psi$) as 0.23. Last, we incidentally detected juvenile coho salmon in four additional reaches (Location codes: 57, 68, 78, and 88) that were not part of the GRTS sample draw but were briefly inspected during field reconnaissance (Figure 12).

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, with the exception of Chinook salmon, were widely distributed throughout the basin during the summer of 2014 (Table 11, Figures 13 [Chinook salmon], 14 [trout spp.], and 15 [adult coastal cutthroat trout]) with ψ ranging from 0.45 (Chinook salmon) to 1.00 (YOY and 1+ 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 1+ trout (spp.) and 2012 coastal cutthroat trout (Table 10). Juvenile Chinook salmon had an estimated proportion of area occupied (PAO) of 0.15, equaling only 56% and 42%

of previous years. This large reduction of Chinook salmon space was likely influenced by the small adult return in the previous winter coupled with an extended drought period observed during the previous winter limiting spawning distributions. Last, we observed one adult chum salmon (*Oncorhynchus keta*) in reach 34 (Figure 1) of the North Fork Smith River representing a new record of this species occurring in the upper North Fork Smith River.

Table 9. Summary statistics of coho salmon occupancy and relative abundance based on snorkel surveys occurring in 67 GRTS drawn reaches during the summer of 2014, 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	6	798	6	4	5.0	20	Non-natal
Lower Smith River	10	2520	9	8	17.0	136	Non-natal
Lower Smith River	12	3335	6	6	5.8	35	Non-natal
Lower Smith River	14	2618	8	2	3.0	6	Non-natal
North Fork Smith River	32	2857	35	6	3.7	22	Non-natal
North Fork Smith River	34	2845	37	19	10.8	205	Natal
North Fork Smith River	36	1902	49	0	-	0	-
Rowdy Creek	59	1228	18	1	NA	1	Non-natal
Rowdy Creek	61	2320	19	0	-	0	-
Rowdy Creek	63	1446	32	0	-	0	-
Rowdy Creek Trib.	70	355	9	0	-	0	-
Rowdy Creek Trib.	71	356	2	0	-	0	-
Copper Creek	73	1098	22	0	-	0	-
Clarks Creek	96	2277	38	0	-	0	-
Clarks Creek Trib.	97	367	18	0	-	0	-
Clarks Creek Trib.	98	968	24	0	-	0	-
Mill Creek	101	1944	13	3	16.0	48	Natal
Mill Creek	102	2329	15	10	10.3	103	Natal
Mill Creek	103	1314	9	5	7.6	38	Natal
Mill Creek	105	1412	11	10	57.8	578	Natal
West Branch Mill Creek	107	2674	53	49	37.0	1815	Natal
West Branch Mill Creek	110	2382	40	32	24.2	774	Natal
Mill Creek Trib.	114	603	9	2	1.5	3	Non-natal
Mill Creek Trib.	118	676	7	0	-	0	-
Mill Creek Trib.	119	115	3	0	-	0	-
East Fork Mill Creek	123	2149	20	18	25.8	465	Natal
East Fork Mill Creek	125	1589	34	30	48.2	1446	Natal
East Fork Mill Creek Trib.	129	436	8	0	-	0	-
First Gulch	130	2506	84	70	11.1	774	Natal
Bummer Lake Creek	134	2997	73	51	12.8	651	Natal
Bummer Lake Creek Trib.	135	300	10	3	3.0	9	Natal
Low Divide	136	863	23	9	9.8	88	Natal
West Branch Mill Creek Trib.	140	741	20	19	14.3	272	Natal
Cedar Creek	146	2351	63	0	-	0	-
South Fork Smith River	160	1766	8	2	2.0	4	Non-natal
South Fork Smith River	166	3582	56	0	-	0	-
South Fork Smith River	168	1730	21	0	-	0	-
Craigs Creek	172	3310	43	0	-	0	-
Rock Creek	189	2075	34	0	-	0	-
Rock Creek Trib.	192	151	7	0	-	0	-
Rock Creek Trib.	193	2280	39	0	-	0	-
Rock Creek Trib.	194	296	4	0	-	0	-
Rock Creek Trib.	195	171	2	0	-	0	-
Goose Creek	203	2057	22	0	-	0	-
Goose Creek	205	1704	10	0	-	0	-
Goose Creek	206	1414	10	0	-	0	-
Goose Creek Trib.	211	92	2	0	-	0	-
Hurdygurdy Creek	219	2729	14	0	-	0	-
Hurdygurdy Creek Trib.	230	1835	32	0	-	0	-
Jones Creek	234	2445	16	0	-	0	-
Jones Creek	236	2232	8	0	-	0	-
Eightmile Creek	253	2178	21	0	-	0	-
Middle Fork Smith River	276	3987	7	0	-	0	-
Middle Fork Smith River	282	3236	22	0	-	0	-
Middle Fork Smith River	285	1944	23	0	-	0	-
Patrick Creek	303	2250	22	0	-	0	-
Patrick Creek	305	1666	21	0	-	0	-
Monkey Creek	318	2513	31	0	-	0	-
Siskiyou Fork	326	1187	10	0	-	0	-
South Siskiyou Fork	331	1888	32	0	-	0	-
Griffin Creek	337	2336	33	0	-	0	-
Cedar Creek (North Fork Smith)	384	2115	49	0	-	0	-
Baldface Creek	392	2473	36	0	-	0	-
Baldface Creek Trib.	403	78	3	0	-	0	-
Baldface Creek Trib.	404	106	6	0	-	0	-
Horse Creek	421	1973	47	2	1.5	3	Natal
North Fork Smith River Trib.	422	249	7	0	-	0	-
Total			1525	361		7496	

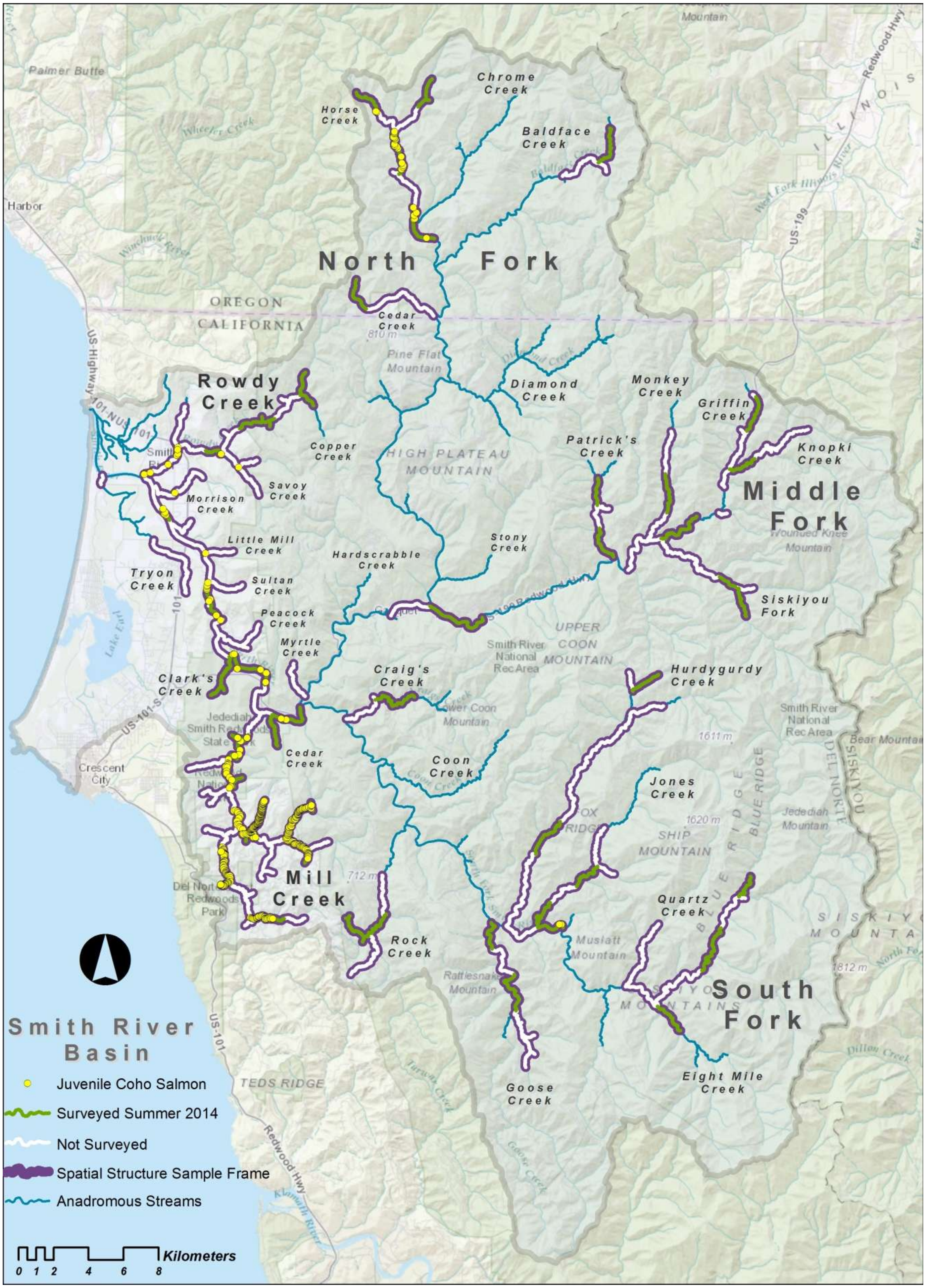

Figure 12. Map showing annual spatial structure survey reaches and the spatial distribution of pools containing juvenile coho salmon from summer 2014, Smith River Basin, California and Oregon. Note: some minimal incidental observations are included on the map in areas outside of the GRTS sampled portion.

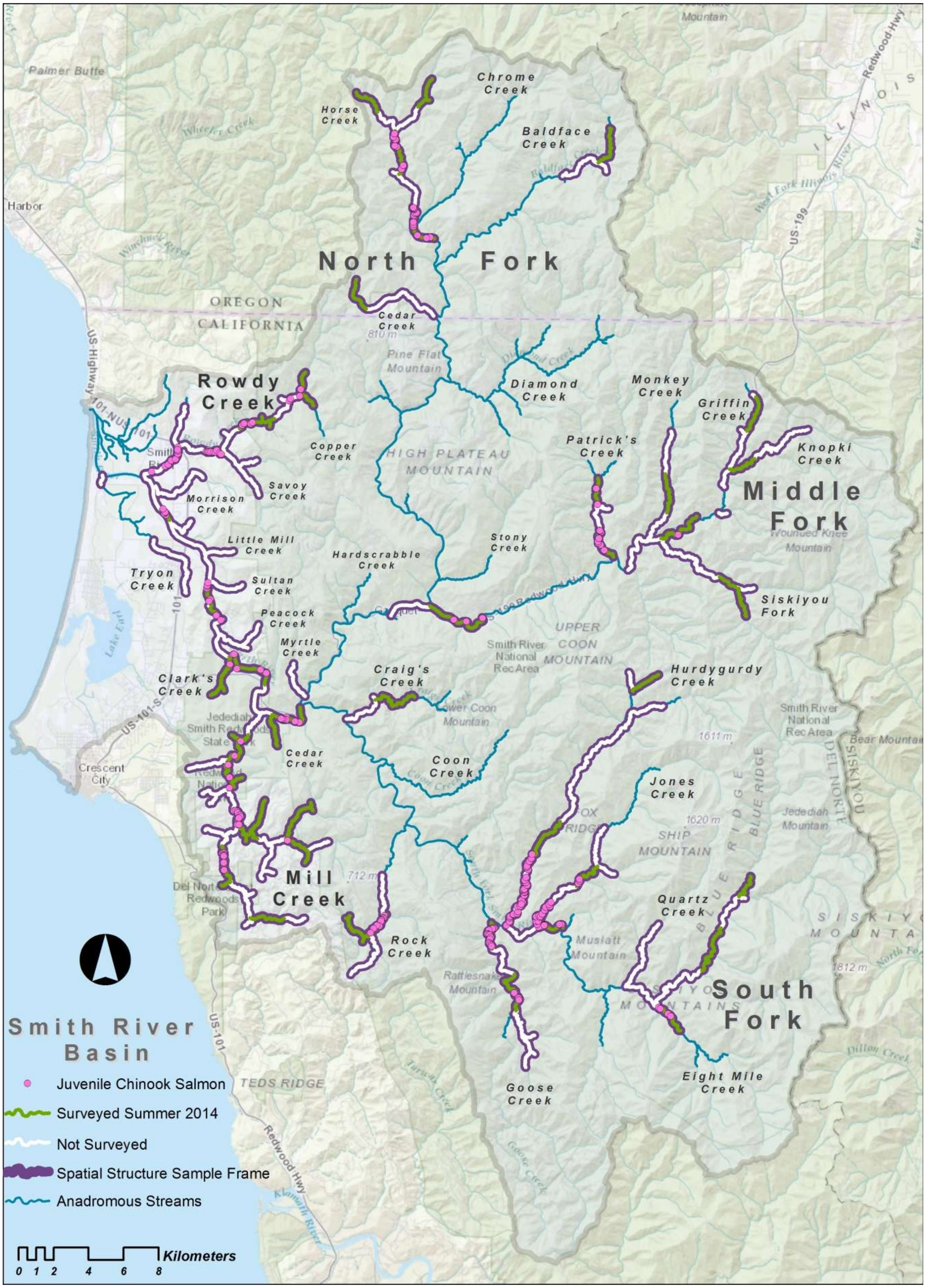

Figure 13. Map showing annual spatial structure survey reaches and the spatial distribution of pools containing juvenile Chinook salmon from summer 2014, Smith River Basin, California and Oregon. Note: some minimal incidental observations are included on the map in areas outside of the GRTS sampled portion.

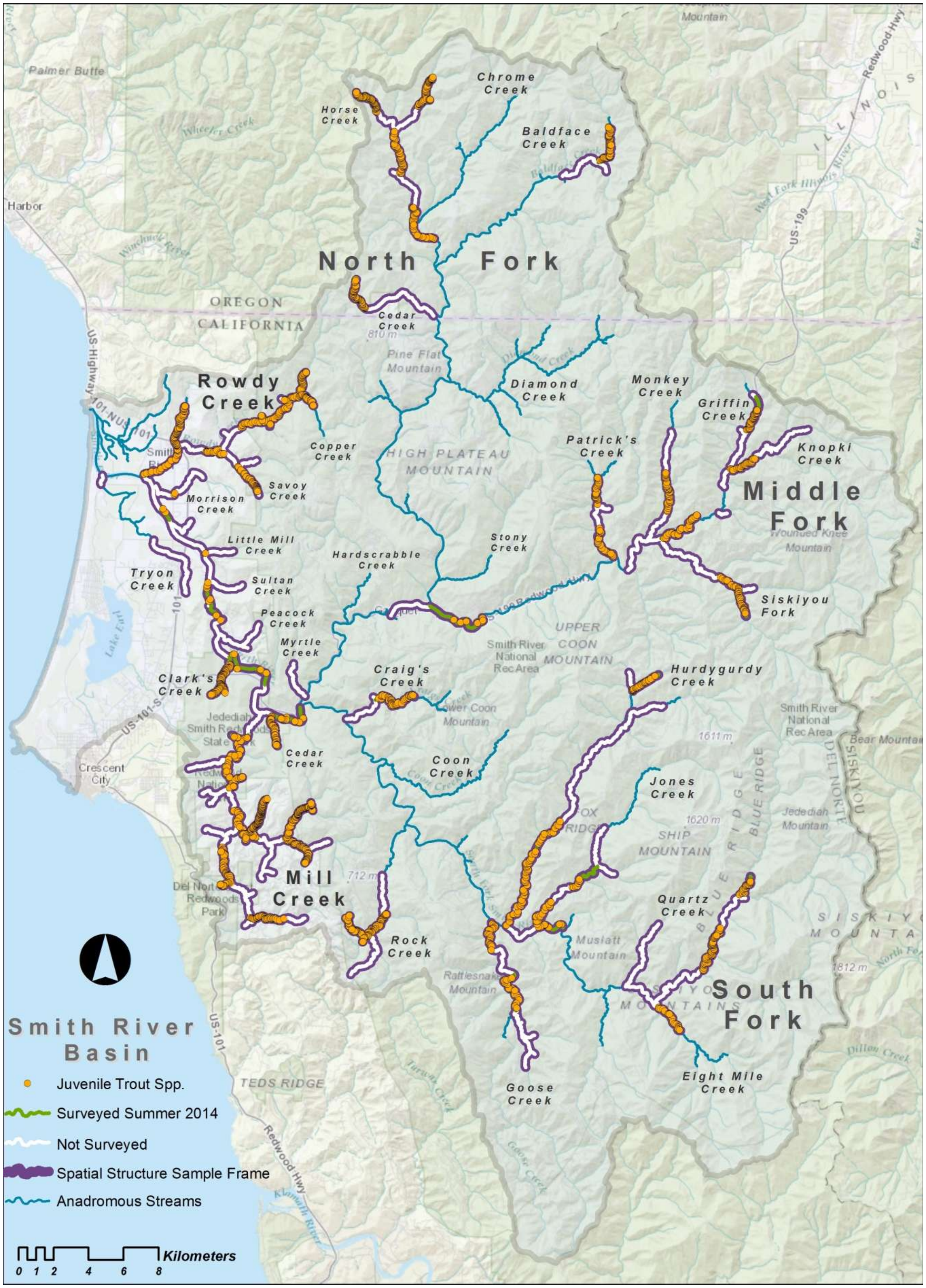

Figure 14. Map showing annual spatial structure survey reaches and the spatial distribution of pools containing juvenile trout (spp.) from summer 2014, Smith River Basin, California and Oregon. Note: some minimal incidental observations are included on the map in areas outside of the GRTS sampled portion.

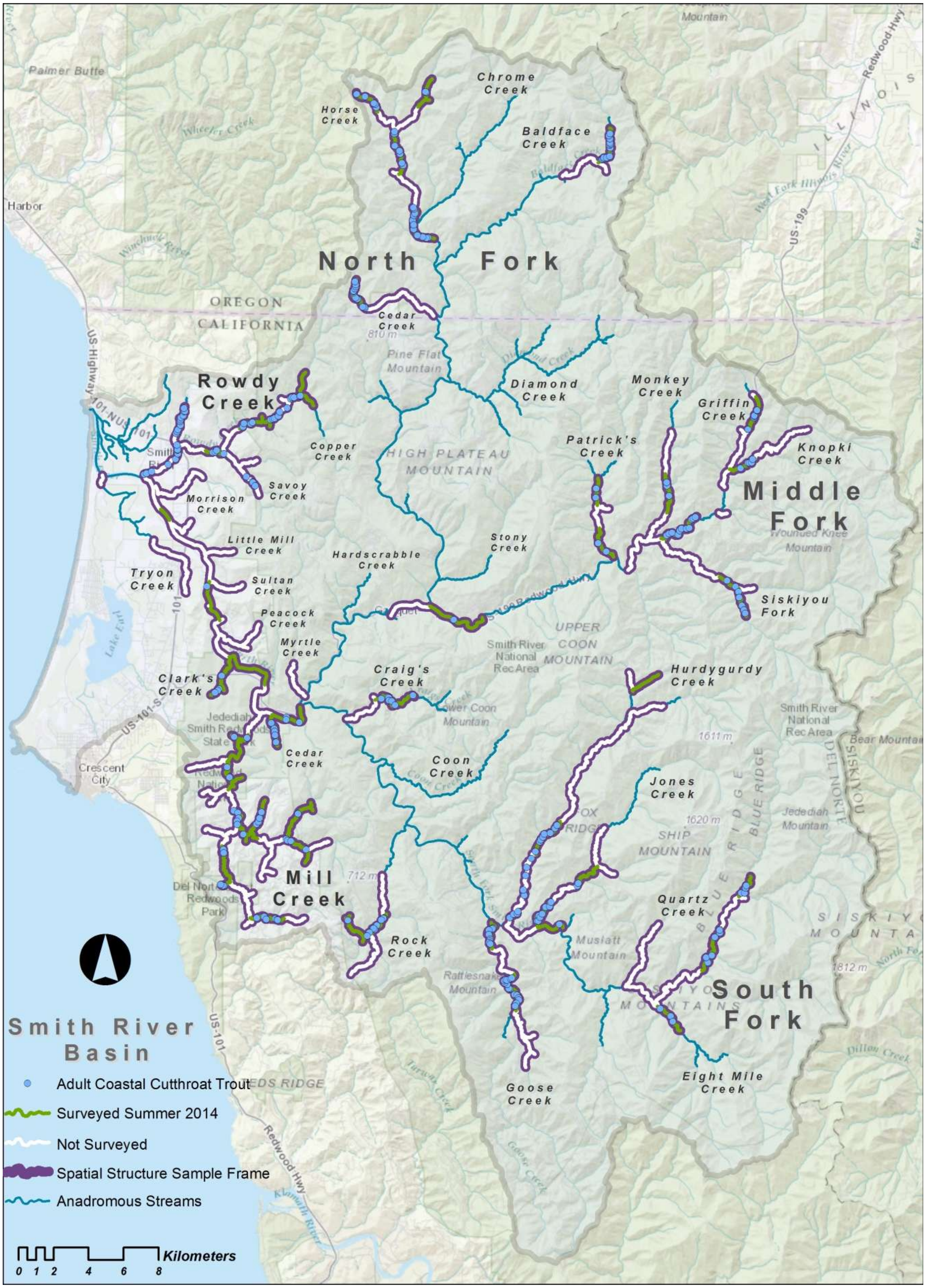

Figure 15. Map showing annual spatial structure survey reaches and the spatial distribution of pools containing adult coastal cutthroat trout from summer 2014, Smith River Basin, California and Oregon. Note: some minimal incidental observations are included on the map in areas outside of the GRTS sampled portion.

Table 10. Occupancy estimates, proportion of area occupied, and relative count densities if salmonids for the summer spatial structure survey during 2012, 2013 and 2014, 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

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.
[1]High counts of coho salmon in Mill Creek reaches, relative to other portions of the basin, make the median more representative of central tendency.

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	6	798	6	5	1.4	2	1.0	1	1.0	-	-
Lower Smith River	10	2520	9	7	15.9	7	6.4	7	5.9	1	1.0
Lower Smith River	12	3335	6	4	18.3	5	5.0	2	4.0	-	-
Lower Smith River	14	2618	8	7	10.3	8	7.3	7	4.6	3	1.0
North Fork Smith River	32	2857	35	14	5.6	35	18.1	24	4.3	13	1.5
North Fork Smith River	34	2845	37	7	1.9	36	15.8	34	7.4	7	1.1
North Fork Smith River	36	1902	49	-		48	11.4	39	3.8	2	1.0
Rowdy Creek	59	1228	18	12	3.9	18	198.5	16	11.9	4	2.8
Rowdy Creek	61	2320	19	4	3.0	19	156.4	19	9.6	6	1.7
Rowdy Creek	63	1446	32	1	2.0	29	29.0	21	2.5	-	-
Rowdy Creek Trib.	70	355	9	-	-	8	1.6	8	1.5	-	-
Rowdy Creek Trib.	71	356	2	-	-	2	2.5	2	1.5	-	-
Copper Creek	73	1098	22	-	-	21	25.2	19	3.1	1	1.0
Clarks Creek	96	2277	38	1	8.0	30	3.8	32	3.1	1	1.0
Clarks Creek Trib.	97	367	18	-	-	11	2.1	12	1.3	-	-
Clarks Creek Trib.	98	968	24	-	-	8	1.6	17	2.2	3	1.0
Mill Creek	101	1944	13	1	6.0	11	14.2	6	2.5	1	2.0
Mill Creek	102	2329	15	2	1.5	15	14.3	8	4.9	1	3.0
Mill Creek	103	1314	9	2	4.5	8	29.5	3	2.3	1	1.0
Mill Creek	105	1412	11	8	9.5	10	87.2	8	4.8	5	1.4
West Branch Mill Creek	107	2674	53	7	1.7	49	58.8	34	5.1	3	1.0
West Branch Mill Creek	110	2382	40	-	-	39	24.7	38	5.1	6	1.2
Mill Creek Trib.	114	603	9	-	-	1	1.0	5	1.2	1	1.0
Mill Creek Trib.	118	676	7	-	-	7	3.1	6	1.5	-	-
Mill Creek Trib.	119	115	3	-	-	2	3.5	2	1.0	-	-
East Fork Mill Creek	123	2149	20	1	2.0	20	28.1	8	3.1	1	1.0
East Fork Mill Creek	125	1589	34	1	2.0	30	62.5	29	5.9	4	1.3
East Fork Mill Creek Trib.	129	436	8	-	-	1	2.0	3	1.7	-	-
First Gulch	130	2506	84	-	-	77	6.4	72	3.6	4	1.0
Bummer Lake Creek	134	2997	73	-	-	71	11.1	56	3.1	1	1.0
Bummer Lake Creek Trib.	135	300	10	-	-	7	4.9	7	1.7	-	-
Low Divide	136	863	23	-	-	20	10.3	17	2.2	-	-
West Branch Mill Creek Trib.	140	741	20	-	-	17	4.9	11	2.5	3	1.0
Cedar Creek	146	2351	63	-	-	55	9.8	27	1.9	6	1.0
South Fork Smith River	160	1766	8	7	7.7	8	17.1	6	4.5	1	1.0
South Fork Smith River	166	3582	56	-	-	52	47.1	47	16.0	6	1.3
South Fork Smith River	168	1730	21	-	-	20	37.4	19	13.2	4	1.0
Craigs Creek	172	3310	43	-	-	43	41.8	38	7.4	7	1.1
Rock Creek	189	2075	34	10	1.5	34	33.9	30	13.1	7	1.4
Rock Creek Trib.	192	151	7	-	-	6	14.7	6	4.2	-	-
Rock Creek Trib.	193	2280	39	-	-	39	24.2	21	3.4	2	1.0

Continued on next page…

Table 11. Continued…

Rock Creek Trib.	194	296	4	-	-	4	14.3	4	1.8	-	-
Rock Creek Trib.	195	171	2	-	-	2	5.5	-	-	-	-
Goose Creek	203	2057	22	13	15.0	22	77.9	21	27.0	8	2.1
Goose Creek	205	1704	10	-	-	10	156.5	10	19.1	9	2.1
Goose Creek	206	1414	10	3	1.7	10	207.5	10	30.6	6	3.3
Goose Creek Trib.	211	92	2	-	-	2	11.0	1	1.0	-	-
Hurdygurdy Creek	219	2729	14	-	-	14	47.3	14	15.1	8	1.5
Hurdygurdy Creek Trib.	230	1835	32	-	-	21	2.8	24	2.3	-	-
Jones Creek	234	2445	16	14	10.4	16	49.6	16	16.8	8	1.8
Jones Creek	236	2232	8	3	4.3	8	32.4	8	13.8	2	1.5
Eightmile Creek	253	2178	21	4	1.5	20	31.2	19	14.2	3	1.3
Middle Fork Smith River	276	3987	7	3	1.7	7	13.4	3	3.7	1	1.0
Middle Fork Smith River	282	3236	22	1	1.0	22	116.0	21	10.4	11	2.0
Middle Fork Smith River	285	1944	23	-	-	23	32.2	22	4.2	5	1.0
Patrick Creek	303	2250	22	7	4.6	22	34.9	16	3.5	2	1.0
Patrick Creek	305	1666	21	2	2.0	20	22.5	18	4.3	2	1.0
Monkey Creek	318	2513	31	-	-	31	15.9	31	3.2	3	1.0
Siskiyou Fork	326	1187	10	-	-	10	55.0	9	10.6	2	1.5
South Siskiyou Fork	331	1888	32	-	-	32	23.2	28	7.0	5	1.2
Griffin Creek	337	2336	33	-	-	32	9.2	27	3.5	6	1.3
Cedar Creek (North Fork Smith)	384	2115	49	-	-	43	5.8	41	2.9	13	1.0
Baldface Creek	392	2473	36	-	-	36	28.1	32	9.2	13	1.8
Baldface Creek Trib.	403	78	3	-	-	3	2.3	3	1.3	-	-
Baldface Creek Trib.	404	106	6	-	-	6	2.8	3	2.7	-	-
Horse Creek	421	1973	47	-	-	38	4.1	43	2.7	5	1.2
North Fork Smith River Trib.	422	249	7	-	-	6	2.3	6	1.5	-	-

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