STATE OF WASHINGTON December 2018

Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2017-2018

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FISH AND WILDLIFE
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FPT 18-09

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December 2018

Acknowledgements

We would like to thank Mike Scharpf for comments made to this draft and our surveyors for collecting data and samples: Brian Barry, Oliver Crew, Amy Edwards, Kim Figlar-Barnes, Chad Gabreski, Jesse Guindon, Craig Loften, Chris Mattoon, Danielle Williams, and Justin Zapata. Thanks to Kim Figlar-Barnes who reconciled and input data. Scale ages were provided by WDFW Fish Ageing and Otolith Laboratories staff. We would also like to thank Panesko Tree Farm, Green Diamond Resource Company, and the Weyerhaeuser Corporation for allowing access to survey on their property.

This work was funded by the Washington State Legislature with funding designated for study, analysis, and implementation of flood control projects in the Chehalis River Basin. Projects under this funding were selected to fill key information gaps identified in the Aquatic Species Enhancement Plan Data Gaps Report published in August 2014. Project funding was administered by the Washington State Recreation Conservation Office.

Recommended citation: L. Ronne, N. Vanbuskirk, C. Holt, and M. Zimmerman. 2018. Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2017-2018, FPT 18-09. Washington Department of Fish and Wildlife, Olympia, Washington.

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Executive Summary

Flood control alternatives being analyzed as part of the Chehalis Basin Strategy include a dam that would be located in the main stem Chehalis River at river mile 108.2 upstream of the town of Pe Ell. Monitoring efforts in the Chehalis River basin have not historically focused on delineating population trends above or below the location of the proposed dam. Information on spawner abundance and distribution data in this area of the river was identified as a data gap by the Aquatic Species Enhancement Plan Technical Committee of the Chehalis Basin Strategy (Aquatic Species Enhancement Plan Technical Committee, 2014). This study was undertaken to understand the numbers and species of salmonids that would be affected above, within and below the footprint of the proposed dam and its associated reservoir. This work also informs fish passage needs should a dam be chosen as a structural solution to flooding within the Chehalis Basin.

Two types of surveys methods were used to evaluate salmonid spawners above the proposed dam site – index surveys were conducted at approximately seven day intervals throughout the spawning period and supplemental surveys were conducted once during peak spawning. Together, index and supplemental surveys covered the entirety of known spawning habitat for each species. Surveys started the third week of September based on prior knowledge of when fish (spring Chinook) begin spawning and continued on a weekly basis through the spawning seasons for spring and fall Chinook salmon, Coho salmon, and winter Steelhead. Surveys concluded in mid-June when no new redds were observed for two consecutive weeks at the end of the project spawning period. An additional survey of the main stem Chehalis River from river mile 108.2 (proposed dam site) downstream to the Newaukum River confluence (RM 75.4) was conducted four times, once during the peak spawn timing for each species and run type. The purpose of these additional surveys was to document the spatial distribution of spawning in the main stem river.

Surveys were conducted either on foot, pontoon-style boats or helicopter. Crews identified and recorded all spawning activity by species per reach segment. Individual redd locations were georeferenced. Live and dead fish counts included the species and sex. Dead fish or carcass sampling included fin mark sampling, fish length, coded wire tag (CWT) status and scale collection for aging Chinook and Steelhead. Additional tissue samples were taken for Coho genetic analysis.

Results from 2017-2018 coincide with the previous year's results (2013-2017) and document the importance of the reaches upstream, within, and below the proposed dam footprint and associated reservoir as a spawning area for spring and fall Chinook, Coho, and winter Steelhead:

- The majority of spawners observed for all species in this area of the watershed were wild; hatchery fish were rare.
- Abundance of spring and fall Chinook salmon within the study area was estimated to be 8 (spring) and 239 (fall) adult spawners. Chinook spawning activity was observed between September and December. Both spring and fall Chinook spawned primarily in the main stem river, 100% and 97% respectively. The percentage of fall Chinook redds found within the dam inundation footprint was 95%. Spring Chinook had only one of the three (33%) redds observed in the inundation footprint.
- Abundance of Coho salmon within the study area was estimated to be 1240 adult spawners. Coho spawning activity was observed between mid-November and February with 33% spawning in the inundation footprint.
- Abundance of winter Steelhead within the study area was estimated to be 942 adult spawners. Steelhead spawning activity was observed between the months of February and June. Steelhead redds observed prior to March 15th composed 9% of the total observed redds. The percentage of estimated redds of pre-March 15th and post March 15th in the inundation footprint were 39% and 23%, respectively.

- On the main stem river from the proposed dam site to Newaukum River, we observed very little Coho and Steelhead spawning but substantial spring and fall Chinook spawning activity. The highest density of fall Chinook occurred between the proposed dam site (RM 108.2) and Elk Creek (RM 100.2). In contrast, spring Chinook spawning distribution was more evenly spread between the proposed dam site and the Newaukum River.

Introduction

Understanding the numbers and diversity of wild salmon and steelhead in the Upper Chehalis River is an important part of the Chehalis Basin Strategy. The Aquatic Species Enhancement Plan Technical Committee (2014) identified adult monitoring of adult salmon and steelhead as an information gap for the area of the Chehalis River where a proposed dam site may be located upstream of the city of Pe Ell, Washington (Figure 1). Chehalis River and its tributaries upstream of river mile (RM) 108.2 near Pe Ell are described as the 'Upper Chehalis River sub-basin' in this report. Spring and fall Chinook salmon (*Oncorhynchus tshawytscha*), Coho salmon (*O. kisutch*), and winter-run Steelhead (*O. mykiss*) (hereafter referred to as Steelhead) were previously known to spawn in this area of the river. Construction of a dam would alter the existing habitat and interrupt their migration patterns in the river. Therefore, there is a need to understand the current migration timing, numbers, and distribution of salmon and steelhead that would be affected within and above the proposed dam footprint and determine fish passage needs of the dam structure.

Spawning ground surveys (redd counts and live counts) along with carcass sampling are commonly used to assess abundance and biological characteristics of adult salmonid spawners (Johnson et al. 2007). In the Upper Chehalis River sub-basin, surveys were conducted throughout the known distribution and the spawn time of each species with additional effort to obtain the upper limits of each species' spawning distribution. These surveys provided intensive and fine-scale information on salmonid use and expanded the spatial coverage of long-term index reaches surveyed by the Washington Department of Fish and Wildlife (WDFW) for stock assessment purposes in the entire Chehalis basin. This report summarizes the results of surveys conducted between September 2017 and June 2018.

Objectives

The overall goal of this study was to describe the abundance, spawn timing, spatial distribution, and diversity of spring and fall Chinook, Coho, and Steelhead in the Upper Chehalis River sub-basin and to document the spatial distribution of spawning in the main stem river downstream of the proposed dam site. In order to accomplish this goal, our objectives were to:

- Conduct weekly surveys by foot or pontoon boat (as conditions allow) and collect information on live fish, carcasses, and redds,
- Calculate the abundance of each species and summarize results related to timing, spatial distribution and diversity of spawners,
- Conduct a peak survey on the main stem river below the proposed dam site for each species collecting information on spatial distribution of spawning, and
- Interpret results with respect to potential impacts of the proposed dam near Pe Ell, WA.

Methods

Study Area

The majority of the land in the Upper Chehalis River sub-basin is owned by Weyerhaeuser Corporation, a privately owned tree farm, with smaller holdings by Panesko Tree Farm, and Green Diamond Resource Company. This area is regenerated Douglas fir managed for production, and the forest ranges in age from freshly harvested to harvest age (40 to 55 years old). Newly harvested sections of the landscape are clear cut, creating open areas with low brush and stumps. Logging roads created to generate access for timber harvest are also used to access streams for surveying.

Prior to 2013, index reaches surveyed for salmon and steelhead were designed as part of a Chehalis basin wide stock assessment effort and had limited spatial coverage within the Upper Chehalis River sub-basin. The current project intensified the spatial and temporal coverage of surveys above the proposed dam site. At the start of this project, spatially continuous survey reaches were added to the project area to create a more inclusive picture of the salmonid use above river mile (RM) 108.2 (Ashcraft et al. 2017). The original extent of these reaches included in the survey frame was selected using the WDFW stream catalog as a guide for potential spawning distribution of each species (Phinney and Bucknell 1975) and prior knowledge within District 17. This survey frame has been further refined over five seasons based on observed spawning distributions (Figure 1; details on survey reaches are provided in the Appendix A).

There were two primary types of surveys used for this project: index and supplemental. Index surveys were designed to cover all or most of the available anadromous areas and occurred approximately every seven days. These surveys were conducted throughout the breath of the spawn timing of all salmon and steelhead in the project area. If heavy rain events were forecasted index surveys were conducted less than seven days apart, or if high water prevented surveying they were conducted more than seven days apart. Supplemental surveys were performed once during peak spawning to cover any potential spawning habitat that was unable to be covered on a weekly basis. The observational relationships between index and supplemental surveys, above the proposed dam site, are used to expand supplemental surveys observations. The index surveys covered 16 sections of the Upper Chehalis including the main stem Chehalis River, Crim Creek and its tributary Lester Creek, Big Creek and its tributary 1179C, Roger Creek, Alder Creek, Thrash Creek, Mack Creek, East Fork (EF) Chehalis River and its tributaries 1211 and 1213, Cinnabar Creek, George Creek, and the West Fork (WF) Chehalis River and its tributary Sage Creek. These 16 sections were further divided up into 41 index reaches for the purpose of surveying. The additional division used distinct breaks in the river environment such as a bridge crossing or at the mouth of a tributary joining the reach, which were accessible by the road system. If no distinct break was observed, flags were added to indicate start and stop breaks between reaches. The reach breaks were created to allow for multiple surveyors in one area, instead of one surveyor conducting the survey for the entire stream. The breaks also defined the spatial distribution of redds among survey reaches. Supplemental surveys were conducted for Coho and Steelhead at the upper extent of the index reaches and in smaller tributaries where it is logistically unfeasible to survey weekly. Spring and fall Chinook did not require any upper supplemental since all the spawning occurred within the index surveys. In an effort to generate a baseline for future monitoring if the dam is installed and to determine the lower extent of spawning in the mainstem above the Newaukum River, a supplemental survey below the dam was implemented for each species during peak spawning. Supplemental surveys were conducted on the ground by foot, raft or flights to the Newaukum River for fall Chinook, spring Chinook and Steelhead. Coho supplemental surveys were conducted from the proposed dam site to Adna, WA (RM 81.2).

Figure 1. Map of Water Resource Inventory Area (WRIA) 23 containing the Upper Chehalis River sub-basin. Black star denotes the location of the proposed dam at river mile 108.2. Black box denotes the project area.

The survey frame for each species was modified slightly based on stream flows and the ability of fish to access certain areas. For example, no Chinook were observed upstream of RM 0.8 in the Crim Creek index reaches in 2017 so no supplemental survey was done above RM 2.9. The absence of Chinook within their potential spawning distribution was determined two ways: by an intensive survey week at the beginning of the survey season to determine presence or absence of live fish, and by the height of water in the survey reach which was determined for each reach. For example, a complete survey would be done for each of the three index reaches in Crim Creek, and if no fish or redds were seen and the water level was low, then only the bottom reach is surveyed until either fish or redd presence was recorded or the water level rose.

Coho and Steelhead had similar total river miles (Table 1) surveyed among years for both index and supplemental reaches. Variation in survey coverage among seasons was due to temporary impediments, such as poor weather conditions, or logging activity, and instream passage barriers, such as log jams or substrates that change from year to year. Logging activity is unique to specific survey reaches and years and occasionally limited surveyor access to a particular reach due to activity near the water (creating safety concerns, or closure of roads needed to reach survey area).

Table 1. Total river miles in the Upper Chehalis River sub-basin surveyed for each species and year. (IND: Index survey, and SUP: Supplemental survey)

	Spring Chinook[a]		Fall Chinook[a]		Coho		Steelhead	
Survey Season	IND	SUP	IND	SUP	IND	SUP	IND	SUP
2013-2014	29.2	---	30.0	---	33.2	10.8	34.6	7.1
2014-2015	27.7	---	31.7	---	35.5	9.9	34.8	15.5
2015-2016	21.5	---	31.7	---	35.5	12.7	34.8	17.2
2016-2017	31.0	---	31.5	7.3	36.8	14.2	36.8	14.8
2017-2018	31.0	---	31.5	---	37.1	15.4	37.7	15.1

[a] No supplemental surveys were conducted for spring or fall Chinook in 2017-18 season because their entire spawning distribution was included in the index surveys.

Data Collection

Spawning ground surveys were conducted for spring and fall Chinook from September through mid-December, Coho from October through February, and Steelhead from December through June. Index reaches were surveyed weekly when possible unless weather conditions, stream flows, clarity, or logging activity made the survey impossible due to limited access, safety concerns, or lack of visibility. Surveys of index reaches started before spawning began in the study area (based on prior knowledge of the basin) and continued until no new redds were observed for two consecutive weeks during the end of the projected spawning period. Supplemental reaches were surveyed four times per season (once per species) with the timing of these surveys selected to be close to peak spawn timing for each species to maximize the numbers of redds visible for enumeration. Supplemental reaches above the proposed dam site were the terminal ends of tributaries. The supplemental reach below the proposed dam site was the main stem river downstream to the confluence with the Newaukum River.

During each survey, we collected information on water clarity, stream flow, riffle and pool visibility, direction being surveyed, and weather (Appendix C). Water clarity was visually approximated as depth (ft.) the surveyor could see in the water column. Stream flow was described on a 1-5 scale, where 1 indicates low flow/height and 5 indicates high flow/height for the reach. Riffle visibility was described as how well fish could be observed in riffle habitat on a qualitative 1-5 scale, where 1 is excellent visibility and 5 is poor visibility. Pool visibility was described as how well fish could be observed in pool habitat on a qualitative 1-5 scale, where 1 is excellent visibility and 5 is poor visibility. The direction being surveyed was either upstream or downstream. The weather was recorded as sunny/clear, cloudy/overcast, rain, or snow. In an effort to standardize observer efficiency, all surveyors wore polarized sunglasses and a brimmed hat while conducting surveys.

Surveys were conducted on foot or by pontoon boat and all spawning activity was recorded by species and reach. Surveys included monitoring new and old redds, counting live and dead fish, and sampling carcasses for both fin mark sampling and biological collections.

Redds

A redd was defined as an excavation made in the stream bed by a female salmonid that contains a partial or full complement of her eggs. A test dig was defined as an excavation that does not contain eggs. The distinction between redds and test digs was important because observed excavations interpreted to be test digs were not used to estimate spawner abundance. For salmon, a redd was recorded when the nest had a defined tail spill (a mound of gravel deposited on the downstream end of the dig during initial excavation) a pit (a pocket in the substrate created during the initial excavation) and a mound (mound of gravel burying deposited eggs) within the pit. Salmon, in general, do not construct many test digs and the females guard their nests after laying eggs. As a result, many salmon redds have an associated live fish over multiple weeks after construction. For Steelhead, our protocol was to call excavations over six feet in length 'redds', and excavations under six feet 'test digs'. However, in small streams where spawning gravel patches were sometimes limited in area, surveyor identified excavations under six feet as redds if the surveyor observed evidence of excavation of a pit, deposition of gravel substantial enough to indicate the reburial of eggs.

Each redd was identified to species, flagged and numbered for future identification. The number consisted of three pieces of information: species code, statistical week (Appendix B), and a unique redd number for that survey reach. Surveyors obtained latitude and longitude locations for each new redd on a handheld Garmin GPSMAP 78sc. In the field, redds were flagged and marked with a distance from the flag to the leading edge of the pit in order to track future redd visibility, identify upstream expansion of the dig, and interpret superimposition by other female salmonids. Previously constructed redds were tracked during subsequent surveys based on their condition (new, 25%, 50%, 75%, or 100% deteriorated) until determined to be absent (Table 2). Redd visibility is variable over survey weeks due to stream flow, scouring, algal growth, location of redd in the river channel, size of redd, superimposition by another redd, and sedimentation.

Table 2. Redd condition categories and their description.

Redd condition	Description
New (N)	Substrate contrasting from surrounding gravel, well defined pit, and mounding
25% deteriorated	Colored up (by algae) at borders of redd, some hydrologic damage
50% deteriorated	Algae ~50%, hydrologic damage - flatter in tail
75% deteriorated	Algae 50-100% but structure good, can distinguish from test dig or scouring
100% deteriorated	Algae 100%, pocket and tail flattened by hydrologic damage but still distinguishable from test dig or scouring
Absent (A)	Absent – either not visible or there is very poor structure not distinguishable between hydrologic damage, or test digging

Since spatial and temporal overlap in spawning activity occurs between fall Chinook and Coho, and between Coho and Steelhead, surveyors were trained to recognize the redd differences between each species based on habitat use and redd structures. Although there are exceptions, Chinook generally prefer to spawn in medium to large rivers with large gravel, and redds are typically long and wide with a well-defined pit and large wavy mounding through the tail spill. Coho prefer to spawn in small streams with smaller gravel and moderate gradient, typically near the edges of the streams or in braids and side channels. Coho redds are well-defined like Chinook redds but narrower and smaller, and will often contain more irregularities in shape due to site selection. Chinook will spawn in deeper water and larger gravel than Coho. Steelhead spawn in faster flowing water than Coho, and redds can be found throughout

the wetted width of the river channel (from margins to mid-channel). Steelhead redds have shallower pockets compared to Coho redds and are typically dug in larger substrate.

There are some factors that may prevent surveyors from identifying a redd properly: overlapping redds counted as a single redd, counting natural scouring as a redd, weather condition or stream flows that reduce visibility of redds, and not surveying all possible spawning areas within a survey. A strong effort was made to reduce this error by using well-trained and experienced surveyors and consistent survey gear (i.e., polarized glasses and brimmed hats). In addition, surveyors continually explored potential spawning areas through supplemental and spot surveys, and optimize survey times to maximize visibility associated with corresponding weather events (e.g., when a rain event is anticipated, we survey main stem prior to small rain events and then survey tributaries that are less affected by rain events and still have good water clarity during rain events). Spot surveys were often performed after a high flow events to determine if spawning occurred above a partial barrier or the normal distribution. Spot surveys focused on known spawnable habitat to determine if any presence was indicated.

We followed the WDFW Region 6 District 17 protocol to assign run type (spring or fall) of a Chinook salmon redd based on timing, redd condition, and phenotypic characteristics, behavior, and condition of associated live fish observed with the redd. These assignments also use information on observations of fall Chinook activity, flow levels, and other spawning activity within the basin. Redds constructed after October 15th were all assumed to be fall Chinook, but redds constructed on or prior to October 15th were assigned either spring or fall Chinook based on the condition of live fish associated with the redd (Appendix D). If a surveyor was unable to make an informed decision on run type of a redd constructed on or prior to October 15th, the redds was assumed to be spring Chinook.

Live fish

Surveyors counted live fish while surveying and recorded species, sex, and mark status (adipose fin present or absent) if possible. All live Steelhead were counted but not assigned as male/female, due to less morphological differentiation between males and females than other salmonids.

Surveyors were trained to recognize species differences among live fish. Mature adult Chinook are generally larger than Coho and Steelhead, are olive green-brown (may also be a darker purple-red color), with large, conjoined spots on back and upper/lower tail lobes, and have black gums. Mature adult Coho are generally smaller than Chinook, with a more forked tail, and a red body for males, and dark purple body for females, both with spots on back and upper lobe of tail. Mature male adult Coho also have a very pronounced kype, or curvature to their jaws. Mature adult Steelhead have a large square tail, many small spots on body and tail, and olive green brown body coloration with a stripe of red or pink color along the length of the body, with a reddish coloring on the operculum. Both Chinook and Coho die after spawning and the female typically guards her redd until death after laying eggs. Steelhead, unlike Chinook and Coho, are iteroparous, meaning that they do not die after spawning and can spawn in more than one year. As a result, Steelhead are less likely to be observed with redds after spawning than Chinook or Coho.

Carcasses

Carcasses were sampled for all species. Few Steelhead carcasses were recovered due to their iteroparous life history. For each carcass, surveyors recorded the species, sex (and if female, determined spawning success), and mark status (i.e., adipose-clipped, CWT presence). Run type of Chinook carcasses in the field was assigned as spring or fall based on timing, coloration, and fungus condition (Appendix D). After sampling was complete, the caudal fin was removed from the carcass to identify the fish as previously sampled if seen in later surveys. Surveyors sampled all carcasses where the species, or previously sampled status (cut caudal fin) could be determined. Sex was recorded as male, female or sex not determined (SND). Jacks were determined by fork length for each species: 60 cm or less for Chinook, and 50 cm or less for Coho. Steelhead were determined to be adults if the fork length measured 50 cm or

longer, with fish less than 50 cm recorded as Rainbow "resident" trout. Spawning success of females was determined as yes or no by splitting the belly of the female. If there was less than 25% of eggs still in the carcass, spawning was determined successful.

Mark status is an important data record as it provides information about the origin of the fish, whether hatchery or wild. Fish with adipose clips were assigned as hatchery origin. Fish with adipose fins intact and no CWT were assigned as wild origin. Fish with adipose fins intact and CWT present were assigned to origin (wild, hatchery) after the CWT code was identified to its source. In the field, adipose fin status was recorded as unmarked (adipose fin present), marked (adipose fin clipped), or unknown (area of the adipose fin was missing from the carcass due to predation or decomposition). CWT status was recorded as beep (CWT presence), no beep (CWT absence), or no head (CWT information missing due to predation or decomposition). The 'beep' refers to results from electronically scanning each carcass for CWT using a hand-held CWT scanner. If the surveyor detected a CWT, the snout of the fish was removed and labeled for later identification by the WDFW CWT Lab.

Fork length (cm) was recorded for all species where possible, from the tip of the snout to fork of the tail. If a portion of the carcass was missing that would affect the length measurement, then no fork length was recorded. Three or more scales were collected from each Chinook carcass and six or more scales from each Steelhead carcass for aging. Coho scales were not sampled due to the consistency in age structure of returning adults (e.g. three years old). Scales were collected from the area posterior to the dorsal fin, anterior to the anal fin and three to six rows above the lateral line. Scales were mounted on adhesive scale cards with a unique identifier for each fish (Appendix E). Ages of each fish were determined by the WDFW Ageing and Otolith Lab.

Tissue samples collected from Coho for a companion genetics study that will be published separately from this report. To ensure quality of tissue for genetic analysis, samples were collected from carcasses with red/pink gills only, using a hole punch through the operculum or a fin clip. Coho tissue samples collected in the field were stored in individually labeled vials of water and later transferred to individually labeled blotter sheets, dried and sorted for future analysis.

Snorkel Surveys

A snorkel survey was conducted in late April to determine proportions of wild (unclipped) versus hatchery (adipose fin clipped) Steelhead in the study area. The timing of the snorkel survey was selected to coincide with the timing of hatchery Steelhead returns to Elk Creek ladder trap (J. Winkowski, WDFW, unpublished data). Elk Creek is the closest location to the Upper Chehalis sub-basin where hatchery Steelhead are released.

Snorkel surveys in the Upper Chehalis sub-basin occurred from the falls (RM 4.2) on West Fork Chehalis to the mouth, East Fork Chehalis from George Creek (RM 124.2) to the confluence with WF, and the mainstem from the East and West Fork Chehalis confluence (RM 120.1) to the proposed dam site (RM 108.2). Teams of two to three divers covered two to four miles of river in a downstream direction, recording observations of Steelhead (unclipped, adipose fin clipped, unknown clip) throughout each reach.

Data Management

Field data cards were collected and summarized by survey crew members on a regular basis throughout the season. Cards were examined for any errors or missing information that was not recorded and the field data and summarized cards were stapled together. Georeferenced locations were downloaded from the GPS units on a regular basis. Locations were visualized in Google Maps in order to ensure redd locations aligned with the stream layer and to reconcile any errors in location. The field data card and summarized survey card were reconciled a second time before the summarized card was entered into the WDFW Spawning Ground Survey database in Microsoft Access 2010. Once all information was entered into the database, the original and summarized data cards were collected for the entire survey year and

stored in a file box in the WDFW Region 6 office. Carcass survey data were entered into the District 17 Biological Sampling database in Access 2010. Once entered, scale cards were copied and the originals were delivered to the WDFW Scale Ageing Lab to be aged. The final ages were added to the database. The genetic numbers were checked against the scale cards to verify that they matched the corresponding biological data.

Analysis

Abundance

Estimates of abundance were based on enumerated redds in index reaches, enumerated and expanded redds in supplemental reaches, and a species-specific expansion factor.

Abundance for spring Chinook and fall Chinook was estimated from data collected in index reaches only and the surveys did not include any supplemental reaches (i.e., the entire spawning distribution was surveyed). Abundances of Coho and Steelhead were estimated from data collected in both index and supplemental reaches. Supplemental reaches reflected the wider spawning distribution typical of these species. Redds observed in supplemental reaches were expanded by the ratio of visible-to-cumulative redds observed in the nearest index reach. The visible-to-cumulative ratio was the number of redds visible in the nearest index reach on the day of the supplemental survey divided by the cumulative redds observed in the nearest index reach for entire spawning season. Supplemental surveys were conducted during peak spawning to sample upper limits of the spawning habitat. Since supplemental reaches are surveyed just once during the spawning season the redd counts in these reaches were expanded to the entire season. The timing of supplemental surveys was selected to coincide with timing in which the highest proportion of the total redds for the season were visible. The visible-to-cumulative expansion was applied if the visible:cumulative ratio was greater than or equal to 0.20 at the time the supplemental survey occurred. If the visible:cumulative ratio was less than 0.20, the number of observed redds in the supplemental reach was included in the abundance estimate, but no expansion was made. The result of this calculation was the estimate of the total number of redds in the supplemental survey reach for the season.

Species-specific expansion factors were 2.5 fish per redd for Chinook (spring, fall), 2 fish per redd for Coho, and 1.62 fish per redd for Steelhead, consistent with stock assessment methods for these species used throughout WDFW Region 6 District 17. Redd-based estimates for Chinook assume 1 female per redd and 1.5 males per female, which is the standard expansion used for WDFW stock assessment in western Washington. For Coho, the expansion from redd estimate to adult spawners assumes 1.0 female per redd and 1.0 male per female, which is also the standard expansion used for WDFW stock assessment in western Washington. For Steelhead, the expansion from redd estimate to adult spawners assumes 0.81 females per redd and 1.0 male per female and is based on historical study conducted in Snow Creek, Washington (US FWS & WDG, 1980; Freymond, 1982). The steelhead expansion factor reflects a combination of observer efficiency (not observing every redd), multiple redds built by a single female steelhead, and an assumed one-to-one ratio for male and female steelhead. These expansion factors were not independently validated (e.g., using abundance from a weir or mark-recapture study).

This redd based estimation methodology is based on multiple assumptions, including:

Assumption 1: redds are correctly identified to species,
Assumption 2: survey reaches cover all areas where and when redds are constructed,
Assumption 3: true redds are accurately distinguished from natural scour and test digs in the field,
Assumption 4: ratio of fish per redd is constant among years and is accurately represented by the species-specific expansion factor, and

Assumption 5: no difference in spawn timing distribution between supplemental reaches and index reaches used in the visual-to-cumulative ratio expansions (proportional visibility of redds between related index reaches and supplemental reaches)

The Steelhead spawner estimate was further partitioned into 'early' Steelhead redds observed on or before March 15th and 'late' Steelhead redds observed after March 15th. For supplemental surveys the abundance estimate of Steelhead in the supplemental reach included the observed number of redds and those estimated using the visible:cumulative ratio. This estimate for the supplemental reach was further partitioned into an early and late estimate based on the ratio of Steelhead redds before versus after March 15th observed in the nearest index reach. In reality, there were few to no early Steelhead redds (that might confound the counts) still visible in index reaches associated with supplemental surveys conducted after March 15th. The Steelhead redd counts were partitioned as early or late to align with WDFW Region 6 District 17 methodology, where early Steelhead redds (on or before March 15th) are assumed to be hatchery origin and late Steelhead redds (after March 15th) are assumed to be wild origin. Early redds have been assumed to be hatchery origin because many hatchery Steelhead programs in western Washington have an early run and spawn timing. However, most hatchery Steelhead programs in the Chehalis River have a similar run and spawn timing to wild Steelhead and ongoing field observations gathered and reported as part of this study suggest that there are minimal hatchery Steelhead returning to the Upper Chehalis River sub-basin. Therefore, the true proportions of wild fish spawning before March 15th and hatchery fish spawning after March 15th are unknown.

Timing

Spawn timing for each species was summarized as the number of new redds observed each statistical week and presented in graphical format.

Spatial Distribution

Redd locations were plotted using ArcGIS v. 10 for each species. These locations were visualized in map form overlaying the areas surveyed as index and supplemental reaches. The maps also included the potential dam inundation footprint for the proposed Flood Retention Only dam alternative. Spatial distribution of spawning activity was also summarized for each species as the proportions of redds within versus outside the dam footprint and the proportions in main stem versus tributary habitat. These calculations were based on the total redds and included those estimated from visible:cumulative expansions in supplemental reaches.

Diversity

Age structure (years in freshwater and the ocean) was summarized based on results from scales retrieved from Chinook and Steelhead carcasses and from live Steelhead captured using hook-and-line methods. Age data were not collected for Coho due to known age composition of returning adults being three years of age.

Hatchery:wild composition was summarized based on mark status of sampled carcasses. Coho and Chinook hatchery:wild composition was determined from the adipose fin and CWT status of recovered carcasses, as described in the Methods section. Steelhead early:late composition was determined from redd timing and the hatchery:wild composition was determined from adipose fin status of live fish and recovered carcasses. Steelhead origin was further validated with observations on dorsal fin height and disfiguration (stubby or disfigured in hatchery fish), and scale growth patterns as determined by the WDFW Otolith and Ageing Lab. Hatchery Steelhead in the Chehalis basin are adipose clipped but do not receive a CWT, though all Steelhead are scanned in case of straying from other basins outside the Chehalis River.

Results

Survey Effort

The 2017-2018 survey season began September 15th and concluded June 16th (Figure 2, Appendix A). The most frequently surveyed areas were the main stem Chehalis, EF Chehalis, and the WF Chehalis as these three areas encompassed spawning habitat for all three salmon species and steelhead. The main stem Chehalis and EF Chehalis were the areas most affected by weather, high flows, or turbidity. Reaches not surveyed, defined as not included in the survey frame, no time to survey or unable to survey due to environmental conditions or logging in progress. The approximate miles of stream surveyed for Chinook was 35. In comparison, both Coho and Steelhead required approximately 53 miles of stream surveyed to cover the complete distribution.

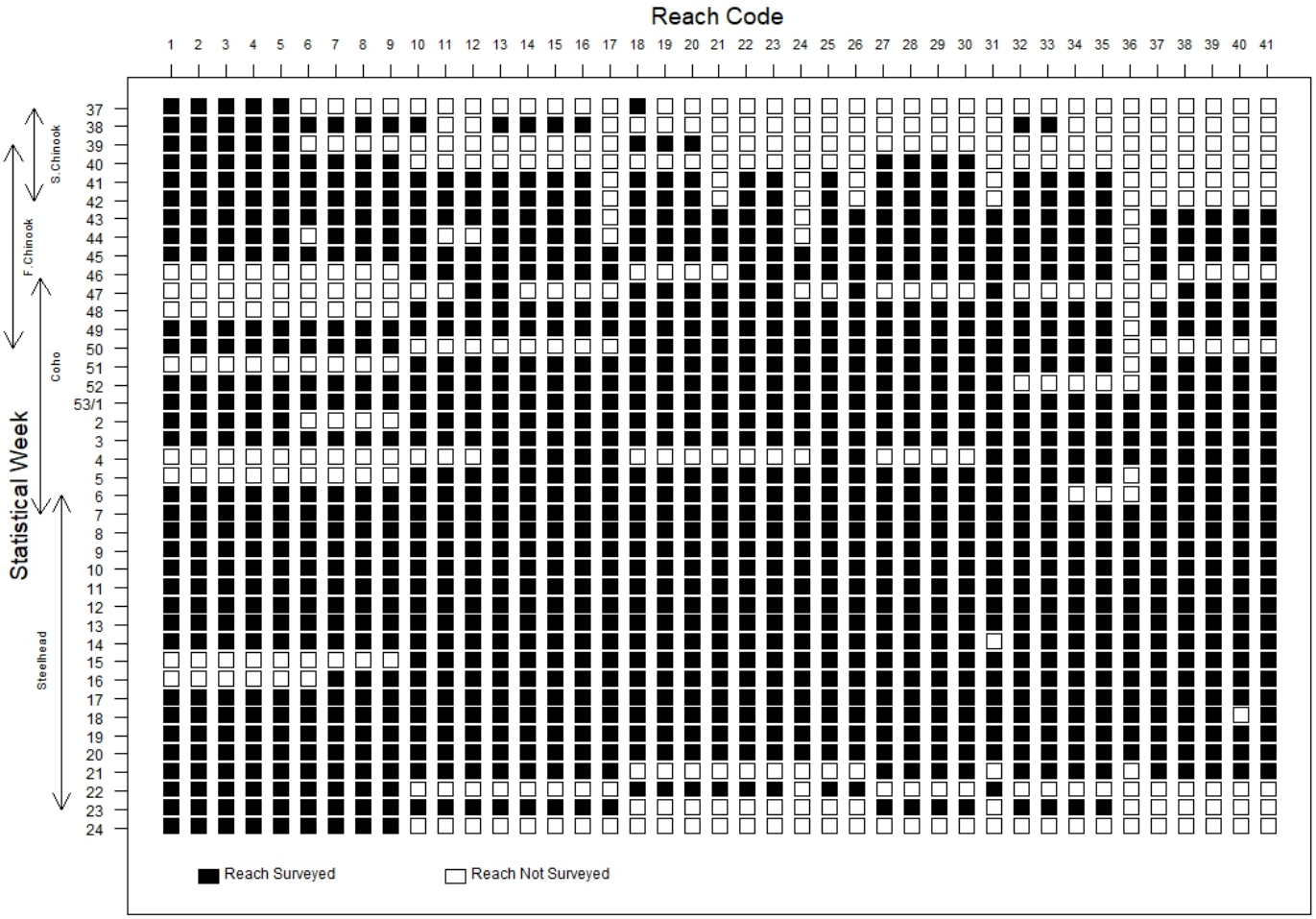

Figure 2. Survey status of index reaches by statistical week for the 2017-2018 survey season. Description of reach codes and statistical weeks provided in Appendix A and Appendix B Timing arrows on the left of the figure are based on the earliest and latest recorded new redd of that species for the spawning season.

Abundance

In 2017-2018 the estimated abundance of spring Chinook was eight adults, fall Chinook was 239 adults, Coho was 1,240 adults, and early and late Steelhead were 82 and 860, respectively (Table 3, Figure 3). With the exception of Coho, the estimated abundance of all species in 2017-2018 was lower than the average for the previous survey years (2013-2017).The percent of early Steelhead redds (on or before March 15th) was 9%, which was similar to the 10% average of early steelhead redds observed in the 2014-2017 seasons.

Table 3. Number of total redds and estimated abundance of adult salmon and steelhead spawners in the Chehalis River sub-basin above the proposed dam site. Redds include those observed in index reaches and estimated from supplemental reaches.

	Spring Chinook		Fall Chinook		Coho		Early Steelhead		Late Steelhead	
Year	Redds	Adults	Redds	Adults	Redds	Adults	Redds	Adults	Redds	Adults
2017-2018	3	8	94	239	618	1236	50	82	528	860
2013-2017 Avg	--	27	--	340	--	764	--	156	--	1213

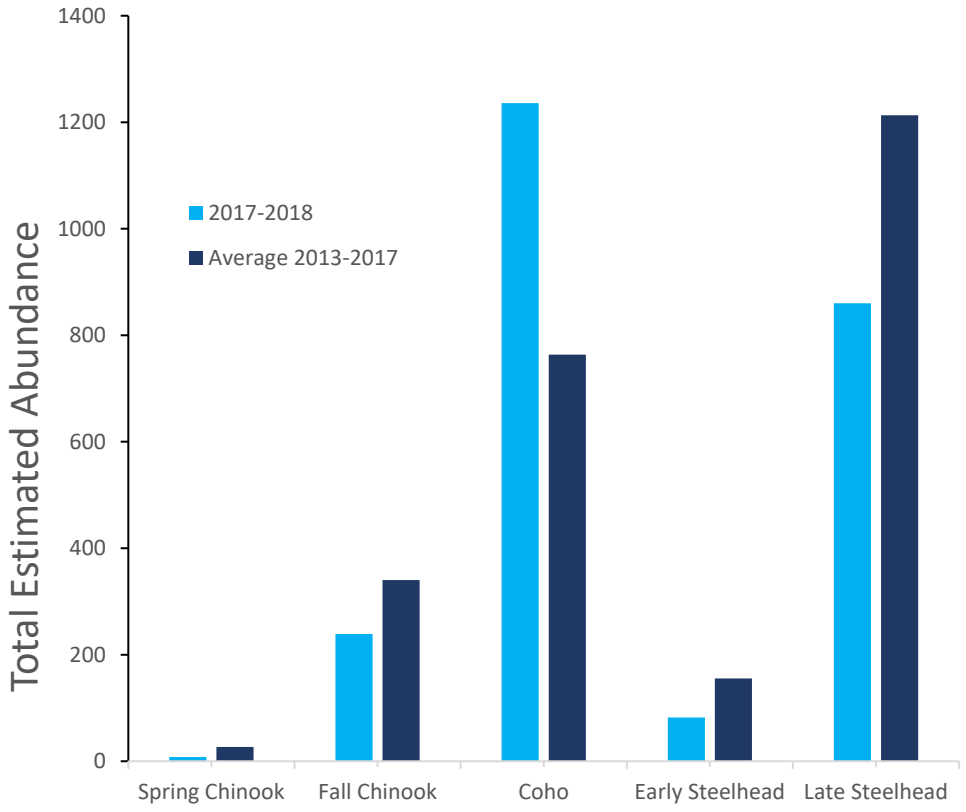

Figure 3. Total estimated abundance of spring Chinook, fall Chinook, Coho, early Steelhead (on or before March 15th) and late Steelhead (after March 15th) in 2017-2018 season and the previous 4-year average.

Timing

Spawn timing for spring Chinook (Figure 4) began late September (SW 40) and ended mid-October (SW 42) with peak spawning occurring in early October (SW 40) (Figure 4). Fall Chinook spawn timing began in early October (SW 42) and ended in early December (SW 50) with peak spawning occurring in mid-October (SW 43). Spawn timing for Coho (Figure 5) began in mid-November (SW 47) and ended in mid-February (SW 7) with peak spawning occurring in late November/early December (SW 49). Steelhead spawn timing (Figure 6) began in early February (SW 6) and ended in mid-June (SW 23) with peak spawning occurring in early May (SW 19).

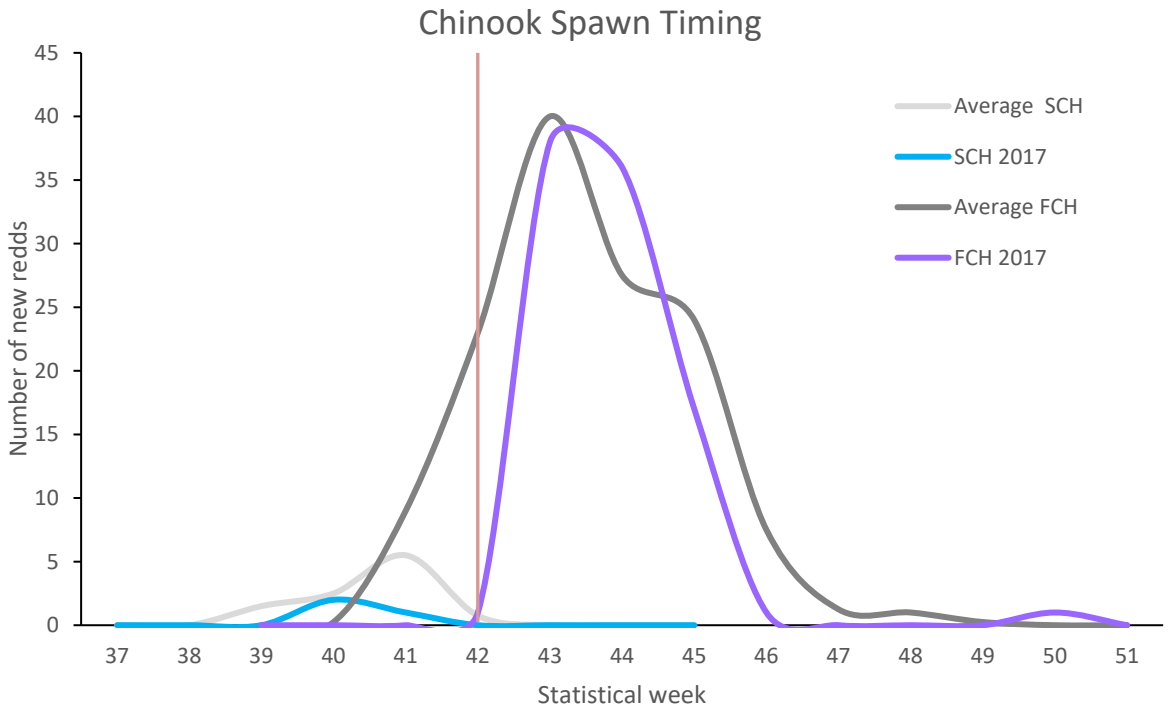

Figure 4. Spawn timing for spring Chinook (SCH) and fall Chinook (FCH) in the Upper Chehalis sub-basin for 2017. The average of SCH and FCH were from survey years 2013-2016. The number of new redds indicates new redds observed each statistical week. Description of statistical weeks provided in Appendix B The vertical line in the spring and fall Chinook spawn timing graphs indicate the WDFW October 15th threshold date for run identification (spring/fall).

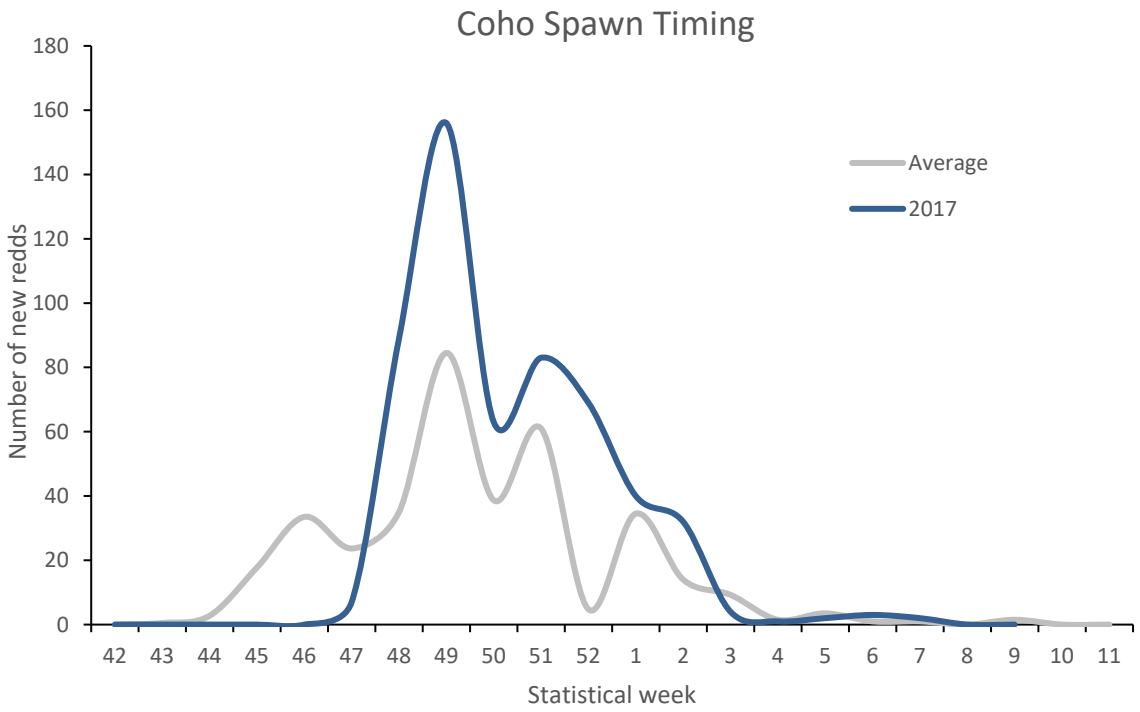

Figure 5. Spawn timing for Coho in Upper Chehalis sub-basin for 2017-2018. The average spawn timing is from survey years 2013-2016. The number of new redds indicates new redds observed each statistical week for index reaches only. Description of Statistical weeks provided in Appendix B

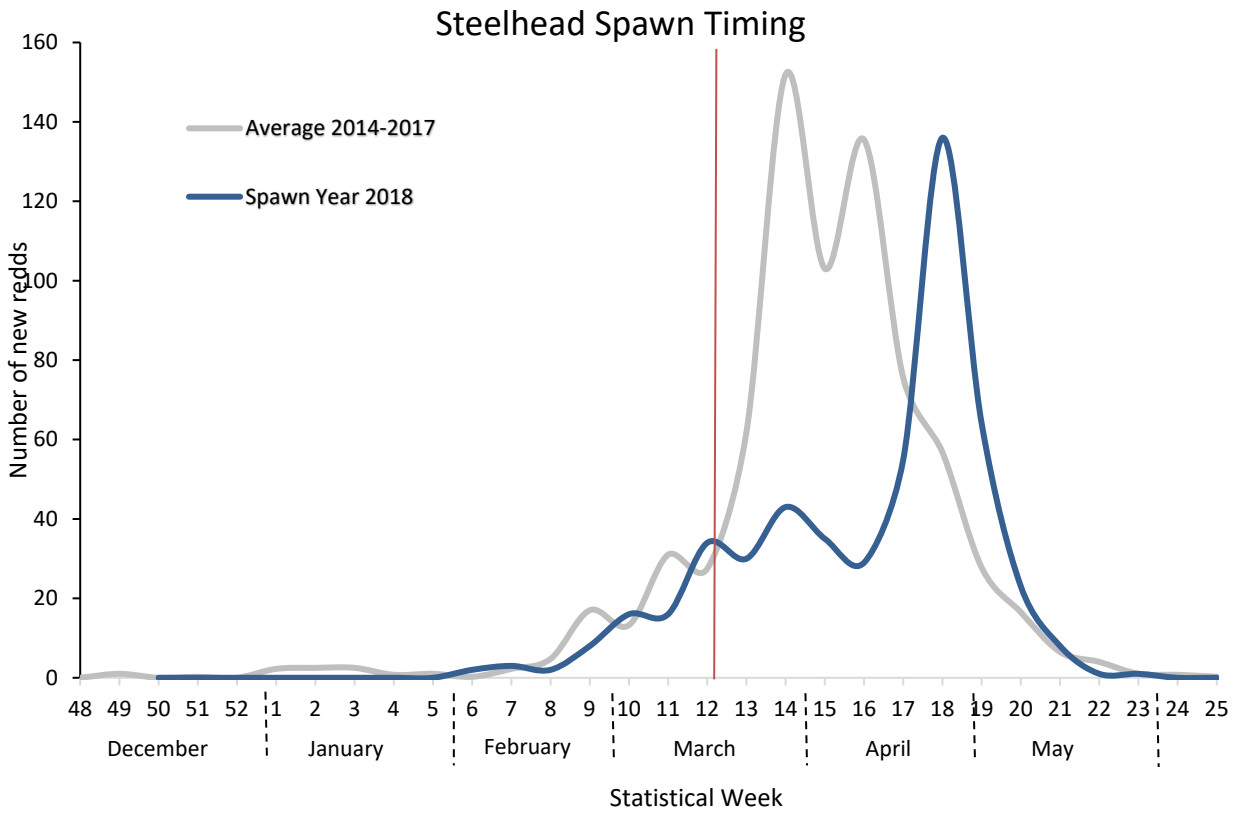

Figure 6. Spawn timing for Steelhead in the Upper Chehalis sub-basin for 2017-2018. The number of new redds indicates redds newly observed each statistical week for index reaches only. The vertical line in the Steelhead spawn timing graph indicates the WDFW March 15th threshold date for origin identification (hatchery:wild). Description of Statistical weeks provided in Appendix B.

Spatial Distribution

Spring Chinook spawned exclusively in the main stem (Figure 7), and 33% of all spring Chinook redds (n = 3) were located within the FRO dam inundation footprint (Table 4). Fall Chinook spawning occurred in both main stem and tributary habitats. Ninety-one percent (91%) of fall Chinook redds occurred in the main stem (Figure 8) and 95% of all fall Chinook redds (n = 94) within the FRO inundation footprint (Table 4).

Coho spawning also occurred in both main stem and tributary habitats. Estimated redds in supplemental reaches represented 7% of observed redds. Nineteen percent (19%) of Coho redds occurred in the main stem, 38% in the EF and WF Chehalis and 43% in tributaries (Figure 9). Thirty-three percent (33%) of Coho redds occurred within the FRO dam inundation footprint (Table 4).

Steelhead spawning distribution was separated into early redds (observed on or before March 15th) and late redds (observed after March 15th), with 9% of redds observed in the early time period (Figure 10). Supplemental surveys were only conducted for the "late" steelhead; estimated late redds represented 14% of observed redds. Of the 'early' redds, 54% occurred in the main stem, 24% in EF and WF Chehalis, and 22% in the tributaries. In comparison, 25% of 'late' redds occurred in the main stem, 46% in the EF and WF Chehalis, 29% in the tributaries. Twenty-six percent (26%) of all Steelhead redds were located within the FRO dam inundation footprint (Table 4).

Table 4. Number of redds estimated in the Upper Chehalis River sub-basin upstream of river mile 108.2. Numbers are shown within and outside the inundation footprint of the proposed Flood Reduction Only and include information from both index and supplemental survey reaches.

	Spring Chinook		Fall Chinook		Coho		Steelhead	
Survey Season	Within	Outside	Within	Outside	Within	Outside	Within	Outside
2013-2014	13	0	86	31	55	32	197	449
2014-2015	24	1	89	34	190	606	359	781
2015-2016	1	0	169	0	269	236	330	585
2016-2017	2	0	99	34	45	94	161	507
2017-2018*	1	2	89	5	203	417	150	428

* 2017-2018 calculated for the FRO inundation footprint.

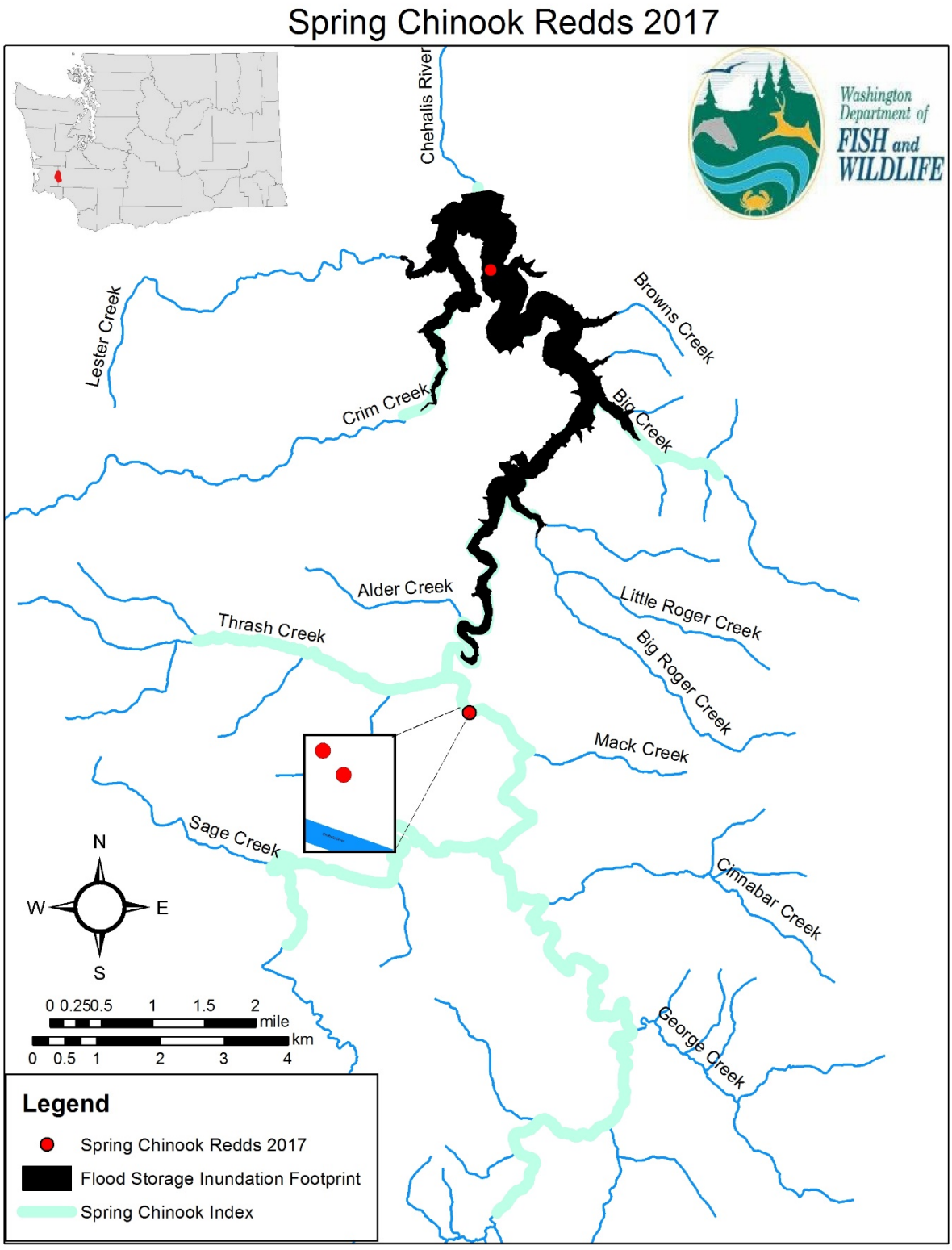

Figure 7. Map of the spatial distribution of redds for spring Chinook on the Chehalis River upstream of river mile 108.2 in 2017. Map show the predicted inundation footprint of flood reduction only dam.

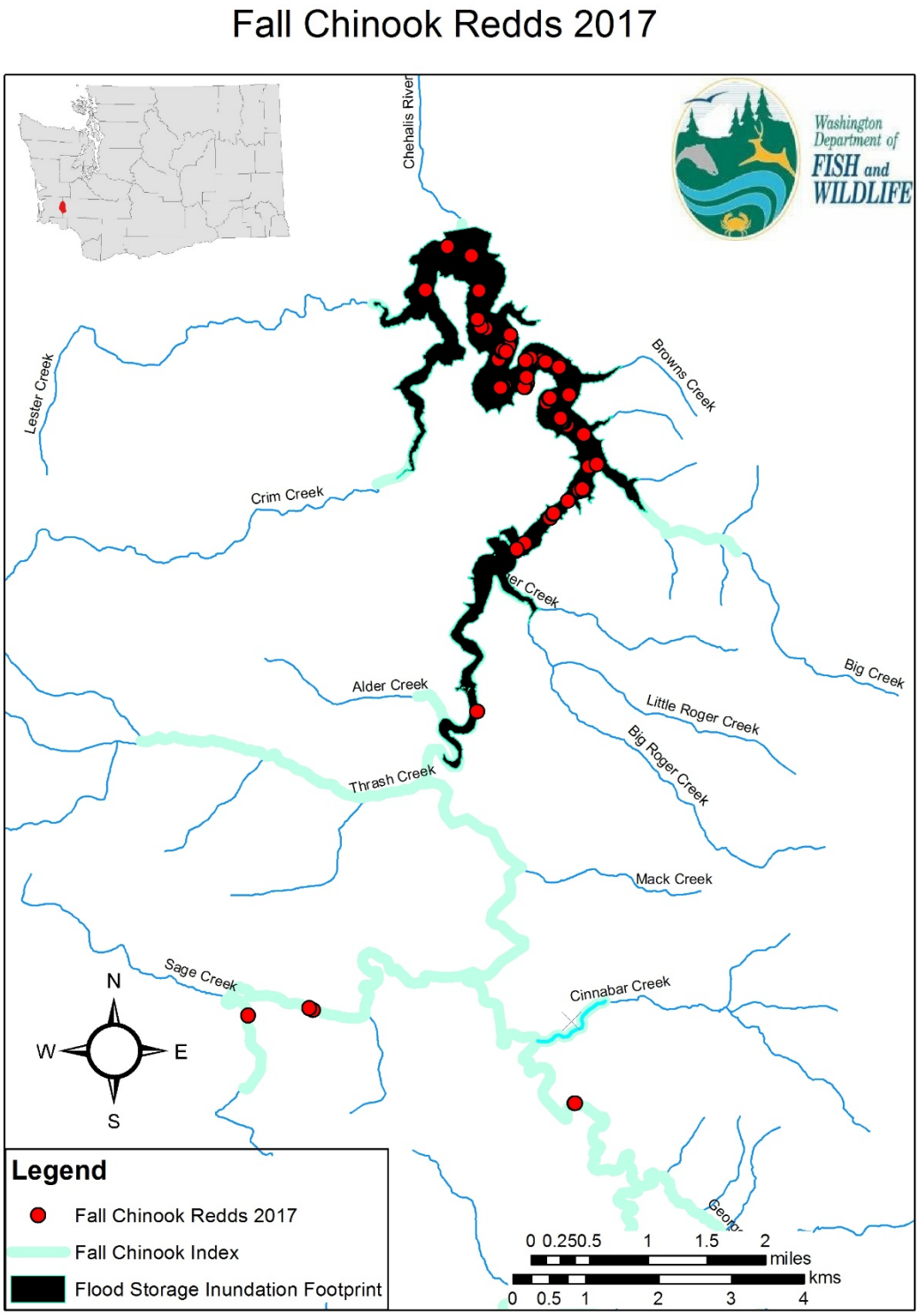

Figure 8. Map of the spatial distribution of redds for fall Chinook on the Chehalis River upstream of river mile 108.2 in 2017. Map show the predicted inundation footprint of flood reduction only dam.

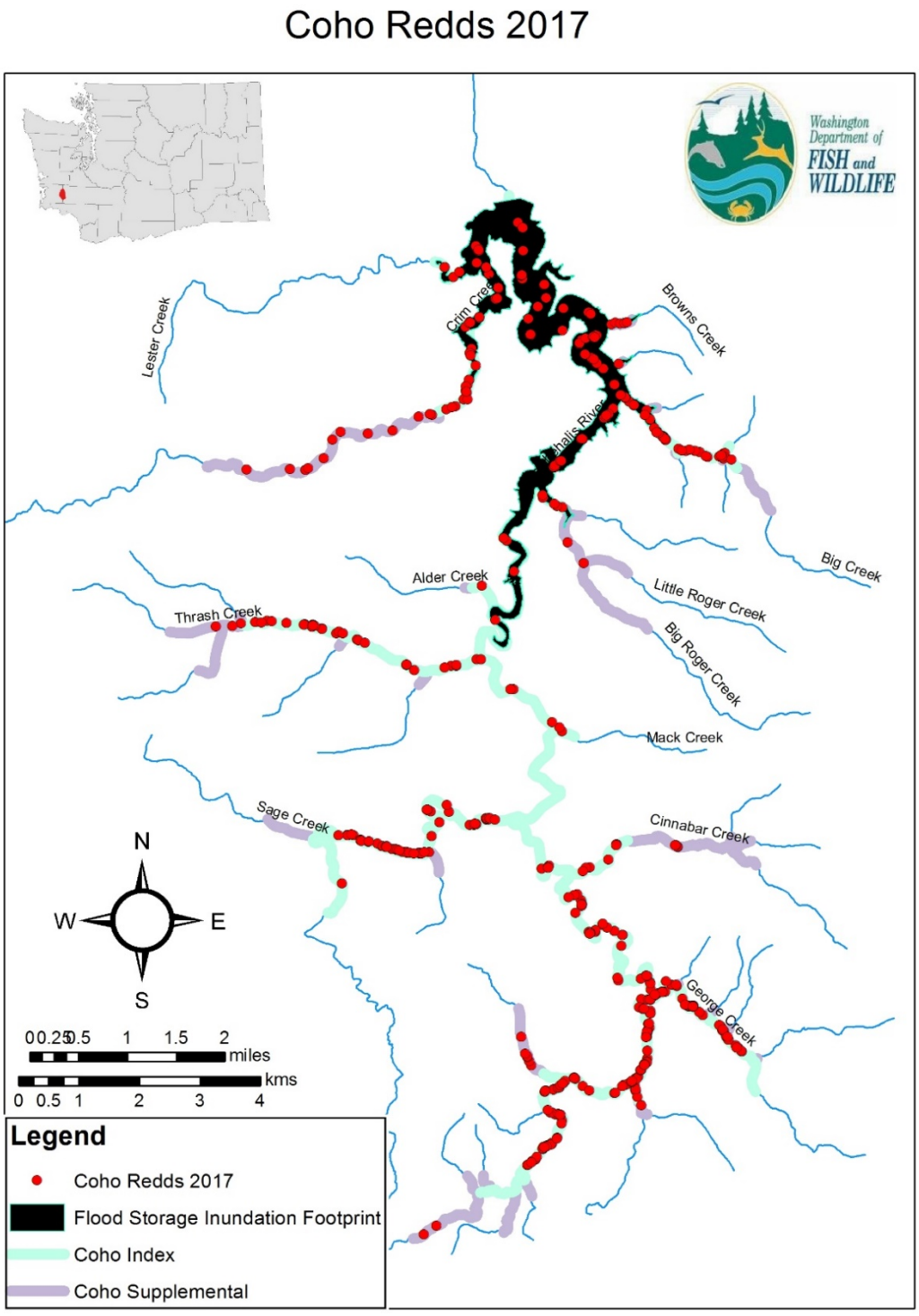

Figure 9. Map of the spatial distribution of redds for Coho on the Chehalis River upstream of river mile 108.2 in 2017-2018. Map show the predicted inundation footprint of flood reduction only dam.

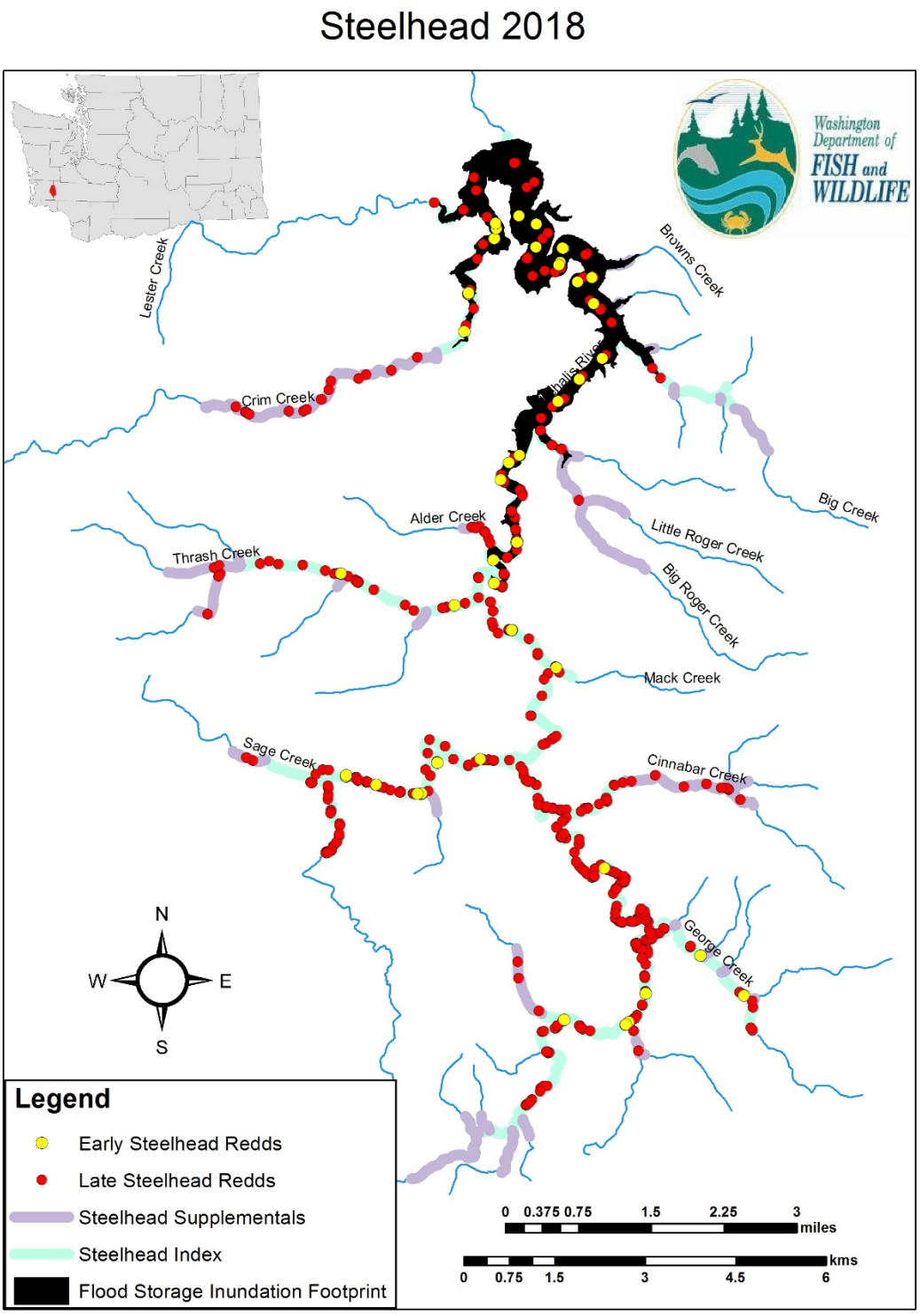

Figure 10. Map of the spatial distribution of redds for Steelhead on the Chehalis River upstream of river mile 108.2 in 2018. Map show the predicted inundation footprint of flood reduction only dam.

Diversity

During the 2017-2018 survey season, a total of 138 carcasses were recovered (0 spring Chinook, 32 fall Chinook, 91 Coho, 15 Steelhead, Table 5). None of the sampled fall Chinook carcasses had a clipped adipose fin or was CWT positive, indicating these were wild fish. Sampling of two fall Chinook carcasses was incomplete no mark status could be determined from either carcass and CWT status (negative) could only be determined from one of those.

Similarly, none of the sampled Coho carcasses had a clipped adipose fin, suggesting that these were wild fish. A total of 70 Coho carcasses had intact adipose fins and no CWT, and an additional 19 had intact adipose fins but an unknown CWT status. Sampling of two Coho carcasses was incomplete – no mark status could be determined from either carcass and CWT status (negative) could only be determined from one of these.

For Steelhead, two of the fifteen sampled carcasses were determined to be hatchery origin. One had a clipped adipose fin and the other had an unknown adipose status but scale growth patterns were consistent with hatchery rearing (WDFW Scale Lab, personal communication). Two additional Steelhead carcasses with unknown adipose status in the field had scale growth patterns consistent with natural rearing (i.e., wild fish). The remaining Steelhead carcasses that were sampled had intact adipose fins indicating they were wild.

A total of 117 Steelhead were observed during the snorkel survey on April 27, 2018. Of these observations, 99 were unclipped and 18 had unknown clip status. No adipose fin clipped Steelhead were observed.

Table 5. Detailed mark status of spring and fall Chinook, Coho, and Steelhead. Chinook and Coho data were obtained from carcasses; Steelhead data were obtained from carcass and hook-and-line sampling of live fish. ADNT: Adipose-clipped no CWT, ADT: Adipose-clipped CWT, ADUK: Adipose-clipped Unknown CWT status, UMNT: Unmarked no CWT, UMT: Unmarked CWT, UMUK: Unmarked, unknown CWT status, UKNT: Unknown mark status no CWT, UKT: Unknown mark status CWT, UKUK: Unknown mark status unknown CWT status.

2017-2018	ADNT	ADT	ADUK	UMNT	UMT	UMUK	UKNT	UKT	UKUK	Total
Spring Chinook	0	0	0	0	0	0	0	0	0	0
Fall Chinook	0	0	0	27	0	3	1	0	1	32
Coho	0	0	0	70	0	19	1	0	1	91
Steelhead	1	0	0	1	0	10	0	0	3	15
Total	1	0	0	98	0	32	2	0	5	138

No carcasses were sampled for spring Chinook; therefore no information was available on age structure.

For fall Chinook, 32 carcasses were sampled. Thirty-eight percent (38%) were female and 59% were male, 3% had no sex determined in the field. Of the sampled carcasses, 19 provided age and length information, six carcasses had length but no age information (due to regenerated scales), and seven carcasses had age but no length information. All sampled fall Chinook with readable scales had emigrated to saltwater as sub-yearlings (migrate to the ocean during the first spring). Age composition of the sampled carcasses was 20% three years old, 60% four years old, 16% five years old and 4% six years old. The average fork length and standard deviation were calculated for each age and sex group (Figure 11).

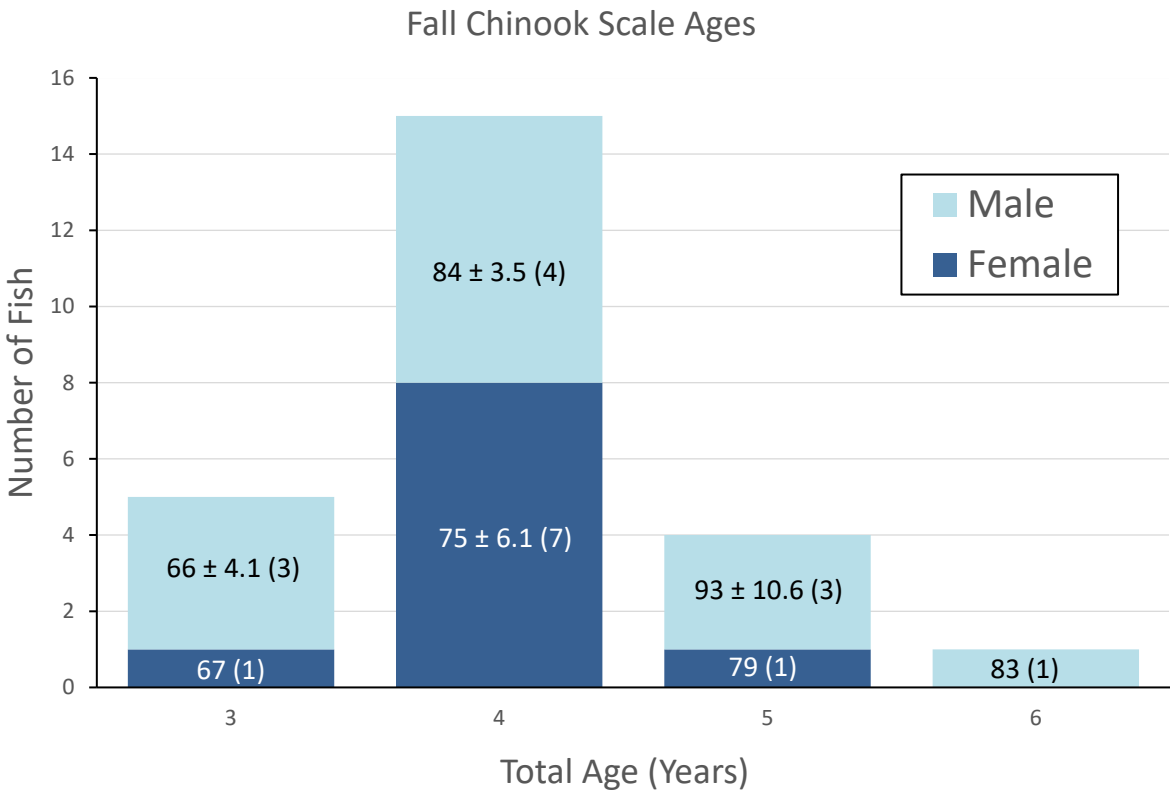

Figure 11. Age structure of fall Chinook by sex for Upper Chehalis basin above the proposed dam site, 2017 spawn year. Age is total number of years (all readable scales indicated that the fish had migrated to the ocean in their first year of life as a sub-yearling). The average fork length (cm) for each age group are represented as text within each age group (fork length cm ± standard deviation (sample size)).

For Steelhead, thirteen carcasses and two live fish were sampled. Fifty-four percent (54%) were male, 8% were female, and 38% did not have a sex determination (SND) due to degradation of the carcass; however, these proportions were likely influenced by small sample size. Of the sampled Steelhead, two were determined to be of hatchery origin and both hatchery origin Steelhead had a total age of four years. The remaining thirteen wild Steelhead sampled had spent one to three years in fresh water and one to three years in saltwater with no repeat spawners among the sampled fish (Figure 12). One Steelhead was a total of three years, three were a total age of four years, five (50%) were a total age of five years, one was a total age of six years and three (23%) had regenerated scales so no age was determined. Due to a limited sample size, the average fork length for each age and sex grouping was not calculated.

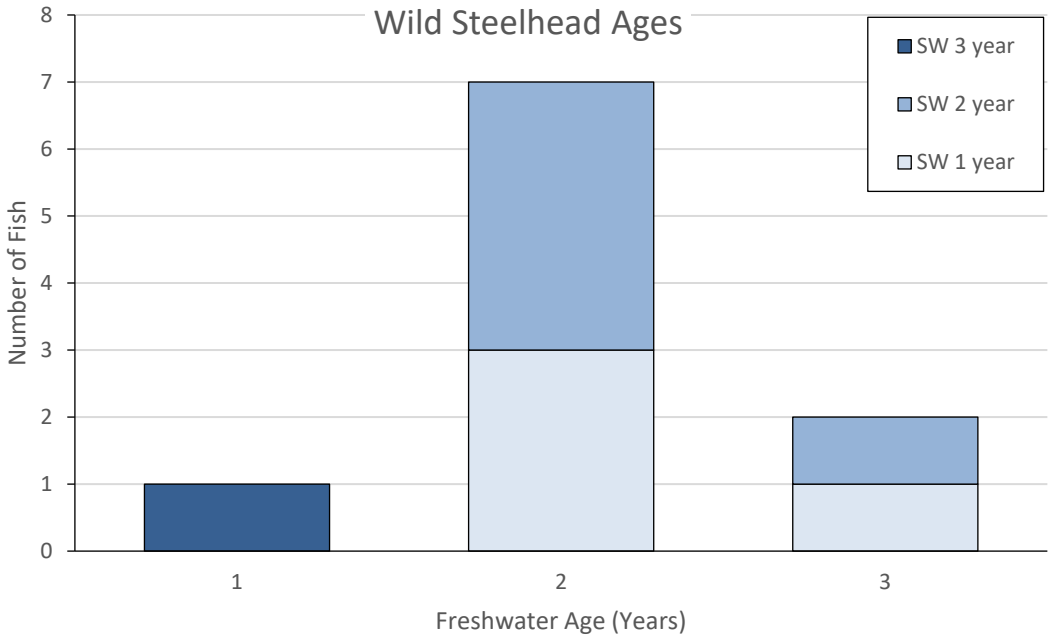

Figure 12. Freshwater and saltwater (SW) age structure of wild winter-run Steelhead returning to the Upper Chehalis sub-basin, 2018 spawn year. Data shown here include age data collected from carcasses and live fish.

Main Stem Spawning Below Proposed Dam Site

Peak survey for Spring Chinook was conducted on October 3, 2017 and a total of 31 redds were observed in this one week survey between the proposed dam site and the Newaukum River (Figure 13). This compares with the total of two redds observed above the proposed dam site during the same survey week. Redds were evenly spread from the proposed dam site downstream to RM 78.5 downstream of the town of Adna (RM 81). No redds were observed between RM 78.5 and the confluence with the Newaukum River.

Peak survey for fall Chinook was conducted on November 1, 2017 and a total of 199 redds were observed in this one week survey between the proposed dam site and the Newaukum River (Figure 14). This compares with 73 fall Chinook redds above the proposed dam site during the same survey week. Redds were heavily concentrated in the upper portion of the survey reach near the town of Pe Ell and were observed downstream to RM 81.2 near Adna, WA. No redds were observed between RM 81.2 and the confluence with the Newaukum River.

Peak survey for Coho was conducted on December 14, 2018 and very few redds (5) were observed in this one week survey between the proposed dam site and Adna (Figure 15). This compares with 367 Coho redds above the proposed dam site during the same survey week. Redds were observed downstream to RM 99.2, one mile downstream of Elk Creek confluence. No redds were observed between RM 99.2 and the town of Adna. Historical surveys indicate there has been no observed spawning of Coho from Adna to the Newaukum River.

Peak survey for Steelhead was conducted on May 9, 2018 and very few redds (7) were observed in this one week survey between the proposed dam site and the Newaukum River (Figure 16). This compares with 283 Steelhead redds above the proposed dam site during the same survey week. Redds were concentrated in the upper portion of the survey reach near the town of Pe Ell and were observed downstream to RM 106, approximately two miles below the proposed dam site. No redds were observed between RM 106 and the confluence with the Newaukum River.

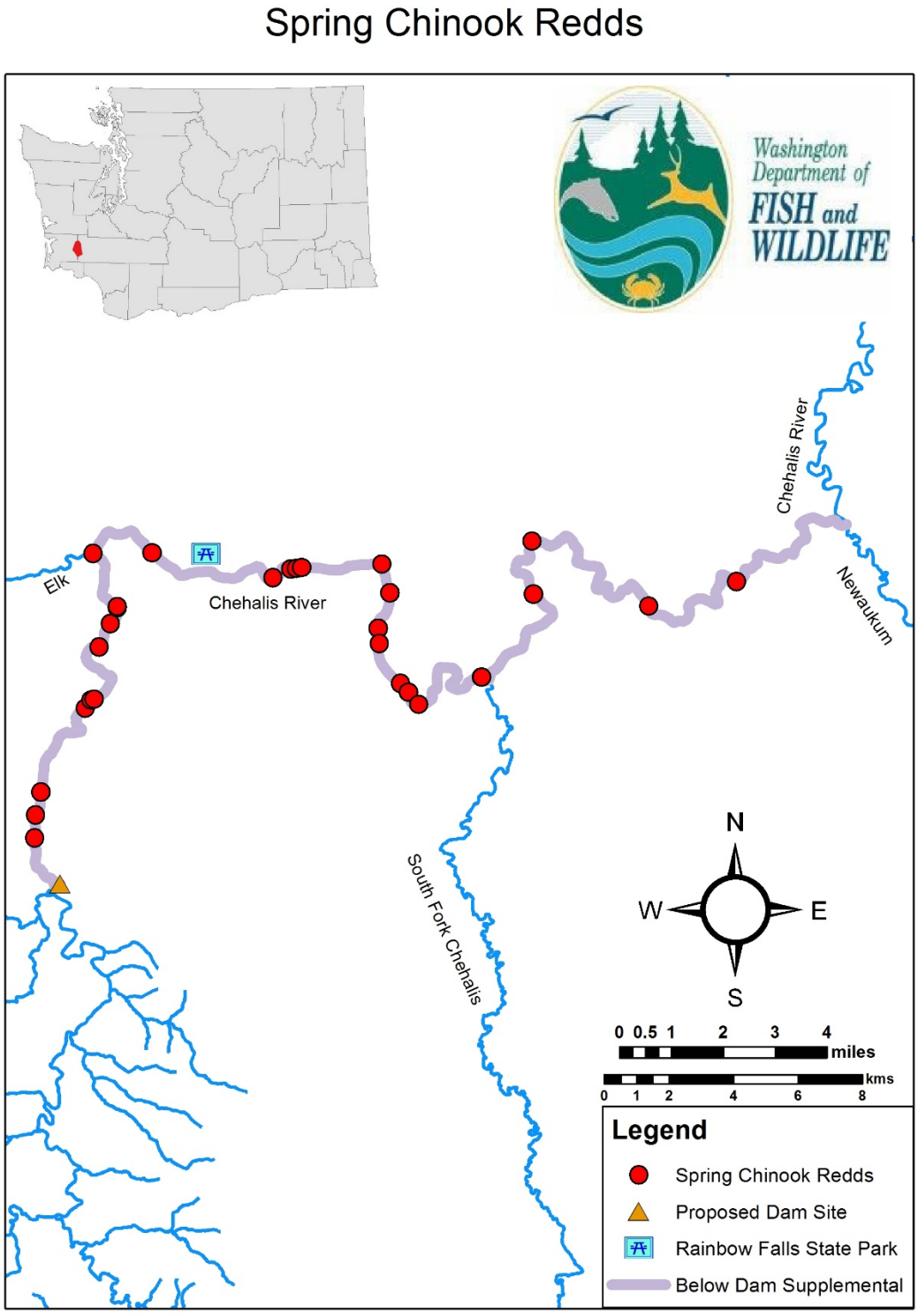

Figure 13. Spring Chinook distribution of redds below the proposed dam site during peak spawn timing (October 3, 2017).

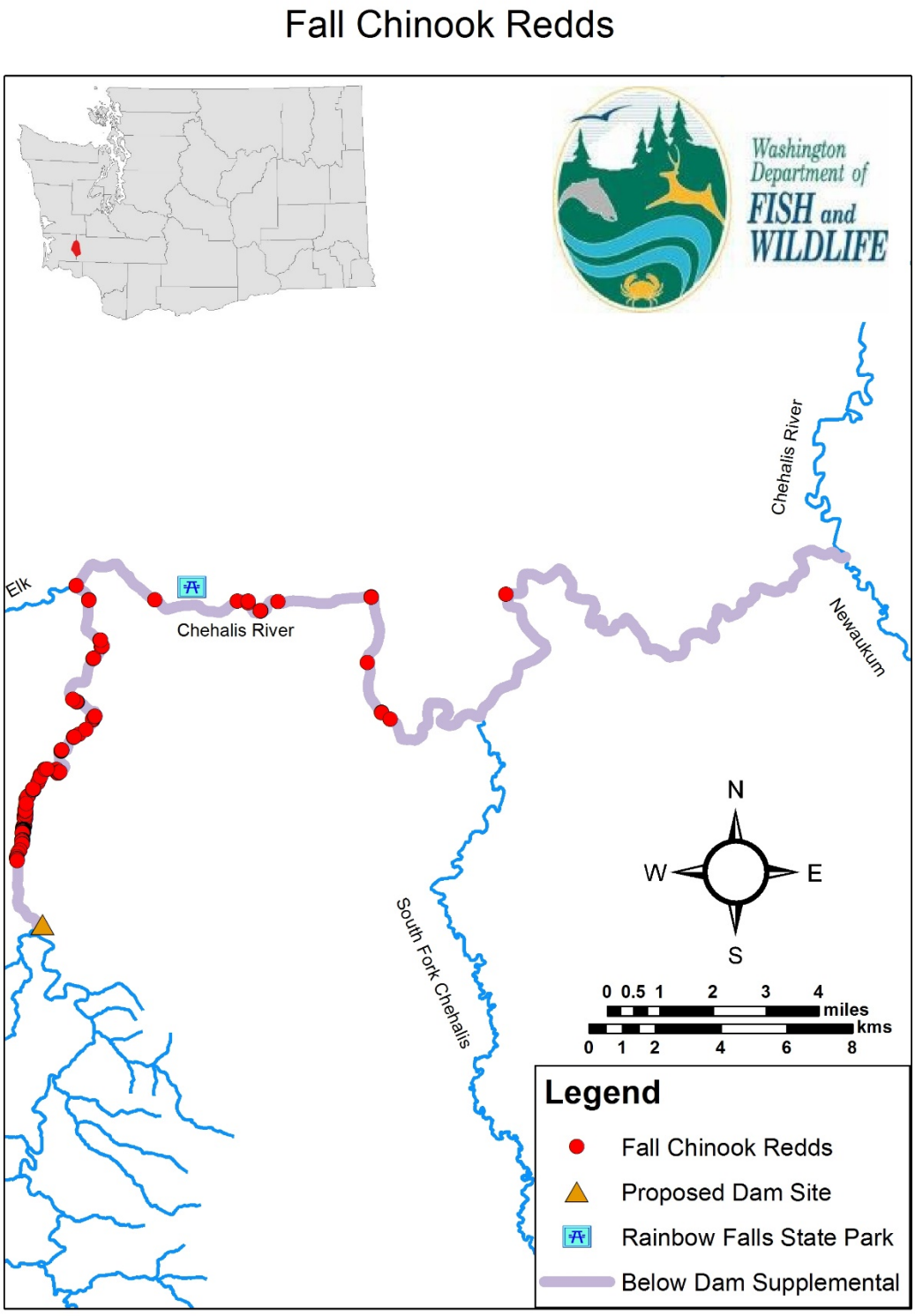

Figure 14. Fall Chinook distribution of redds below the proposed dam site during peak spawn timing (November 1, 2017).

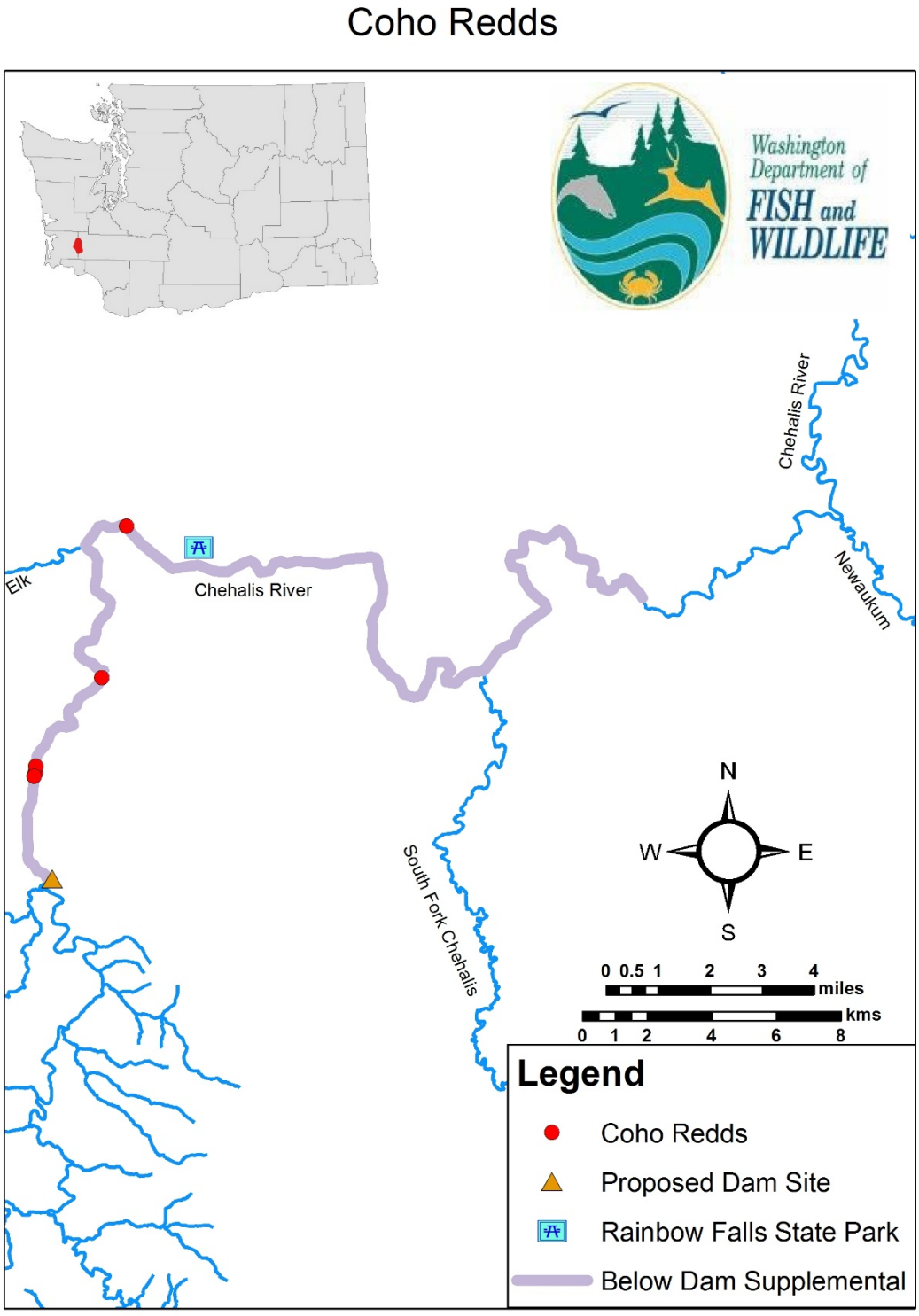

Figure 15. Coho distribution of redds below the proposed dam site during peak spawn timing (December 14, 2018).

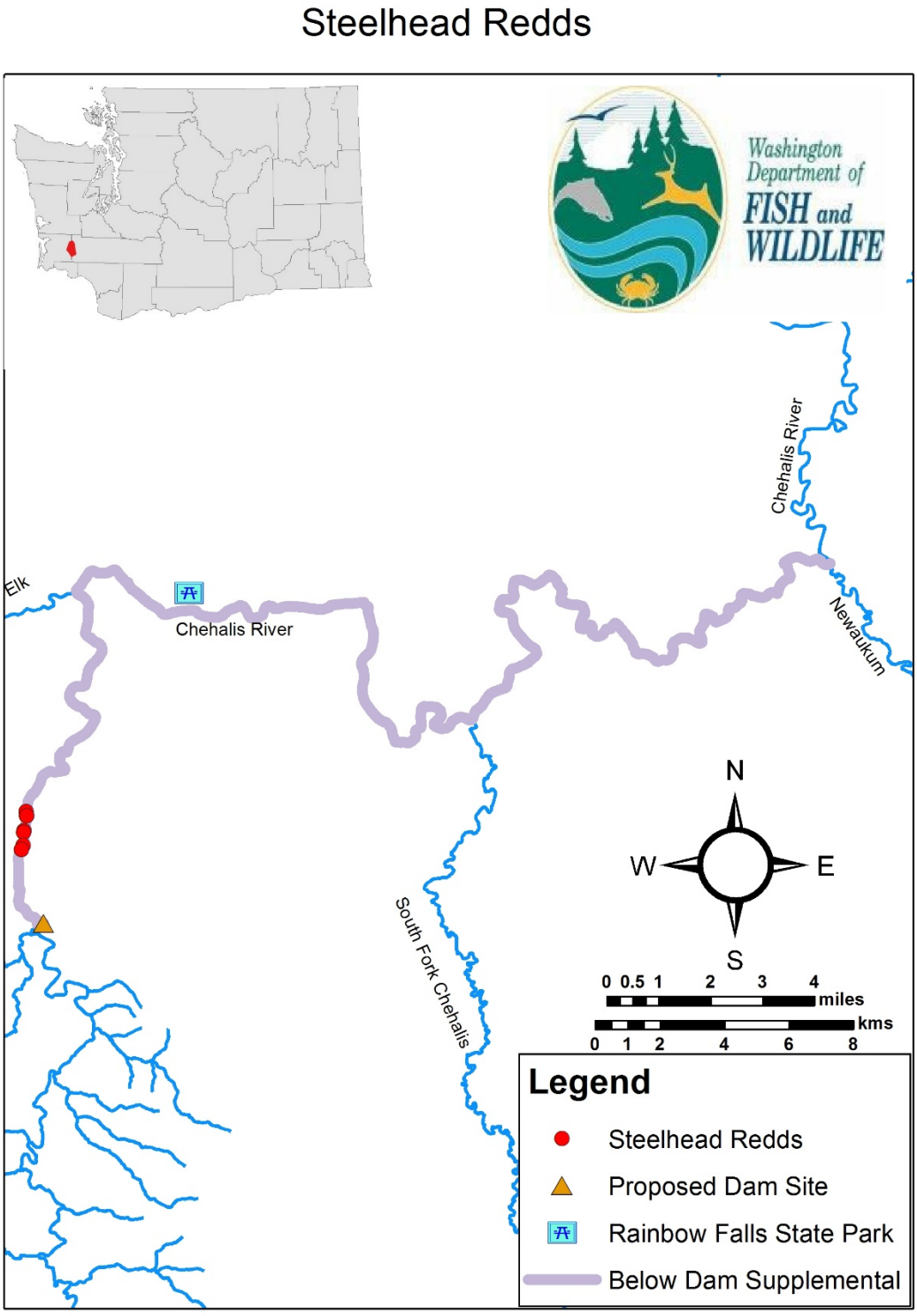

Figure 16. Steelhead distribution of redds below the proposed dam site during peak spawn timing (May 9, 2018).

Discussion

The overall goal of this study was to describe the abundance, spawn timing, spatial distribution, and diversity of spring and fall Chinook, Coho, and Steelhead in the Upper Chehalis River sub-basin and to document the spawning distribution for each species in the main stem river downstream of the proposed dam site.

The 2017-2018 survey season was the fifth year of study upstream of the proposed dam site and the first year of study in the main stem river downstream of the proposed dam site. Results from all five years indicate that Chinook (spring and fall runs), Coho, and Steelhead spawn in the Upper Chehalis River sub-basin almost continuously between the months of September and June. Additional work in the 2017-2018 season indicated that the main stem river downstream of the proposed dam site was primarily used for spawning by Chinook salmon (spring and fall runs) with less use as spawning habitat by Coho or Steelhead. Our study of main stem spawning did not extend downstream of the Newaukum River confluence.

Across all years of study, spawner abundances of Coho and Steelhead have been higher than spring or fall Chinook in the Upper Chehalis River sub-basin. In the previous four years, Steelhead have been the most numerous species, averaging roughly three times more spawners than Coho, and four times more spawners than Chinook. However, in 2017-2018, Coho were the most numerous among all the species. The 2017 Coho spawner abundance was thirty percent more than the 2018 Steelhead spawner abundance and five times the 2017 fall Chinook spawner abundance. These differences reflect a relatively strong return of Coho to the Upper Chehalis River sub-basin and a relatively weak return of Steelhead and Chinook to the Upper Chehalis River sub-basin for the 2017-2018 return year (relative to the previous four-year time series). Coho were 1.6 times higher than the four-year average whereas Steelhead and fall Chinook were about 70% of the four-year average and spring Chinook were only 30% of the four-year average.

As observed in the previous four years of study, hatchery fish were rare to absent in our surveys and the majority of spawners in this area of the Chehalis River watershed were wild fish. There are no releases of hatchery salmon or steelhead above the proposed dam site at RM 108.2 and no hatchery releases of Spring Chinook anywhere in the Chehalis River basin. The closest release location for hatchery Fall Chinook is the Satsop River sub-basin located near RM 20. The closest release location for hatchery Coho and Steelhead is Elk Creek (Chehalis RM 100.2). A potential error associated with using mark status to estimate hatchery:wild composition of Coho are plants of hatchery Coho through Remote Site Incubation (RSI) where hatchery Coho resemble wild Coho based on their mark status. However, the nearest RSI location is downstream in the Chehalis River at RM 75, and straying to the surveyed area of the watershed is likely to be minimal.

Species Summaries

Spring Chinook are the earliest arrivals to the study area and spawn in September and October, followed by Fall Chinook, which spawn October to November. In fall 2017, spawning of Spring Chinook peaked around the threshold date of October 15th, and their spawn timing was very short in length, lasting only two weeks. Fall Chinook spawning also peaked around mid-October, but their spawning time was four times as long as spring Chinook, nine weeks. The overlap in spawning location and timing of spring and fall Chinook means that field calls are necessarily subjective and additional investigation on the distinctions between these runs is being conducted as part of a separate project. This additional work should help to clarify the proportion of spring and fall Chinook spawners using information not available to field surveyors such as genetics and otoliths (microchemistry composition).

Coho had a more protracted spawning period (13 weeks) than Chinook with spawning activity observed between mid-November and February. Coho spawning in the Upper Chehalis sub-basin has typically peaked twice during this period (Ashcraft et al. 2017), once in late November/early December

and again in late December/early January. Redds associated with the first peak are consistently more numerous than those associated with the second peak. The bimodality of Coho spawn timing is consistent with that observed elsewhere in the Chehalis River basin. In 2017-2018, the overall duration of Coho spawning was similar to past years but the bimodal pattern was not as evident as the previous four years. The lack of a bimodal pattern may have resulted from overall higher abundances resulting in overlap between the 'modes' or may reflect inter-annual variation in spawn timing associated with stream flow.

Steelhead had the most protracted spawning period (18 weeks) of all species with spawning activity observed between the months of December and June, three times as long as the duration of fall Chinook spawning. Even though the overall spawning period for Steelhead was longer than Coho, peak spawning of Steelhead between late March and early April is more condensed than Coho allowing for more precise estimates of visible:cumulative ratios to be calculated. Environmental conditions are much different between the Steelhead and Coho spawning season (i.e., lower flows in the spring) and Steelhead redds often remain visible for weeks after spawning with algae growth and hydrology as the primary factors in declining redd visibility. Approximately 9% of the Steelhead run was 'early' (on/before March 15th). Few Steelhead (n = 15) were sampled to accurately estimate hatchery versus wild proportions for the 2017-2018 season. Two of the fifteen carcasses (13%) were determined to be hatchery origin. However, combined with the Steelhead carcasses and live fish that were sampled between 2013-2014 and 2016-2017 seasons, available information suggest that most of the Steelhead spawners in the Upper Chehalis River sub-basin are wild (Ashcraft et al. 2017). In addition, snorkeling efforts conducted in late April 2018 indicated that the majority of 'late' Steelhead returning to the Upper Chehalis sub-basin are of wild origin.

Conclusions

The 2017-2018 season provided information on spawning activity within and above the FRO dam inundation footprint as well as the main stem river downstream of the proposed dam site. Spawning habitats above and downstream of the proposed dam site are likely to be impacted by dam operations. For example, the main stem and tributaries above the proposed dam site will be influenced by clearing of riparian areas and periodic inundation during high flow events whereas the main stem river downstream of the proposed dam site will be influenced by changes in bed-load movement, scouring, and substrate size caused by regulated flows. Spring and fall Chinook are primarily main stem spawners which means that their spawning will be influenced by alteration of main stem spawning habitat upstream and downstream of the proposed dam. Based on the 2017-2018 survey, a much larger proportion of Chinook spawning occurs in the main stem river downstream than above the proposed dam site. This suggests that any dam-caused changes to main stem habitat downstream of the structure may be particularly important to the spawning success of both spring and fall Chinook salmon.

Coho and Steelhead have a broader spatial extent of spawning habitat than Chinook and use both main stem and smaller tributaries for spawning in the Upper Chehalis River sub-basin. In the 2017-2018 season, approximately one third of Coho and Steelhead redds above the proposed dam site were located within the FRO inundation footprint. In contrast to Chinook, very little spawning activity for Coho and Steelhead was observed in the main stem river downstream of the proposed dam site. This suggests that any dam-caused changes to main stem and tributary habitat upstream of the structure may be particularly important to the spawning success of Coho and Steelhead.

Continuation of this work is planned for one additional year (fall 2018 - spring 2019) and will include snorkel counts of hatchery:wild steelhead and surveys of the main stem river below the proposed dam site. If flow conditions are suitable, snorkel surveys will be performed between late February and late March to increase understanding of in-river proportions of hatchery vs. wild Steelhead present before, during, and after the March 15th threshold in the Upper Chehalis River. Spawner surveys will be conducted from RM 108.2 downstream to the Newaukum River confluence to determine spatial distribution below the proposed dam site of current spawning activity for all four species.

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Appendices

Appendix A. Survey reaches for the 2017-2018 survey season in the Upper Chehalis river basin. Reach Codes correspond to Survey Effort (Figure 2), RM: River Mile, S.CH: spring Chinook, F.CH: fall Chinook, CO: Coho, STHD: Steelhead

Reach Codes	River/RM	RM Surveyed	Type of Survey	Species Surveyed
1	Chehalis River 108.2-108.7	0.5	Index	S.CH,F.CH,CO,STHD
2	Chehalis River 108.7-110.2	1.5	Index	S.CH,F.CH,CO,STHD
3	Chehalis River 110.2-111.5	1.3	Index	S.CH,F.CH,CO,STHD
4	Chehalis River 111.5-112.6	1.1	Index	S.CH,F.CH,CO,STHD
5	Chehalis River 112.6-113.7	1.1	Index	S.CH,F.CH,CO,STHD
6	Chehalis River 113.7-116.7	3.0	Index	S.CH,F.CH,CO,STHD
7	Chehalis River 116.7-117.5	0.8	Index	S.CH,F.CH,CO,STHD
8	Chehalis River 117.5-118.1	0.6	Index	S.CH,F.CH,CO,STHD
9	Chehalis River 118.1-120.1	2.0	Index	S.CH,F.CH,CO,STHD
10	East Fork Chehalis 120.1-121.3	1.2	Index	S.CH,F.CH,CO,STHD
11	East Fork Chehalis 121.3-122.5	1.2	Index	S.CH,F.CH,CO,STHD
12	East Fork Chehalis 122.5-123.3	0.8	Index	S.CH,F.CH,CO,STHD
13	East Fork Chehalis 123.3-124.3	1.0	Index	S.CH,F.CH,CO,STHD
14	East Fork Chehalis 124.3-125.4	1.1	Index	S.CH,F.CH,CO,STHD
15	East Fork Chehalis 125.4-126.4	1.0	Index	S.CH,F.CH,CO,STHD
16	East Fork Chehalis 126.4-127.7	1.3	Index	S.CH,F.CH,CO,STHD
17	East Fork Chehalis 127.7-128.6	0.9	Index	CO,STHD
18	Crim Creek 0.0-0.8	0.8	Index	S.CH,F.CH,CO,STHD
19	Crim Creek 0.8-1.9	1.1	Index	S.CH,F.CH,CO,STHD
20	Crim Creek 1.9-2.9	1.0	Index	S.CH,F.CH,CO,STHD
21	Lester Creek 0.0-0.7	0.7	Index	CO,STHD
22	Big Creek 0.0-0.9	0.9	Index	S.CH,F.CH,CO,STHD
23	Big Creek 0.9-1.7	1.7	Index	S.CH,F.CH,CO,STHD
24	Big Trib C 0.0-0.3	0.3	Index	CO,STHD
25	Roger Creek 0.0-0.5	0.5	Index	F.CH,CO,STHD
26	Alder Creek 0.0-0.4	0.4	Index	CO,STHD
27	Thrash Creek 0.0-0.6	0.6	Index	S.CH,F.CH,CO,STHD
28	Thrash Creek 0.6-1.2	0.6	Index	S.CH,F.CH,CO,STHD
29	Thrash Creek 1.2-1.6	0.4	Index	S.CH,F.CH,CO,STHD
30	Thrash Creek 1.6-2.7	1.1	Index	S.CH,F.CH,CO,STHD
31	Mack Creek 0.0-0.3	0.3	Index	CO,STHD
32	West Fork Chehalis 0.0-1.2	1.2	Index	S.CH,F.CH,CO,STHD
33	West Fork Chehalis 1.2-2.3	1.1	Index	S.CH,F.CH,CO,STHD
34	West Fork Chehalis 2.3-3.2	0.9	Index	S.CH,F.CH,CO,STHD
35	West Fork Chehalis 3.2-4.2	1.0	Index	S.CH,F.CH,CO,STHD
36	Sage Creek 0.0-0.6	0.6	Index	STHD
37	Cinnabar Creek 0.0-0.7	0.7	Index	CO,STHD

Appendix A. Continued

Reach Codes	River/RM	RM Surveyed	Type of Survey	Species Surveyed
38	George Creek 0.0-1.0	1.0	Index	CO,STHD
39	George Creek 1.0-2.0	1.0	Index	CO,STHD
40	23.1211 0.0-0.2	0.2	Index	CO,STHD
41	23.1213 0.0-0.2	0.2	Index	CO,STHD
	East Fork Chehalis River 128.6-129.7	1.1	Supplemental	CO,STHD
	Crim Creek 2.9-5.8	2.9	Supplemental	CO,STHD
	Browns Creek 0-0.3	0.3	Supplemental	CO,STHD
	Unnamed Tributary 0-0.2	0.2	Supplemental	CO,STHD
	Big Creek 1.7-2.7	1.0	Supplemental	CO,STHD
	Big Trib A 0-0.2	0.2	Supplemental	CO,STHD
	Big Trib D 0-0.1	0.1	Supplemental	CO
	Big Trib E 0-0.04	0.04	Supplemental	CO
	Roger Creek 0.5-1.2	0.7	Supplemental	CO,STHD
	Roger Creek 1.2-2.2	1.0	Supplemental	CO,STHD
	Roger Trib 1182 0-0.2	0.2	Supplemental	CO,STHD
	Little Roger Creek 0-0.5	0.5	Supplemental	CO,STHD
	Alder Creek 0.4-0.5	0.1	Supplemental	CO,STHD
	Thrash Creek 2.7-3.5	0.8	Supplemental	CO,STHD
	Thrash Trib 1187 0-0.2	0.2	Supplemental	CO,STHD
	Thrash Trib 1188 0-0.1	0.1	Supplemental	CO,STHD
	Thrash Trib 1189 0-0.1	0.1	Supplemental	CO,STHD
	Thrash Trib 1190 0-0.5	0.5	Supplemental	CO
	Thrash Trib 1190 0-0.7	0.7	Supplemental	STHD
	West Fork Trib 1194 0-0.3	0.3	Supplemental	CO,STHD
	Sage Creek 0.0-0.6	0.6	Supplemental	CO
	Sage Creek 0.6-0.9	0.3	Supplemental	CO,STHD
	Cinnabar Creek 0.7-2.1	1.4	Supplemental	CO,STHD
	Cinnabar Trib 1204 0-0.1	0.1	Supplemental	CO,STHD
	Cinnabar Trib 1205 0-0.2	0.2	Supplemental	CO,STHD
	George Creek 2.0-2.4	0.4	Supplemental	CO,STHD
	George Trib 1208A 0-0.1	0.1	Supplemental	CO,STHD
	George Trib 1208B 0-0.1	0.1	Supplemental	CO
	George Trib 1209 0-0.1	0.1	Supplemental	CO,STHD
	George Trib 1210 0-0.1	0.1	Supplemental	CO,STHD
	Unnamed Trib 1211 0.2-0.4	0.2	Supplemental	CO,STHD
	Unnamed Trib 1212 0-0.2	0.2	Supplemental	CO,STHD
	Unnamed Trib 1213 0.2-1.0	0.8	Supplemental	CO,STHD
	East Fork Trib A 0-0.2	0.2	Supplemental	CO,STHD
	East Fork Trib B 0-0.5	0.5	Supplemental	CO,STHD
	East Fork Trib C 0-0.2	0.2	Supplemental	CO,STHD

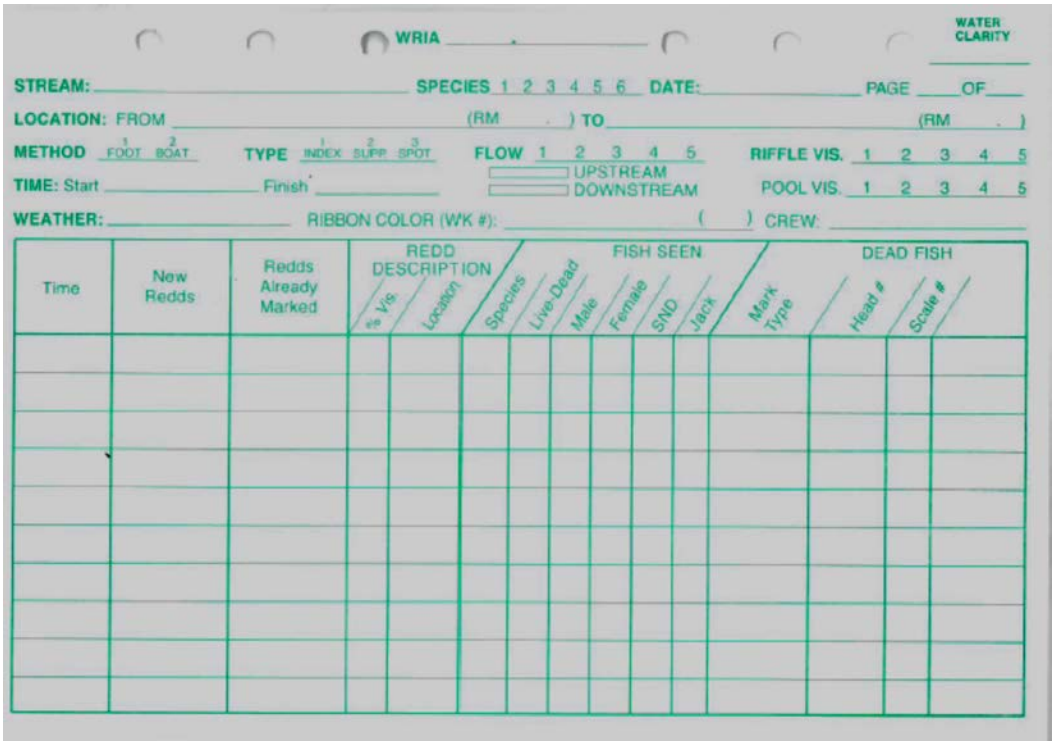
Appendix A. Continued

Reach Codes	River/RM	RM Surveyed	Type of Survey	Species Surveyed
	East Fork Trib D 0-0.2	0.2	Supplemental	CO,STHD
	East Fork Trib E 0-0.2	0.2	Supplemental	CO,STHD

Appendix B. Statistical weeks by date for survey season 2017-2018.

Statistical Week	Start Date	End Date
37	9/10/2017	9/16/2017
38	9/17/2017	9/23/2017
39	9/24/2017	9/30/2017
40	10/1/2017	10/7/2017
41	10/8/2017	10/14/2017
42	10/15/2017	10/21/2018
43	10/22/2017	10/28/2017
44	10/29/2017	11/4/2017
45	11/5/2017	11/11/2017
46	11/12/2017	11/18/2017
47	11/19/2017	11/25/2017
48	11/26/2017	12/1/2017
49	12/3/2017	12/9/2017
50	12/10/2017	12/16/2017
51	12/17/2017	12/18/2017
52	12/19/2017	12/30/2017
1	12/31/2017	1/6/2018
2	1/7/2018	1/13/2018
3	1/14/2018	1/20/2018
4	1/21/2018	1/27/2018
5	1/28/2018	2/3/2018
6	2/4/2018	2/10/2018
7	2/11/2018	2/17/2018
8	2/18/2018	2/24/2018
9	2/25/2018	3/3/2018
10	3/4/2018	3/10/2018
11	3/11/2018	3/17/2018
12	3/18/2018	3/24/2018
13	3/25/2018	4/31/2018
14	4/1/2018	4/7/2018
15	4/8/2018	4/14/2018
16	4/15/2018	4/21/2018
17	4/22/2018	4/28/2018
18	4/29/2018	5/5/2018
19	5/6/2018	5/12/2018
20	5/13/2018	5/19/2018
21	5/20/2018	5/26/2018
22	5/27/2018	6/2/2018
23	6/3/2018	6/9/2018
24	6/10/2018	6/16/2018

Appendix C. Field data card used by the surveyor to record information in field.



WRIA ____.____ WATER CLARITY ____

STREAM: ____ SPECIES 1 2 3 4 5 6 DATE: ____ PAGE ____ OF ____

LOCATION: FROM ____ (RM ____.____) TO ____ (RM ____.____)

METHOD 1 FOOT 2 BOAT TYPE 1 INDEX 2 SURF 3 SPOT FLOW 1 2 3 4 5 RIFFLE VIS. 1 2 3 4 5

TIME: Start ____ Finish ____ ☐ UPSTREAM ☐ DOWNSTREAM POOL VIS. 1 2 3 4 5

WEATHER: ____ RIBBON COLOR (WK #): ____ (____) CREW: ____

Time	New Redds	Redds Already Marked	REDD DESCRIPTION: Vis.	REDD DESCRIPTION: Location	FISH SEEN: Species	FISH SEEN: Live-Dead	FISH SEEN: Male	FISH SEEN: Female	FISH SEEN: SND	FISH SEEN: Jack	DEAD FISH: Mark Type	DEAD FISH: Head #	DEAD FISH: Scale #	DEAD FISH:

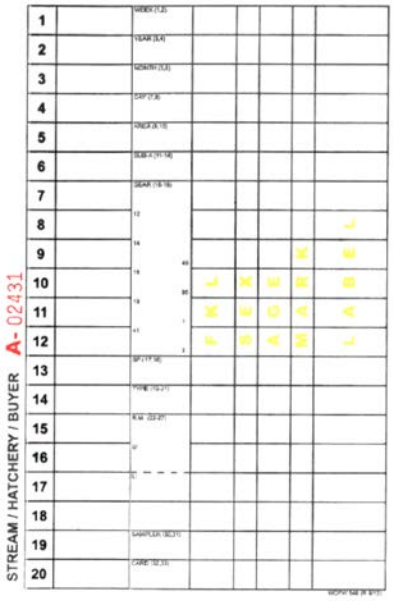
Appendix D. Description of spring-run Chinook vs. fall-run Chinook characteristics used to distinguish between run-type during their overlapping spawning period around October 15th.

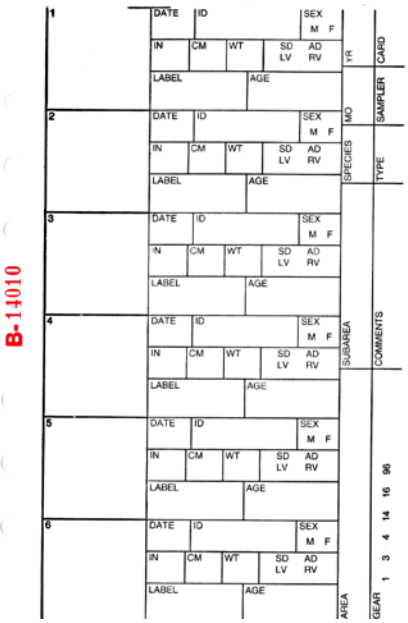
Pre-overlap	Fish/redds seen prior to October 7th are spring-run.	
Overlap		
	Spring Chinook	Fall Chinook
Fish[a]	Grey, olive, or black/dark in color; Dull and/or dusky appearance, not bright and shiny colors;	Red, green, or purple in color; Bright, shiny colors, vivid
	Low energy level, lethargic, exhibiting an unwillingness to be spooked off of redds (for females) or into quick currents; [b]	High energy level, spooking easily and powering through riffles and low water areas, exhibiting a frantic behavior when spooked or scared
	Fungus present on fish and edges of snout, and fins showing wear;	No or minimal amounts of fungus and/or wear
	Have a soft caudal peduncle	Have a firm caudal peduncle
Redds	Presence of a spring Chinook female;	Presence of a fall Chinook female;
	If no female presence:	
	Before/on October 15th the redd was recorded as spring-run type	
	After October 15th the condition of the redd determines run type	
	If redd was built on/prior to Oct. 15th it was recorded as spring-run type	
	If redd was built after Oct. 15th it was recorded as fall-run type	
Post-overlap	After Oct. 15th live fish and redds are fall-run type unless the observation is different from the rest of the observations in the survey	

[a]: For live fish – justify decision with 3 of the 4 characteristics; for carcasses – justify decision with 2 of the 3 characteristics

[b]: Energy level and behavior of fish on a redd was use to clarify run type on live fish and associated redds only

Appendix E. Scale cards used by the surveyor to mount scales and record information in the field. The card on the left is used for spring and fall Chinook (3 scales/carcass), and the card on the right is used for Steelhead (6 scales/carcass). Notice the Steelhead scale card has more space for mounting scales.





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