California Department of Fish and Wildlife

LOWER EEL RIVER AND VAN DUZEN RIVER CALIFORNIA COASTAL CHINOOK MONITORING PROJECT REPORT

Results of regional spawning ground surveys in the Lower Eel River and Van Duzen River Watersheds, Humboldt County, California, 2017/2018.

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ABSTRACT

The first year of the Lower Eel River and Van Duzen River California Coastal Chinook Monitoring Project yielded 86 spawning ground surveys were conducted over 18 selected Chinook salmon stronghold reaches and 10 reconnaissance reaches in the Lower Eel and Van Duzen River Watersheds from November 13, 2017 to February 20, 2018. California Coastal Salmonid Monitoring Plan (CMP) style reaches were surveyed an average of 4.1 times, and the average interval between surveys was 22 days. Reconnaissance reaches were surveyed one to two times. During the 2017-2018 survey season, crews observed 226 live Chinook salmon, 27 live coho salmon, 4 live steelhead, and 3 live unidentified salmonids. Crews encountered 83 Chinook salmon carcasses, 4 coho salmon carcasses, 2 steelhead carcass, and 24 unidentified salmonid carcasses. A total of 355 redds were detected, of which 68 redds were observed to be associated with a specific salmonid species while in the field. The remaining 287 redds were inferred by surveyors to be 163 Chinook salmon redds, 26 coho salmon redds, 15 steelhead redds, and 83 unidentified salmonid redds. 113 salmonid carcasses that were eligible for a jaw tag were located of which 95 had tissue and/or scale samples taken depending on the level of degradation. The objectives for this pilot project were met and exceeded during this spawner surveying season.

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1 INTRODUCTION

1.1 BACKGROUND

Chinook salmon (*Oncorhynchus tshawytscha*) in the California Coastal Chinook Salmon (CC Chinook) Evolutionary Significant Unit (ESU) were listed as threatened under the federal Endangered Species Act in 1999 (64 FR 50394) and later reaffirmed in 2005 (70 FR 37160) due to decreasing population sizes in comparison to historical abundance in the rivers and tributaries south of the Klamath River to and including the Russian River. California's third largest watershed, the Eel River, composes a significant proportion of the overall CC Chinook salmon ESU range and natural production and is designated critical habitat for the CC Chinook. In 2015, The California Department of Fish and Wildlife (CDFW) in collaboration with the National Marine Fisheries Service (NMFS) developed future monitoring and recovery plans for the CC Chinook salmon ESU, calling for increased data collection of spawning adults and escapement of CC Chinook in strongholds such as the Eel River (Lacy et al. 2016). A focused long-term monitoring project for the Lower Eel and Van Duzen River Watersheds is essential to expanding the range of known population trends and is one part of the development of abundance-based fishery management (ABM) for the CC Chinook ESU.

The 2011 CDFW "*Fish Bulletin 180 California Coastal Salmonid Monitoring Plan*" (CMP) established the approach for monitoring ESA/CESA listed anadromous salmonid population(s) status and trend in California. In the CMP's Northern California area, adult salmonid population abundance are monitored using extensive spawning ground surveys to estimate total redd escapement within a survey area/sample frame. The exploratory years of the CMP survey are used to set up a survey frame by visiting a combination of "strongholds" streams where salmonids have historically been observed and streams that have suitable spawning habitat as determined by previous habitat surveys. In subsequent years spawning ground surveys are conducted on a random and spatially balanced sample of survey reaches, drawn from a survey frame encompassing all potential spawning habitat available to anadromous salmonid specie(s) within the designated study area. Georeferenced live salmonids, salmonid carcasses, and redd observation data are collected in each reach. The number of redds per salmonid species identified by observation and data analysis within the sample reaches is then be expanded to estimate total redd escapement for the entire sample frame (Adams et al. 2011). CDFW has been operating these CMP survey methods within the in Eel River watershed with the South Fork Eel River Adult Redd Salmonid Abundance Monitoring Project. This project initiated in 2010 as a long-term effort to provide estimates of adult coho salmon redd abundance in the South Fork Eel River Watershed over time. The Lower Eel River CC Monitoring Project will utilize knowledge gained through the South Fork Eel River monitoring project to conduct an effective monitoring project in the Lower Eel and Van Duzen River watersheds.

1.2 **STUDY AREA**

The Van Duzen River Basin drains approximately 430 square miles of mountainous terrain in California's North Coast Range. Eighty-four percent of the basin is within Humboldt County and the remaining portion (16%) is within Trinity County. The Van Duzen River is a major tributary to the lower Eel River which flows into the Pacific Ocean approximately 15 miles south of Eureka, in Humboldt County. Elevations in the Van Duzen River Basin range from approximately 5,900 feet at the upper basin headwater peaks (Mount Lassic, Black Lassic, and Red Lassic) to a low elevation of 60 feet where the Van Duzen River joins the Eel River near the town of Fortuna, and approximately 13 miles from the Pacific Ocean. The Lower Eel Basin is composed of less than 5% of the entire Eel River catchment at approximately 172 square miles and is defined as the watershed area from the mouth, upstream approximately 21 miles upstream (CDFG 2013). The survey frame encompasses the Lower Eel River extended to the tributaries and confluences before the South Fork Eel River and the lower sub basins of the Van Duzen River (Figure 1). The total drainage area is 602 square miles which captures the majority of Chinook salmon distribution in the area.

Historically, the Eel River was one of the state's most productive rivers for anadromous salmonids, supporting runs of coho salmon (*O. kisutch*), Chinook salmon (*O. tshawytscha*), and steelhead/rainbow trout (*O. mykiss*). However, Pacific salmon runs in the Eel River have markedly declined over the last 100 years and the distribution of Chinook salmon and in the lower Eel River watershed is known to be limited (O'Farrell et al. 2015). The Van Duzen River is one of the remaining un-dammed rivers of California, and thus the Chinook winter runs in this area may serve as an important bastion for CC Chinook population recovery.

The Lower Eel River Coastal Chinook Monitoring Project was initiated by the California Department of Fish and Wildlife as a part of an U.S. Fish and Wildlife's Sport Fish Restoration Act grant as an exploratory effort to provide estimates of adult California Coastal Chinook salmon redd abundance in the Lower Eel River and Van Duzen River Watersheds. This report presents the results of the 2017-2018 spawning survey season, the pilot year of the study.

Figure 1. Map of the Lower Eel River and Van Duzen River Watersheds and its location within the Eel River Watershed.

2 METHODS

2.1 SAMPLE FRAME

A sample frame was established for the Lower Eel River and Van Duzen River using five parameters: (1) documented salmonid distributions, (2) stream gradient and stream size where salmonid distributions are unknown, (3) fish passage barrier data, (4) expert knowledge of salmonid distribution and migration barriers, and (5) field reconnaissance (Garwood and Ricker 2011). These data were compiled within a Geographic Information System (GIS) to develop species-specific (Chinook, coho, and steelhead) spawning distributions (sample frames).

As the focus of this project is adult Chinook salmon, streams within the identified Chinook-specific sample frame were segmented into one to three kilometer reaches, with start and end points at identifiable landmarks (e.g. tributaries) and upstream extents at barriers to anadromy, both known and model-derived. All reaches were assigned a numeric identification, known as the location code, starting at the lower-most reach and moving upstream from north to south (Figure 2, 3). (Garwood and Ricker 2011).

2.2 SAMPLE REACH SELECTION

Spawning ground surveys were conducted in order to inform the viability of an annual, reproducible Chinook monitoring project in the Lower Eel River and Van Duzen River watersheds. The sample frame included 211 potential reaches of which 28 reaches were selected based off of historic observations of fish, or based off of suitable Chinook spawning habitat. Out of the 28 selected reaches ten of them were reconnaissance reaches that were not periodically surveyed/ Since much of the Eel River and Van Duzen Rivers are under private ownership, a reach's inclusion on the list of 28 sample reaches is dependent on gaining permission from the relevant landowners. If permission was denied or if a landowner did not respond in time for the start of the spawning season, the reach was skipped for the year and the next stream in order was added to the survey list.

Reconnaissance reaches were necessary for the first year of the study to deduce if a reach was accessible, the quality and quantity of Chinook spawning habitat present, and to collect adult Chinook cascasses which would contribute information to determine frame size of potential future monitoring efforts. Reconnaissance reaches included an upper Lawrence Creek reach that was not originally survey frame, the mainstem Van Duzen River, and smaller tributaries that have had little to no historical spawner survey data collected (Table 2). In future years of the lower Eel River and Van Duzen River spawning surveys the General Randomized Tessellation-Stratified (GRTS) sampling design (Adams et al. 2011) will be used in order to assure less bias in the study design and the following statistical analysis.

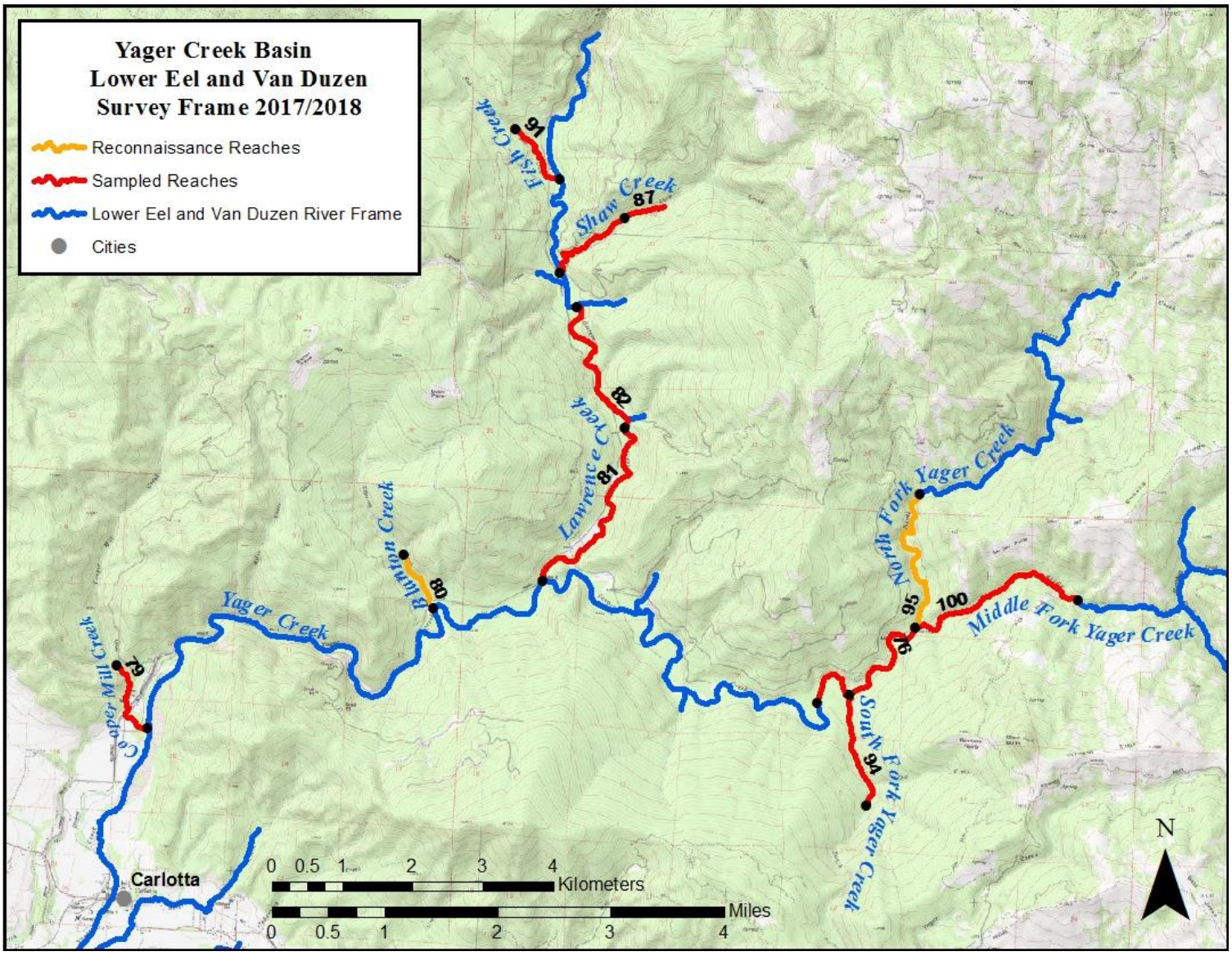


Figure 2. Map of the Yager Creek subbasin Chinook-specific spawner survey frame. Sampled reaches that were surveyed 3+ times during the 2017-2018 spawner survey season are red; reconnaissance reaches are yellow. Unsurveyed sample frame reaches are blue. Each visited reach is labelled with its numeric location codes.

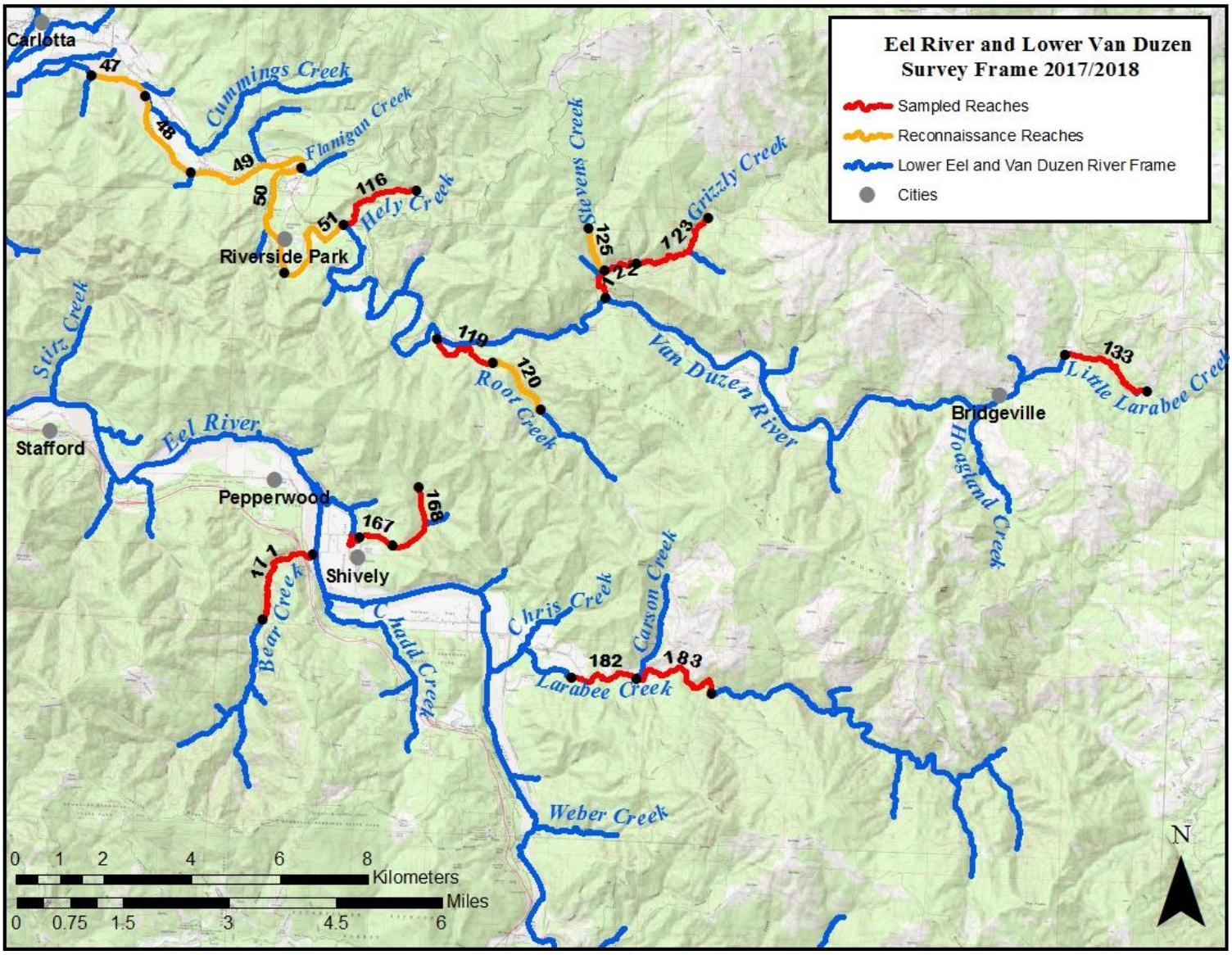


Figure 3. Map of the Eel River and lower Van Duzen River Chinook-specific spawner survey frame. Sampled reaches surveyed during the 2017-2018 spawner survey season are red; reconnaissance reaches subreaches are yellow. Unsurveyed sample frame reaches are blue. Each visited reach is labelled with its numeric location code.

2.3 REACH SURVEY PROTOCOL

Spawning ground surveys were conducted following the methods of ground survey and data capture outlined in Gallagher et al. (2014) and Adams et al. (2011). The surveys were conducted during the entire length of the Chinook salmon spawning season and a majority of the coho salmon spawning season (roughly mid-November to late February). This survey range also captured the early portion of the winter steelhead trout spawning season. The surveys were primarily completed by a two-person team by foot; the exception being the Van Duzen River mainstem survey, which utilized kayaks to float down the river to best identify live fish, redds, and any carcasses. Each reach is intended to be surveyed once every 7 to 14 days, or as weather, flow, and turbidity conditions allow.

Live fish and carcasses were identified to species and sex if possible and X-Y coordinates are acquired with a handheld Global Positioning System (GPS) unit. Carcasses were assigned a condition code ranging from 1 to 6 based on level of degradation upon observation: condition (1) carcasses are fresh with a clear eye; condition (2) have low fungus with a cloudy eye; condition (3) carcasses have heavy fungus with no eye; condition (4) are skin and bones with a head; condition (5) are skin and bones with no head; and lastly condition (6) is a loose tag, without any fish. The two Chinook carcasses pictured below (Figure 4) were assigned a condition code three for the above fish and condition one for the lower fish. Carcasses were measured to fork length if possible, and marked as "captured" with a uniquely numbered jaw tag. Condition of the fish permitting, scale and tissue samples were also taken from each "captured" carcass. Tissue samples are the sent to NOAA for DNA analysis, and scale samples are sent to the CDFW Arcata office for age valuation of each fish. If a carcass was recovered with a jaw tag on a subsequent survey it was considered "re-captured".

The location of all newly observed redds was geo-referenced by acquiring X-Y coordinates with a GPS unit and marked with flagging labelled with that redd's unique record number (Figure 5). All new redds encountered were assigned an age of (1) new since last survey. On subsequent surveys, encountered flags were matched with their associated redds, which were then re-assigned a new age of (2) still visible and measurable, (3) visible, but not measurable, (4) not visible, or (5) unknown due to poor visibility. If a new redd was unattended or an old redd was not previously measured, physical measurements were taken, including length and width of pot and tailspill, substrate size of pot and tailspill, and depth of the pot relative to the surrounding substrate (Ricker et al. 2013).

Figure 4. Chinook male (top) and female carcasses found on Lawrence Creek.

2.4 VISIBILITY AND TURBIDITY MONITORING

Visibility is measured in centimeters (cm) using a secchi disc attached to the bottom of a measuring pole which was slowly lowered into a pool as one observer about a meter away watched until they could no longer see the middle of the secchi disc. Stream visibility greater than 150cm could not be accurately recorded due to the length of the measuring pole. As the discharge at the Van Duzen River increased due to precipitation, run-off, or snow pack melting, the discharge of proximal creeks also increased. The larger flows brings with it increased suspended sediment, organic matter, and turbidity which lowers visibility (see Appendix, Picture 8). This limits ability to see redds, fish, and carcasses while surveying. Generally, a creek with 40 centimeters or less visibility will not be surveyed until flows decrease and water quality becomes better with increased clarity. Reach visibilities measurements were taken at the beginning of each survey. Supplementary visibility data was collected on reconnaissance and selected reaches that were in close proximity if time permitted.

2.5 ASSIGNING SPECIES TO REDDS

Only redds directly associated with a live and identifiable fish actively digging or guarding them were considered unambiguously known to a species (e.g. known Chinook redds). When there wasn't a fish observed on a redd, measurements were taken and the surveyors would guess the species of the fish that made the redd to the best of their abilities using seasonality, redd shape, substrate size, and associated live fish and carcasses observed on the stream that day (e.g guess

Chinook redds) (Figure 5). If a redd still could not be accurately identified to species, then the redd would be labelled as an unidentified salmonid redd. Unidentified redds were later assigned a species.

Figure 5. Chinook redd, age code 1.

2.5.1 ESTIMATION OF WITHIN-REACH ABUNDANCE

High stream discharge and time between repeated surveys may scour or flatten redds and therefore obscure them from potential counting (Jones 2012). To account for the unseen fraction of redds deposited then subsequently obscured from view between repeated surveys, the total number of redds constructed within a survey reach was estimated using a flag-based mark-recapture model. The total count of individually observed and flagged redds for a given reach is divided by the square root of the seasonally pooled redd survival rate. Redd survival is calculated as the fraction of re-observed and still identifiable flagged redds ("recaptures" assigned age 2 or 3) to the total number of flagged redds available to for potential re-observation ("marked"). Taking the square root of this fraction assumes the deposition of redds occurs at the midpoint between survey intervals (see below) (Schwarz et al. 1993). Bootstrap resampling from an assumed binomial distribution was used to represent the uncertainty of the pooled seasonal redd survival term in the estimator of total number of redds within the reach. The variance of the estimated total number of redds within a reach is calculated as the variance of the resultant bootstrap distribution (Manly 1997, Ricker et al. 2014). Additional assumptions applied to this model are as follows:

1. Surveyors correctly identify all redds and no redds are missed during each survey.
2. Once a redd has been classified as "not visible" it does not become visible at a later occasion.
3. All redd flags are re-observed, identifiable, and recorded.
4. All marked redds have the same probability of survival, regardless of species or age and across all occasions.
5. New redds are constructed at the mid-point between survey intervals.

Table 1. Survey frequency of sampled reaches. Reaches are listed by stream name and location code. Mean indicates the average number of days between surveys, Max is the maximum number of days between surveys, Min is the minimum number of days between surveys, and N is the total number of surveys.

Location Code	Stream Name	Mean (Days)	Max (Days)	Min (Days)	N (Surveys)
76	Yager Creek	31.50	48	15	3
79	Cooper Mill Creek	21.33	42	7	4
81	Lawrence Creek*	14.17	9	7	7
82	Lawrence Creek	13.33	12	11	4
87	Shaw Creek	15.50	15	7	7
91	Fish Creek	15.60	34	7	6
94	SF Yager Creek	21.25	13	11	5
100	MF Yager Creek	33.50	35	32	3
116	Hely Creek	29.50	38	21	3
119	Root Creek	35.00	38	32	3
122	Grizzly Creek	16.40	15	13	6
123	Grizzly Creek*	16.50	18	8	5
133	Little Larabee Creek	42.00	68	16	3
167	Shively Creek	31.50	55	8	3
168	Shively Creek	31.50	55	8	3
171	Bear Creek	22.00	23	21	3
182	Larabee Creek	29.00	44	14	3
183	Larabee Creek	33.00	44	22	3
	All Reaches	21.96	33.67	14.44	4.11

* Indicates one survey for the reach took two consecutive days due to time constraints or weather conditions. Consecutive days surveyed are counted as one day when calculating mean, maximum, minimum days, and number of surveys.

Table 2. Number of reconnaissance reach surveys. Reaches are listed by stream name and location code. N is the total number of times the reach was visited.

Location Code	Stream Name	N (Surveys)
N/A*	Lawrence Creek	1
47	Van Duzen River	1
48	Van Duzen River	1
49	Van Duzen River	1
50	Van Duzen River	1
51	Van Duzen River	1
80	Blanton Creek	1
95	NF Yager Creek	1
120	Root Creek	2
125	Stevens Creek	2

*Indicates reach outside of established survey frame. Reach is further upstream of established Lawrence Creek reaches in the frame.

3 RESULTS

3.1 SAMPLE FRAME CHANGES AND STATUS

Field reconnaissance of the Lower Eel and Van Duzen Rivers sampling frame is ongoing and appropriate updates will be transferred to the state-wide CMP Geo database in Sacramento and the luLocation table of the CMP Aquatic Survey's Survey Management Switchboard. Sample frame updates include changes to reach lengths, start stop locations, and total number of reaches. Reach additions will occur to include upper Lawrence Creek reaches where steelhead and coho have been observed and where potential Chinook spawning habitat exists. Lawrence reaches 81 and 82 are also good candidates to split into multiple reaches as during peak Chinook season as the over 2.5km reaches are difficult to complete in a single day due to the amount of new fish and redds in such a large creek. Booths Run, tributary to upper Lawrence Creek, is another prospective addition to the sample frame as a coho carcass was recovered and spawning habitat was observed in an incidental survey by seasoned volunteer surveyor Eric Stockwell (not included as reconnaissance reach). In making these updates, the final sampling frame will likely increase from the original 211 reaches, and the survey frame will need to be extended.

3.2 SURVEY STATISTICS

Survey crews conducted a total of 86 spawning ground surveys from November 13, 2017 to February 20, 2018 over the 28 selected stream reaches within the Lower Eel River and Van Duzen River Watersheds. Of the 28 selected streams, 18 were surveyed 3 to 7 times (an average number of 4.11 visits per survey) and can be considered CMP style reaches or sampled reaches (Table 1). The last 10 reconnaissance reaches were surveyed 1 to 2 times (an average of 1.2 visits) as supplementary reaches to the main selected streams (Table 2). The average interval between surveys over all CMP reaches was 21.96 days (Table 1).

3.3 FISH OBSERVATIONS

A total of 226 Chinook salmon, 27 coho salmon, 4 steelhead, and 3 unidentified fish were observed over the survey period. Survey crews counted 83 Chinook salmon carcasses, 4 coho salmon carcasses, 2 steelhead carcass, and 24 unidentified carcasses (Table 4). Of the Chinook carcasses counted, 73 were jaw tagged; 9 of which were recaptured at least once (Table 5). Peak Chinook observations occurred from the week beginning November 13, 2017 to the week beginning January 15, 2018. Peak coho salmon observations occurred from the week beginning January 15, 2018 to the week beginning February 12, 2018 (Figure 7). Table 3 summarizes live fish observations by stream name. Table 4 summarizes observations of live fish and carcasses by survey week. Table 5 summarizes the Chinook carcass condition and tagging by stream name.

3.4 REDD OBSERVATIONS

Surveyors identified 58 known Chinook salmon redds, 10 known coho salmon redds, and 0 known steelhead redds. Redds that did not have an associated known fish were assigned an assumed species; there were 163 assumed Chinook redds, 26 assumed coho redds, 15 assumed steelhead redds, and 83 unidentified redds (Tables 3 and 4, Figure 7).

3.5 FLOW DISCHARGE AND TURBIDITY OBSERVATIONS

The United States Geological Survey (USGS) records discharge (in cubic feet per second, cfs) on the Van Duzen River near Bridgeville, CA four times every hour. The USGS Bridgeville gauge (BRI) was used to compare discharge to the turbidity of sample and reconnaissance streams (Figure 6). Stream visibility is taken at the beginning of each attempted survey and was also taken throughout the survey frame as time permitted. A total of 109 stream visibilities and paired stream flows were collected to determine the effect of turbidity on surveys in chinook spawning habitat.

Small streams have a tendency to clear faster after rain events, whereas, large and medium creeks can take a week or more to become surveyable. The larger creeks such as Larabee Creek, Yager Creek and all of its main branches (South Fork, Middle Fork and North Fork Yager) may be less reliable to survey using CMP protocol due to their turbulence and silt-filled drainages. The more precipitation in a winter will lead to more accessible habitat for spawning salmonids, but less availability for surveyors to document them in large systems. Figure 6 presents the stream discharge measured at the Van Duzen River USGS gauging station near Bridgeville, CA versus the stream visibility.

Figure 6. Discharge of the Van Duzen River near Bridgeville (BRI) compared to visibility measurements taken at the beginning of each survey. Discharge (in cubic feet per second, cfs) is recorded from the BRI gauge at the same time visibility was measured. "Large Creek" include reaches on Van Duzen River, Yager Creek, Lawrence Creek, and Larabee Creek. "Medium Creek" include reaches on Grizzly, Little Larabee, South Fork and Middle Fork Yager, and Bear Creeks. "Small Creek" includes reaches on Root, Stevens, Cooper Mill, Shaw, Fish, Shively, and Hely Creeks.

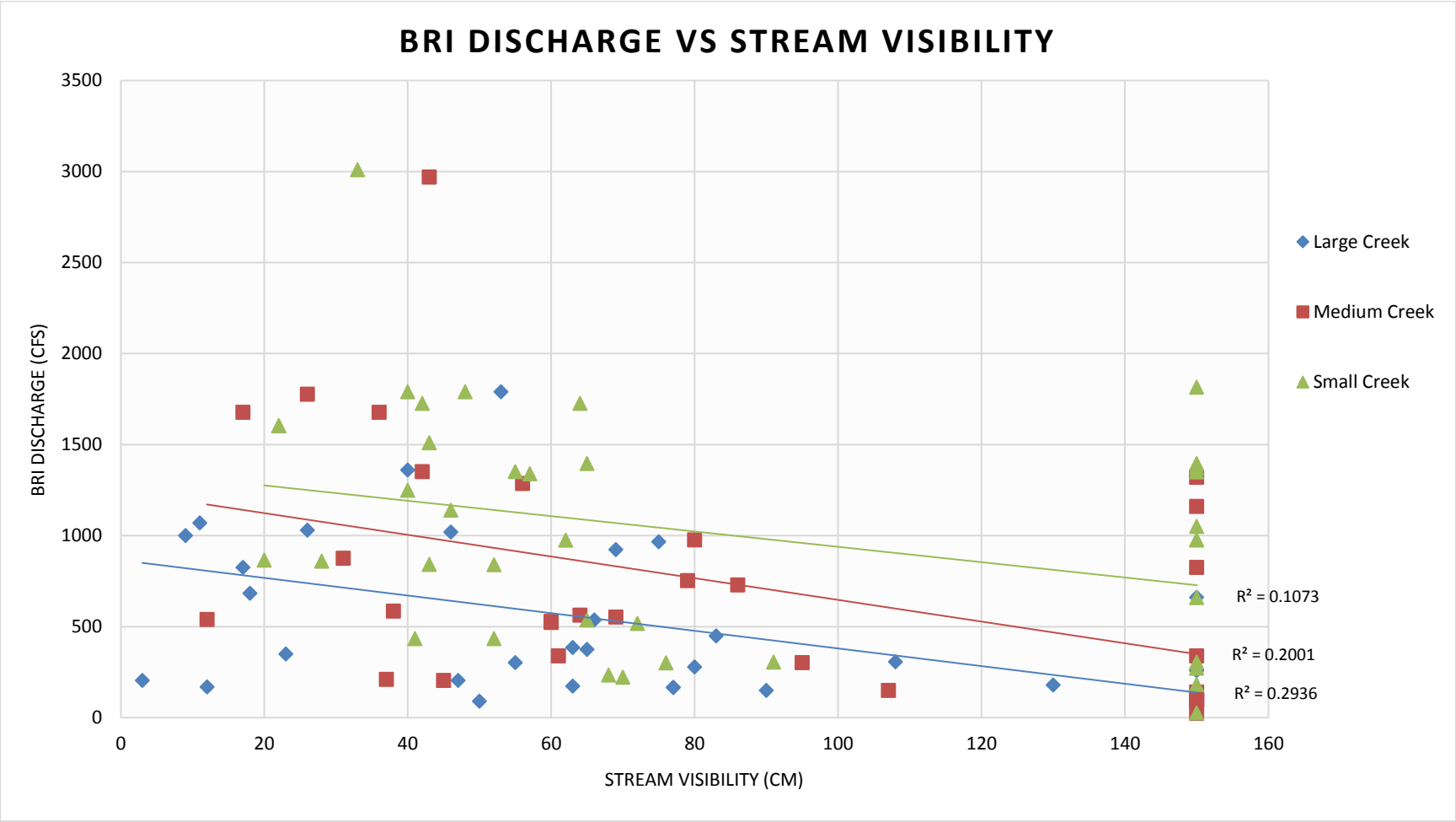


Table 3. Counts of observed live fish and redds by stream. Known redds had an observed fish constructing or on the redd. Assumed redds have been given an associated species based on field identification including time of season, redd features, and measurements. **Bold** streams indicate CMP style surveys were conducted.

Stream Name	Live Chinook	Known Chinook Redds	Assumed Chinook Redds	Live Coho	Known Coho Redds	Assumed Coho Redds	Live Steelhead	Known Steelhead Redds	Assumed Steelhead Redds	Live Unidentified Salmonids	Unidentified Redds
Van Duzen River	4	1	5	0	0	0	0	0	0	0	0
Yager Creek	**2**	**0**	**26**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Cooper Mill Creek	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Blanton Creek	0	0	0	0	0	0	0	0	0	0	0
Lawrence Creek	**171**	**41**	**87**	**1**	**0**	**5**	**4**	**0**	**7**	**1**	**35**
Shaw Creek	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**2**	**0**	**4**
Fish Creek	**0**	**0**	**0**	**22**	**8**	**7**	**0**	**0**	**2**	**0**	**0**
South Fork Yager Creek	**4**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**
North Fork Yager	0	0	0	0	0	0	0	0	0	0	0
Middle Fork Yager Creek	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**1**	**0**	**0**
Hely Creek	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Root Creek	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
Grizzly Creek	**32**	**14**	**29**	**1**	**1**	**6**	**0**	**0**	**1**	**1**	**32**
Stevens Creek	0	0	0	0	0	0	0	0	1	0	0
Little Larabee Creek	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Shively Creek	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Bear Creek	**0**	**0**	**0**	**3**	**1**	**3**	**0**	**0**	**0**	**0**	**2**
Larabee Creek	**13**	**1**	**15**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**5**
Totals	226	58	163	27	10	26	4	0	15	3	83

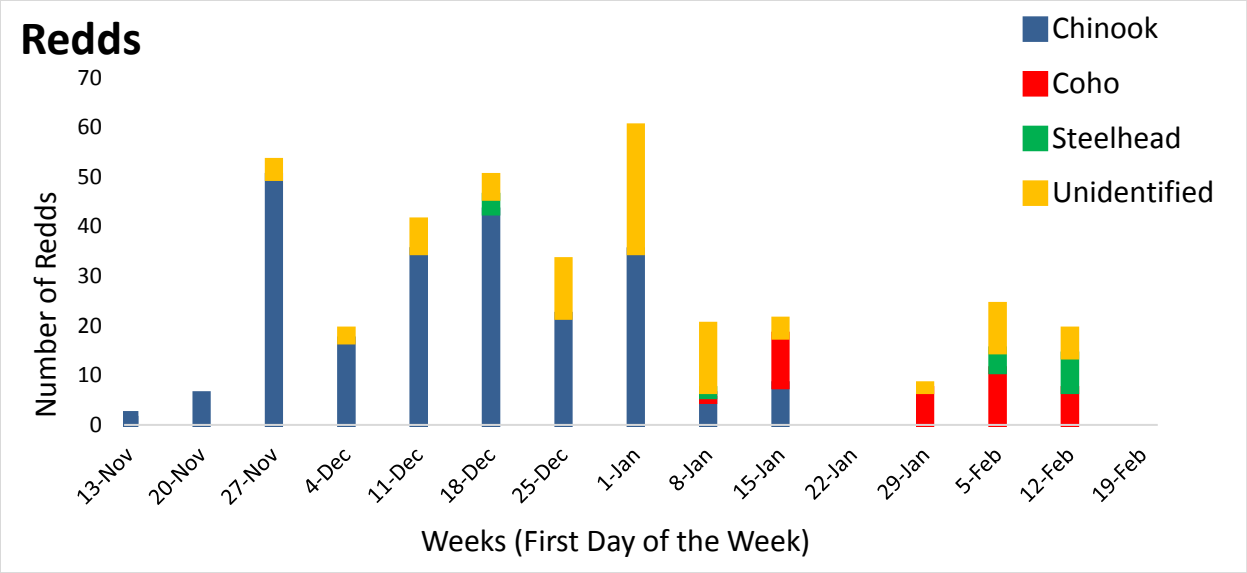
Table 4. Counts of observed live fish, carcasses and redds by week over the survey season, November 13, 2017 to February 20, 2018. Carcass counts are unique carcasses with a lower jaw excluding carcasses with a recaptured status.

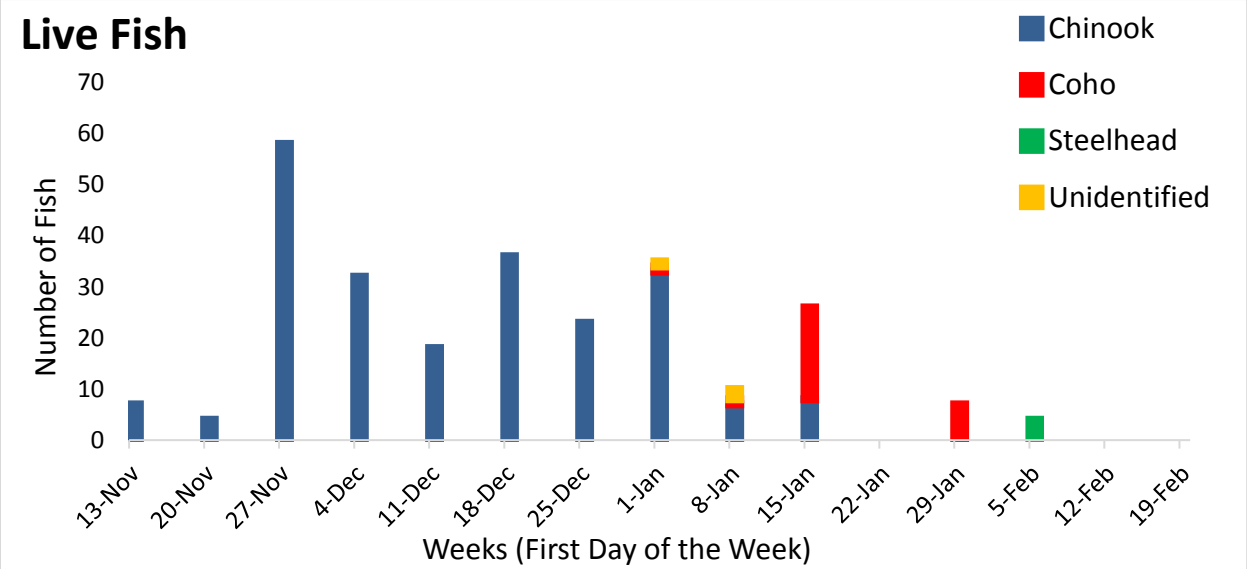
Week	Chinook Redds	Coho Redds	Steelhead Redds	Unidentified Redds	Live Chinook	Live Coho	Live Steelhead	Unidentified Live Salmonids	Chinook Carcasses	Coho Carcasses	Steelhead Carcasses	Unidentified Carcasses
13-Nov	1	0	0	0	7	0	0	0	1	0	0	0
20-Nov	6	0	0	0	4	0	0	0	0	0	0	0
27-Nov	50	0	0	3	58	0	0	0	3	0	0	0
4-Dec	17	0	0	2	32	0	0	0	7	0	0	0
11-Dec	35	0	0	6	18	0	0	0	2	0	0	0
18-Dec	43	0	3	4	36	0	0	0	12	0	0	0
25-Dec	21	0	0	12	23	0	0	0	12	0	0	1
1-Jan	35	0	0	25	33	1	0	1	26	0	0	4
8-Jan	5	1	1	13	7	1	0	2	2	0	0	0
15-Jan	8	10	0	3	8	18	0	0	14	0	0	7
22-Jan	0	0	0	0	0	0	0	0	0	0	0	0
29-Jan	0	7	0	1	0	7	0	0	0	2	0	0
5-Feb	0	11	4	9	0	0	4	0	4	0	2	7
12-Feb	0	7	7	5	0	0	0	0	0	1	0	0
19-Feb	0	0	0	0	0	0	0	0	0	1	0	5
Totals	221	36	15	83	226	27	4	3	83	4	2	24

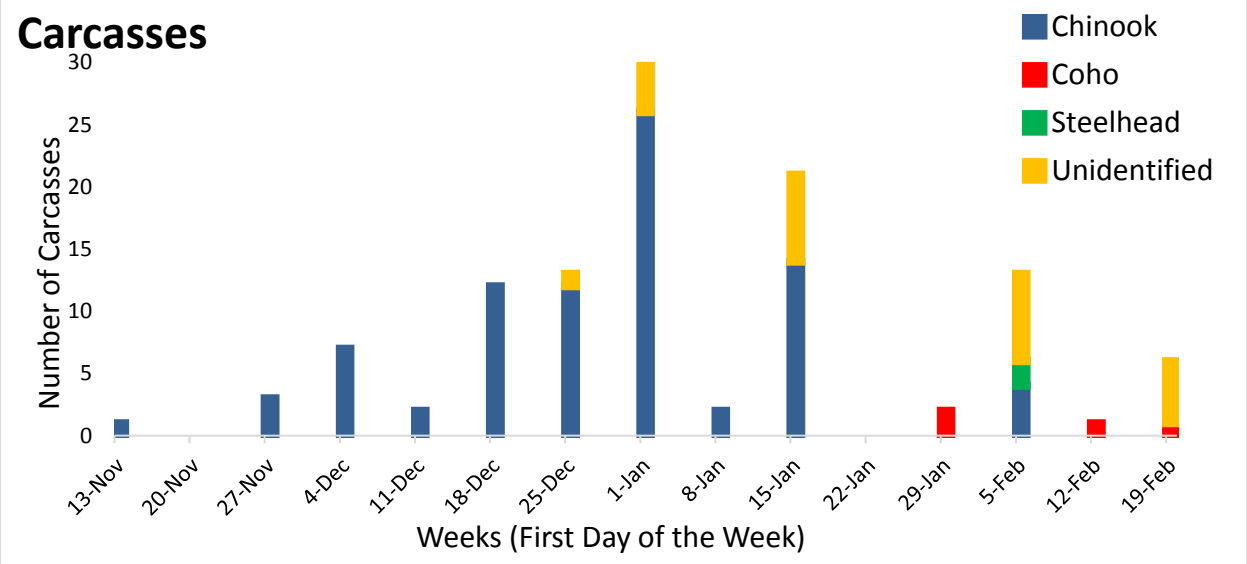
Table 5. Chinook carcass condition by stream. Carcass condition 1 through 4 are eligible for a jaw tag which may be recaptured on subsequent surveys. Recaptured tags are carcasses which have been recaptured at least once.

Stream Name	Condition 1	Condition 2	Condition 3	Condition 4	Condition 5	Condition 6	Total Carcasses	Applied Tags	Recaptured Tags
Yager Creek	1	0	0	2	2	0	5	2	1
Lawrence Creek	22	12	14	24	9	1	82	64	8
Grizzly Creek	3	0	0	0	0	0	3	3	0
Larabee Creek	0	0	1	3	3	0	7	4	0
Total	26	12	15	29	14	1	97	73	9

Figure 7. Stacked bar plots of observed live fish, carcasses, and redds by week over the survey season, November 13, 2017 to February 20, 2018.







4 DISCUSSION

The Lower Eel River and Van Duzen River Coastal Chinook Monitoring Project was initiated as an effort to analyze population abundances, assess status and trend of CC Chinook Salmon ESU population. By providing counts of adult Chinook salmon redds and adult salmonid escapement in the Lower Eel River and Van Duzen River Watersheds, an abundance-based fishery management (ABM) plan may be developed in conjunction with other CC Chinook Salmon management areas within the ESU. Eventually, with sufficient survey crews and data an estimated abundance of total redds would give estimates of population viability and progress toward recovery. In turn helping fisheries managers make informed decisions relative to habitat restoration, species recovery, and fisheries management strategies being implemented to maintain or increase CC Chinook salmon stocks. The primary focus of this year's project was to establish a feasible survey frame and see if the effort of monitoring would be cost effective and reproducible in consecutive years.

The Eel River is the largest river in the CC-Chinook salmon ESU and is therefore a priority area for basin-wide escapement estimation (O'Farrell et al. 2015). The main goal of this project is to identify and monitor the distribution, abundance, and age-structure of adult CC Chinook spawning in the Lower Eel River and Van Duzen River Watersheds. By doing so, salmonid escapement into the Eel River watershed can be a more accurately estimated. With the focus on adult Chinook species spawning, choosing Chinook salmon stronghold reaches in the survey frame, and survey season timing, the Lower Eel River and Van River surveys' scope was unable to capture the full extent of coho salmon and steelhead spawning both spatially and seasonally. Therefore for the purpose of this project, the data collected on coho and steelhead is supplementary to the overall actionable application of Chinook monitoring over the survey season of November 13th, 2017 to February 20th, 2018.

The 2017-2018 survey season was characterized by a dry, early winter followed by sporadic periods of heavy rainfall later on. The first significant rain event came in early November, allowing initial fish passage into the Yager Creek basin of the Van Duzen River watershed. Subsequently, a small number of adult Chinook (8) were observing spawning in Lawrence Creek (tributary to lower Yager Creek). However, the precipitation was not sustained and stream flows quickly lowered and Chinook salmon were not observed in other portions of the Van Duzen River watershed, upstream of Yager Creek. A second significant rain event did not occur until late November, which finally allowed fish passage into middle portion the Van Duzen River as Chinook were documented in Grizzly Creek. At this time a significant pulse of Chinook also entered the Yager Creek basin as increased numbers of live Chinook salmon and their redds were documented in Lawrence Creek and SF Yager Creek.

However, no precipitation occurred in early to mid-December. While receding base flows still allowed for continued spawning on the larger stream reaches such as Lawrence, Yager, Grizzly, and Larabee Creek, water levels on the smaller creeks such as Shaw and South Fork Yager Creek

spawning was limited to only the very lower portion of these stream (approximately just 50 meters upstream of their confluences). These low flow conditions in early to mid-December (lowest flows of the winter season) may have also initiated more mainstem Van Duzen River spawning as witnessed by survey crews during a December 12th spawning survey conducted utilizing kayaks to float a section of the mainstem from Hely Creek to just upstream the confluence with Yager Creek (Appendix, Picture 6). The survey documented live Chinook near redds as well as additional unknown redds.

Moreover, due to the abnormal low flow conditions and unseasonably timing of the winter precipitation, survey crews did not observe Chinook adults or their redds on historically populated Chinook streams. These streams included, but were most likely not limited to: Shively Creek, Hely Creek, Root Creek, and Little Larabee Creek. A second rain event during the late-middle of December helped increase stream levels slightly; however, Chinook runs began to taper off until a subsequent rain event at the beginning of January gave a new push of fresh Chinook. This latter run of Chinook was more short-lived than the earlier runs with Chinook spawning from the week of January 1st until the week of January 15th. During this time, back to back rainfall events helped swell smaller streams in the watershed, opening them up to coho and steelhead runs, most notably on Fish, Shaw, Middle Fork Yager, and South Fork Yager Creek. A heavy rainfall event from January 18th to January 25th blew out larger streams, drawing an end to the detection of Chinook redds from earlier in the season. One of the smaller tributaries, Shively Creek, (which usually maintains spawning Chinook salmon), was not accessible to Chinook salmon during their run, because of a large deposit of sand and silt that caused the creek to have subsurface flow into the Eel River (Figure 8). It wasn't until storm in mid-January that the creek connected to the Eel River (Figure 9). The final Chinook carcasses were observed the week of February 5th. Detection of coho redds and live fish tapered off into the end of February, while steelhead detection remained sporadic as the survey season came to a close during a final rain event on from February 18th to February 20th.

Figure 8. The mouth of Shively Creek, January 12, 2018.

Figure 9. The confluence of Shively Creek and the Eel River January 23, 2018.

The Lower Eel River and Van Duzen River are a part of a large and complex system. As such, survey intervals and the number of visits per reach are more influenced by the unique discharge and turbidity characteristics of the individual reaches than by conditions basin wide. For example, smaller reaches such as Shaw Creek and Fish Creek display low turbidity rates during storm events and tend to present a flashy behavior with quick rise and fall of stream flows, making it easier to conduct surveys within three to five days after a significant rain event. In contrast, reaches on Yager Creek, Larabee Creek, are Van Duzen River are very high turbidity streams and can take weeks before conditions are clear enough to survey following a rain event. Consequently, some reaches within the sample frame will be more heavily sampled during a season. Medium-sized creeks such as Grizzly Creek, Little Larabee Creek, and Lawrence Creek had variable settling times after a rain event, however, the reaches could usually be surveyed at most a week after a heavy or sustained rain. In general, smaller creeks cleared up faster than medium or large-sized creeks, which determined the ability to survey (Figure 4). As this first exploratory monitoring field season experienced a below average and unusual rainfall pattern, subsequent surveys may have variable survey frequencies, and thus fluctuating Chinook redd detection, especially for larger creeks such as Larabee Creek and Yager Creek.

Due to the limited scope of the study, analysis tools such as k-nearest-neighbor (kNN) prove unreliable to use because of the limited extent of collected coho and steelhead data. For instance, surveyors were able to identify a fresh steelhead redd in a stream such as Shaw Creek in late January due to the shape, size, and substrate moved during construction of the redd without observing a steelhead actively on the redd. Since we did not observe a live steelhead on the stream; either due to the quick in and out behavior steelhead display during spawning season to minimize their time in stream and chance of predation or due to the cover available for them to hide, the field identification will hold no bearing on the kNN algorithm which may instead identify the redd as either a Chinook or coho redd due to a previous fish observation in the stream. This will inflate the estimated number of Chinook or coho redds on a stream, as well as, incorrectly shift the timing

of when Chinook and coho spawning occurs. Subsequent data collection from continued surveys may bolster the usefulness of using kNN to assign unidentified redds species. Using a preliminary kNN analysis, the 83 unidentified redds were classified as 77 Chinook redds and 6 coho redds, increasing the total redd counts to 298 Chinook redds, 42 coho redds, and 15 steelhead redds throughout the survey frame.

Next year Chinook salmon monitoring will the implementation of dual-frequency identification sonar (DIDSON) units and supplemental spawning ground surveys. Placing DIDSON sonar camera units on the mainstem Eel River and in the lower South Fork River will help provide a more complete and accurate count of the adult Chinook salmon run. CDFW will be operating and monitoring the DIDSON camera unit in the mainstem Eel River, approximately 4 mile upstream of the confluence with the South Fork Eel River. CalTrout will operated the other DIDSON camera unit in the South Fork Eel River, approximately 1-2 miles upstream of its confluence with the Eel River. These DIDSON units will yield a more complete picture of the whole Eel River system since ground surveys are not completed on a regular basis in the mainstem Eel River above the confluence with the South Fork Eel Watershed.

The Lower Eel River and Van Duzen River are a small part of the entire CC Chinook population in the Eel River Watershed. The data collected as a part of this survey thus must be used in conjunction with other spawning ground surveys in the Eel River Watershed and elsewhere within the CC Chinook ESU's range to determine the overall abundance and recovery of the ESU at large. There is a need for the continued monitoring of Chinook in the larger, main channel streams and tributaries of the Lower Eel and Van Duzen River in order to establish a comprehensive recovery action plan for these at risk species. Future survey years will also allow for comparison amongst run timing, and an estimations of total redd abundance; which is important as California's winters continue to fluctuate into more reoccurring periods of drought like conditions. Continued spawning ground surveys allow for a more complete count of redd abundance and escapement numbers throughout the Eel watershed. Likewise, supplementation of the Lower Eel Coastal Chinook Monitoring Project with a future DIDSON sonar camera project in the Lower Eel River may help establish higher precision CC Chinook counts as they travel to their spawning habitat.

5 ACKNOWLEDGEMENTS

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7 APPENDIX

Picture 1. Female Chinook using the bubble curtain and root wad for cover on Larabee Creek. Photo taken January 2, 2018 by Kaydee Boozel.

Picture 2. Surveyor, Chad Moura, giving a thumbs-up after flagging new redds found on Lawrence Creek. Photo taken on November 29, 2018 by Theodore Masters.

Picture 3. Tagged, measured male Chinook carcass from Lawrence Creek December 7, 2017. Photo taken by Chad Moura.

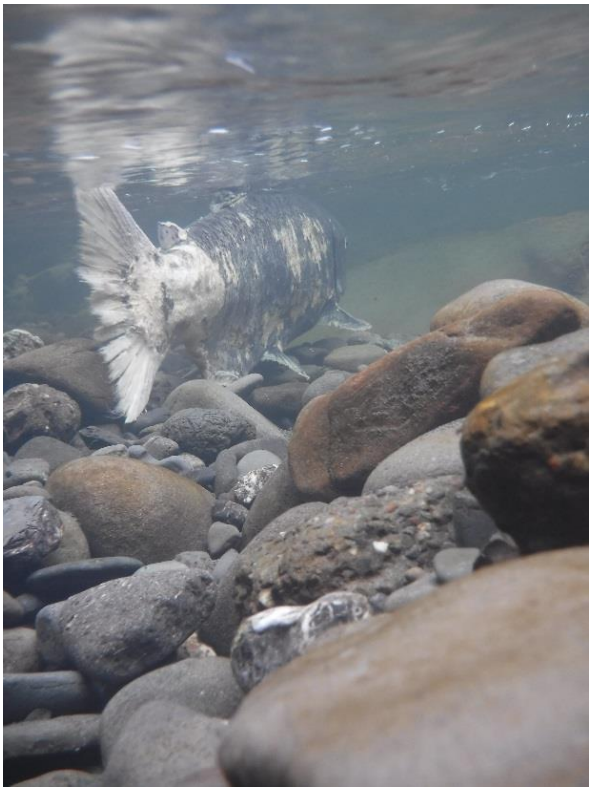
Picture 4. Female Chinook on Grizzly Creek December 14, 2017. Photo taken by Kaydee Boozel.

Picture 5. The Van Duzen River on December 12, 2012. Photo taken by Eric Stockwell.

Picture 6. David Kajtaniak, Kaydee Boozel, and Chad Moura surveying the Van Duzen River via kayak. This photo was taken December 12, 2012 by Eric Stockwell.

Picture 7. Male chinook carcass found on Yager creek December 13, 2017. Photo credit to Chad Moura.

Picture 8. The confluence of Lawrence Creek running into Yager Creek after a rain event. Yager Creek (behind gravel bar) is much more brown and opaque than the water that is darker and clearer from Lawrence creek. Taken on November 14, 2017 by Chad Moura.



Picture 9. Female Chinook guarding her pot. Her white tail scarred from digging makes it apparent that this is indeed a female and not a male. This photo was taken on Lawrence Creek January 5, 2018 by Kaydee Boozel.

Picture 10. Surveyor, Kaydee Boozel, holding a 112 centimeter male Chinook carcass. Which was the largest carcass documented this year in the lower Eel River and Van Duzen River survey. Photo on Lawrence Creek January 5, 2018 taken by Chad Moura.

Picture 11. Male Chinook on Lawrence Creek reach 82 taken on December 18, 2017 by Kaydee Boozel.

Picture 12. Chad Moura taking scale samples from Chinook carcasses on Lawrence Creek December 29, 2017. Photo taken by Rachel Karlov.

Picture 13. Female Chinook carcass that was predated before having the chance to dig her redd. Found in Grizzly Creek on November 30, 2017. Photo taken by Eric Stockwell.

Picture 14. The end of survey for Little Larabee Creek February 7, 2018 taken by David Kajtaniak.

Picture 15. Fresh Chinook carcass partially eaten by a predator found on Lawrence Creek. Photo taken by Kaydee Boozel on January 25, 2018.

Picture 16. Female coho digging her redd on Fish Creek. Photo taken on January 29, 2018 by Chad Moura.

Picture 17. Male coho carcass found on Fish Creek. Photo taken by Chad Moura on January 29, 2018.

Picture 18. Redd on Middle Fork Yager Creek found February 12, 2018. Photo taken by Chad Moura.

Picture 19. North Fork Yager with too much suspended sediment to survey on January 08, 2018. Photo taken by Chad Moura.

Picture 20. Surveyor Kaydee Boozel checking the end of survey on Shaw Creek. Photo taken November 13, 2017 by Chad Moura.