California Department of Fish and Wildlife Plan for Assessment and Management of California Coastal Chinook Salmon

Michael K. Lacy
Kristine Atkinson
Sean P. Gallagher
Brett Kormos
Eric Larson
George Neillands
Allan Renger
Seth J. Ricker
Kevin E. Shaffer

State of California
The Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
1416 Ninth Street
Sacramento, CA 95814

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Note to Readers

The California Coastal (CC) Chinook Salmon Evolutionary Significant Unit was listed under the federal Endangered Species Act as Threatened in 1999. The species occurs across a broad geographic distribution in a variety of stream sizes and types, and is caught in recreational and commercial fisheries off the California Coast. However, the status and trend of CC Chinook populations are poorly understood as are their contribution to ocean fisheries. Monitoring is complicated by many factors including broad latitudinal species distribution, historical lack of a coordinated monitoring plan, and lack of a marked and tagged stock.

This report describes the California Department of Fish and Wildlife's (CDFW) plan to assess status and trend of CC Chinook Salmon populations and explores a path forward for improving fishery management while protecting the species. In the short term, we will improve status and trend monitoring by increasing the priority of CC Chinook Salmon monitoring and implementing the California Coastal Salmonid Monitoring Plan (CMP) in key watersheds for CC Chinook Salmon. In the longer term, CDFW will move toward full implementation of the CMP for CC Chinook Salmon and other anadromous salmonids across California's coastal watersheds. CDFW will also work with NOAA Fisheries' Southwest Fisheries Science Center (SWFSC) to explore and evaluate alternatives to the existing Klamath four year-old surrogate for CC Chinook ocean fishery management.

This administrative report is an outgrowth of a joint CDFW/NOAA Fisheries SWFSC workshop entitled *"California coastal Chinook Salmon (CC-Chinook).fishery management: future prospects,* "held in Santa Rosa, California, on September 3-4, 2014. A NOAA Fisheries Technical Memorandum entitled *"California Coastal Chinook Salmon: Status. Data, and Feasibility of Alternative Fishe1y Management Strategies"* (NMFS-SWFSC-494) documented that meeting. This paper expands on a CDFW white paper entitled *"CDFW Proposed Plan for Addressing Assessment and Management of the California Coastal Chinook Salmon ESU."*

As with all of its products, Fisheries Branch welcomes feedback that helps us understand and evaluate the usefulness of this document for improving the Department's programs, particularly regarding fisheries assessment and management decision processes. We encourage you to provide us with your comments. Please be assured that they will help us direct future efforts. Comments should be directed to Mr. Michael Lacy, Fisheries Branch, 830 S Street, Sacramento, CA 95814, (916) 445-4513, Michael.Lacy@wildlife.ca.gov.

Kevin E. Shaffer
Acting Fisheries Branch Chief
California Department of Fish and Wildlife

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Michael K. Lacy*, Kristine Atkinson, Sean P. Gallagher, Brett Kormos, Eric Larson, George Neillands, Allan Renger, Seth J. Ricker, and Kevin E. Shaffer

California Department of Fish and Wildlife, Fisheries Branch, 830 S Street, Sacramento CA 95814 (MKL, KA, KES)

California Department of Fish and Wildlife, Northern Region, 32330 North Harbor Drive, Fort Bragg CA 95437 (SPG)

California Department of Fish and Wildlife, Marine Region, Ocean Salmon Project, 5355 Skylane Boulevard, Suite B, Santa Rosa, CA 95403 (BK)

California Department of Fish and Wildlife, Bay Delta Region, 7329 Silverado Trail, Napa, CA 94558 (EL, GN)

California Department of Fish and Wildlife, Northern Region, 1487 Sandy Prairie Court, Suite A

Fortuna, CA 95540 (AR)

California Department of Fish and Wildlife, Northern Region, 5341 Ericson Way, Arcata CA 95521 (SJR)

Correspondent: Michael.Lacy@Wildlife.ca.gov

The lack of monitoring data and a comprehensive monitoring plan for California Coastal (CC) Chinook Salmon have made it difficult to establish population status and trend and slowed the development of direct fishery assessment and abundance-based fishery management (ABM). This report describes the major CC Chinook Salmon monitoring issues, provides an overview of current monitoring, describes and reviews additional monitoring options, and presents a strategic monitoring approach and plan for near-future and longer-term implementation. The California Department of Fish and Wildlife (CDFW) proposes to improve status and trend monitoring in the short-term by increasing the priority of CC Chinook Salmon monitoring and implementing elements of the California Coastal Salmonid Monitoring Plan (CMP) in watersheds that hold key CC Chinook salmon populations. In the longer term, CDFW will continue to pursue full implementation of the CMP for CC Chinook Salmon and other anadromous salmonids in all relevant watersheds along the California coast. Gaining the ability to assess status and trend will enable direct evaluation of CC Chinook Salmon ESU population viability and progress toward recovery. However, even full implementation of the CMP coast-wide will not provide the data necessary to implement ABM of CC Chinook salmon. CDFW will continue working with scientists at NOAA Fisheries' Southwest Fisheries Science Center to explore and evaluate alternatives to the existing Klamath four year-old surrogate for CC Chinook ocean fishery management. We will also undertake an investigation of carcass recovery potential in the Eel River as a first step to evaluating the potential for collecting sufficient data for abundance based management

Keywords: California Coastal Chinook salmon, *Oncorhynchus tshawytscha*, California Coastal Salmonid Monitoring Plan, California Department of Fish and Wildlife, Salmon management, Salmon assessment, abundance-based fishery management.

Assessment and management of the California Coastal Chinook Salmon (CC Chinook salmon) Evolutionarily Significant Unit (ESU) is challenging. First, CC Chinook Salmon inhabit streams over a broad latitudinal range (2°50') extending from Redwood Creek in Humboldt County south to the Russian River in Sonoma County (Figure 1). This diversity of stream types, stream sizes, and the large area covered by the ESU makes it difficult to monitor as a single unit, or, alternatively, to use any one location as an index stream that is representative of the whole.

Second, the quality and quantity of recent and historical CC Chinook Salmon population data are very limited. Lack of data has made it difficult to clearly establish population status and trend for this ESU. Where available, escapement data often do not span multiple CC Chinook Salmon generations, thus limiting our ability to evaluate trends in abundance, spatial structure, productivity, and diversity. Also, past surveys did not employ a unified sampling design at the scale necessary to provide ESU or population abundance estimates. Various groups including the California Department of Fish and Wildlife (CDFW), private companies, private consultants, and non-governmental organizations have employed a variety of monitoring methods to meet differing data requirements. Some historical and present day monitoring focuses only on small portions of watersheds or is conducted at fixed locations that are not representative of a run or population as a whole. For example, data quality from long term monitoring at the Van Arsdale Station (Eel River) is compromised by year-to-year variation in hydrological conditions that affect fish migration and their ability to either reach the station or pass above it.

Lastly, due to lack of escapement and ocean and river fishery information specific to the CC Chinook Salmon ESU, the NOAA Fisheries Biological Opinion established an ocean fishery consultation standard for CC Chinook Salmon specified as a cap on the projected preseason ocean harvest rate on 4-year old Klamath fall-run Chinook, a surrogate for the adjacent Upper Klamath-Trinity River Chinook Salmon ESU where a long-term data set is available (NMFS 2000). This surrogate management strategy, which set a cap of 0.17 maximum ocean harvest rate of age-four Klamath River fall-run Chinook, was subsequently changed to 0.16 when the cohort reconstruction model was updated (O'Farrell et al. 2012). Use of the surrogate to manage ocean harvest is not ideal because the surrogate population is outside the ESU and its demographic relationship to the CC Chinook Salmon ESU is unknown. (But see Satterthwaite et al. (2014) for an evaluation of the strengths and weaknesses using this surrogate for CC Chinook Salmon ocean fisheries management.)

Objectives of this report — Additional and/or expanded monitoring of this ESU are required to establish adult population and ESU-level status and trend for fishery management and Endangered Species Act evaluations. New or expanded programs are also needed to collect additional data sufficient to directly manage ocean recreational and commercial harvest, and/or to validate the use of existing or other surrogate populations.

In this report we provide an overview of recent and historical CC Chinook Salmon monitoring, present a strategic monitoring approach and specific monitoring plan based on expansion and refocussing of the California Coastal Salmonid Monitoring Plan (CMP) for near-future and longer-term implementation, and consider monitoring options for improving ocean harvest management, including investigation of carcass recovery potential in the Eel River.

This administrative report expands upon a white paper developed by CDFW entitled *"CDFW Proposed Plan for Addressing Assessment and Management of the California Coastal Chinook Salmon ESU"* (Lacy et al. 2014). The white paper was used as a discussion document at the NOAA Fisheries/CDFW joint workshop entitled *"California coastal Chinook Salmon (CC-Chinook) fishery management: future prospects,"* held in Santa Rosa, California, on September 3-4, 2014. This report contains additional material and expanded plan and funding details.

LIFE HISTORY AND LISTING STATUS

The CC Chinook Salmon ESU contains the most southerly distributed coastal Chinook Salmon runs in North America. The ESU was federally listed as "threatened" under the Endangered Species Act in 1999 (64 FR 50394) and the listing status and ESU boundaries were reaffirmed in 2005 (Good et al. 2005). Williams et al. (2011) contains the most recent federal status review update. The CC Chinook Salmon ESU is not listed under the California Endangered Species Act. In the past the ESU contained both spring-run and fall-run components, because of the historical documentation of spring-runs in the Mad River and North and Middle Forks of the Eel River (Keter 1995, Myers et al. 1998). However, the spring-run component is thought to be extirpated (Spence et al. 2008).

Most fall-run Chinook Salmon return to their natal streams between September and October, and spawn soon after freshwater entry. Fall-run CC Chinook Salmon adult migration can be later when compared to other fall-run Chinook Salmon, because the rivers they inhabit open later in the season in response to large winter storms (November through January). Late freshwater entry is especially common in watersheds that form seasonal sandbars at the mouth during the dry season (summer to early fall). The typical life cycle for CC Chinook Salmon is to outmigrate as smolts during the spring/summer after hatching, then spend one to five years in the ocean before returning to spawn. Most return as three year-olds, and a few return as two year-old "jacks" or four year-olds. Very few spend five years in the ocean (Myers et al. 1998, Bjorkstedt et al. 2005).

In the ocean, CC Chinook Salmon mingle with other more numerous stocks, including those from the Klamath River, Trinity River, and California Central Valley (CV) fall- run Chinook salmon. These other stocks contribute the overwhelming bulk of the catch in ocean recreational and commercial Chinook Salmon fisheries (Satterthwaite et al. 2014).

Mad River Hatchery and Warm Springs Hatchery (located on Dry Creek, tributary to the Russian River) were the last two hatcheries that marked and released juvenile CC Chinook salmon. However, they no longer propagate this species. Warm Springs Hatchery ended its CC

Chinook Salmon program in 1999 when staff saw low returns (range in annual abundance between one and 304) after releasing more than two million juvenile CC Chinook Salmon during 1981 and 1998 (Chase et al. 2007). Hatchery records show that the last CC Chinook Salmon observed at Mad River Hatchery was trapped in January 2003 (S. Overton, personal communication). Although unclear from available records, the ESA listing in 1999 and difficulty obtaining broodstock appear to have been the factors leading to cessation of the CC Chinook Salmon program at Mad River Hatchery (P. Bairrington, M. Sparkman, and S. Overton, California Department of Fish and Wildlife, personal communication).

MONITORING STATUS

Recent and historical population data — Most of the freshwater data for CC Chinook Salmon is from watersheds from the Mattole River north and from the southernmost extent of distribution, the Russian River. The Eel River in the north, and the Russian River in the south, are the two largest watersheds in the ESU and thus likely hold the largest CC Chinook Salmon populations. CC Chinook Salmon are also commonly observed in mid-sized watersheds in other portions of the ESU. However, there is considerable uncertainty about the historical presence and relationships of CC Chinook Salmon in coastal watersheds between Cape Mendocino and the Russian River (Bjorkstedt et al. 2005). Watersheds in this region currently do not seem to support persistent runs (Bjorkstedt et al. 2005). However, there is uncertainty about whether and in what numbers CC Chinook Salmon inhabit these streams. The authors are uncomfortable propagating the conclusion that CC Chinook Salmon are not important residents of these streams, which have not been surveyed specifically for them. CC Chinook have been observed in limited surveys in Big Creek, and Albion, Garcia, Navarro, Noyo, and Ten Mile Rivers.

Sonoma County Water Agency's (SCWA) counts based on video camera recordings installed on fish ladders at Mirabel Dam (mainstem Russian River) are thought to be the best available CC Chinook Salmon escapement estimates in the ESU because the monitoring station is low enough in the watershed to enumerate a large proportion of the total run. However, some returning fish are likely not included in the estimate because some spawning occurs in the mainstem and tributaries downstream of Mirabel Dam. Some fish are also likely missed during large storm runoff events when the inflatable dam is lowered early in the wet season allowing fish to by-pass the ladders. Since 2011, operation during nighttime hours and periods of high turbidity has been improved by pairing two visual cameras with sonar cameras. This dual system (visual plus sonar) is providing more accurate counts over a wider range of turbidity conditions. However, the inflatable dam still needs to be removed during very high flows, which will preclude complete counts in very wet years.

The SCWA has been working since 2013 to modify the west-side fish ladder. Although the elevation of the fish ladder will allow year-round streamflow, it is expected that when the dam is deflated the majority of upstream migrating adults will not use the ladder and simply swim upriver over the dam. Video monitoring will commence in August prior to the start of the adult CC Chinook salmon migration period and continue as long as turbidity is not too high. When the dam is deflated SCWA will use the dual DIDSON (Dual Frequency Identification Sonar) cameras to count fish migrating upstream of the dam until river flow conditions preclude safe operation. There will be much to learn about how best to monitor at the modified site including the relative use of the new ladder as compared to the old one. Modifications were completed in 2016 and video operation commenced in August 2016 (G. Horton, SCWA, Personal Communication).

Genetic relationships — Recent population genetic data are presented and discussed along with aggregate re-analyses of older published data sets in Bjorkstedt et al. (2005). Genetic analyses show that the extant fall-run CC Chinook Salmon differ from both more northern Chinook Salmon stocks and those from California's Central Valley (Bjorkstedt et al. 2005; Figure 2). Population genetic structure roughly corresponds to geography. However, interpretation of historical and present day genetic relationships within the ESU are complicated by a long history of stock transfers, reductions in population size, possible extirpations (e.g., Russian River in the 1800s; Steiner Environmental Consulting, 1996; Myers et al. 1998; Chase et al. 2007), and metapopulation fragmentation (Bjorkstedt et al. 2005).

The California Coastal Salmonid Monitoring Plan — Accurate and complete status and trend evaluations of CC Chinook Salmon did not exist at the time of ESA listing. In response to the need for expanded comprehensive monitoring for all coastal salmonids, CDFW and NOAA Fisheries developed the California Coastal Salmonid Monitoring Plan (CMP; Adams et al. 2011).

The CMP is the most comprehensive coastal monitoring plan for anadromous salmonids undertaken in California to date. It is designed to estimate Viable Salmonid Population (VSP; McElhany et al. 2000) parameters using a spatially balanced sampling design that allows inference at multiple spatial scales (e.g., ESU, diversity stratum, population). This plan was designed to provide data that will enable evaluation of status and trend of Southern Oregon/Northern California Coast and Central California Coast Coho Salmon ESUs, the CC Chinook Salmon ESU, and five coastal steelhead ESUs[1] inhabiting all of California's coastal watersheds. The CMP is documented primarily and most recently in Adams et al. (2011). Other important references documenting the development and implementation of this plan include Boydstun and McDonald (2005) and Shaffer (in prep.). Gallagher and Gallagher (2005), Gallagher et al. (2010a, 2010b), Ricker (2011), and Gallagher and Wright (2012) reported on important lessons learned about application of CMP field methods in California coastal streams.

The CDFW and its partners are in the process of developing sampling frames for coastal streams throughout the State (Figure 3). Once finalized, the sampling frames are used to develop rotating panels of sample locations using the Generalized Random Tessellation Stratified (GRTS; Stevens and Olsen 2004) sampling method. This sampling technique provides statistically robust estimates of adult population abundance, productivity, and adult spatial structure at the larger regional/ESU and smaller population, diversity stratum, or sub-watershed) spatial scales as desired. Although most sampling frames in the CC Chinook Salmon ESU are at the stage of working frames, several sub-basins (North Fork Eel River, middle section of the mainstem Eel River, and the upper Eel River basin) have yet to be developed (Figure 3).

The CDFW and partners are also developing life-cycle monitoring (LCM) stations throughout the state. Currently, within the CC Chinook Salmon ESU, LCM stations are operated

[1] There are five steelhead ESUs inhabiting California coastal streams: (North to South, with ESA listing status) Klamath Mountain Province (not warranted), Northern California (Threatened), Central California (Threatened), South Central California (Threatened), and Southern California (Endangered).

for three salmonid species, including CC Chinook salmon, on Redwood Creek, Freshwater Creek, and the Russian River (Table 1). Existing LCM stations are mostly located in smaller (ca. 80 square kilometer) sub-basins of larger watersheds that contain only a portion of an entire population. For example, the Freshwater Creek LCM station is situated on one of five sub-basins that contain the Humboldt Bay Tributaries population. Redwood Creek, at the northern-most boundary of the CC Chinook Salmon ESU, is the only current LCM station that monitors an entire CC Chinook Salmon population.

The LCM station on Freshwater Creek has been in operation since 2001. The Eel River watershed does not currently have a LCM station that conforms to CMP protocols. Low trapping efficiency of smolts at traps on the Russian River LCM (formally established 2013), an unquantified number of spawners downstream, and the lowering of the inflatable dam during high flows limit the Russian River facility's ability to fully function as a LCM station (Gallagher and Gallagher 2005, Adams et al. 2011, Ricker 2011, Chase et al. 2007, Spence et al. 2008). Because the Eel and Russian Rivers have the potential to be the largest producers of CC Chinook Salmon within the ESU they may be critical sites for location of complete LCM stations.

Fixed stations that only count returning adult CC Chinook Salmon (and not out-migrating smolts) are located on the Mad River and the upper mainstem Eel River (Van Arsdale fish ladder). As previously stated, escapement data at Van Arsdale has limited use because of its location high in the watershed. However, because fish counts at Van Arsdale represent the longest time series of abundance data in the basin, we recommend that data from this site be taken into account as a data source.

PLAN FOR EXPANDED STATUS AND TREND EVALUATION

The CDFW proposes to address the need for status and trend monitoring by 1) continuing implementation of the CMP across the California Coast, and 2) elevating the priority of CC Chinook Salmon monitoring and initially expanding CMP monitoring to gather data on CC Chinook Salmon in what we think are key watersheds for the species. Eventually, CDFW intends to fully implement CMP in all coastal watersheds within the CC Chinook Salmon ESU. Limitations in funding and infrastructure, as well as technical implementation uncertainties, make it impossible at this time to implement the CMP both quickly and completely as designed. Implementation of CMP methods in key watersheds in the range of CC Chinook Salmon is an important step toward full CMP implementation. The proposed plan will provide useful status and trend information on which to base future status evaluations and recovery plans.

Expanded watersheds and elevated priority — Taking a stepwise approach to addressing monitoring needs for CC Chinook salmon, CDFW has begun by implementing components of the CMP in watersheds within the ESU and upgrading the priority of monitoring for CC Chinook Salmon relative to that for other salmonids[2]. Over the longer-term, CDFW will continue to work toward achieving robust estimates of total abundance within the ESU and will prioritize the CMP

[2] Both Southern Oregon and Northern California and Central California Coast Coho Salmon ESUs are listed as either threatened (SONC) or endangered (CCC) under both the ESA and CESA and are therefore the highest priority for CDFW implementation of coastal salmonid monitoring. Of all coastal ESUs, CC Chinook Salmon are second in priority to coho.

effort to focus on watersheds that are major producers of CC Chinook salmon. The primary CC Chinook watersheds for which we propose focused and expanded monitoring include Redwood Creek, Eel River, Mattole River, and Russian River. Current monitoring, additional work that CDFW is proposing in the near-future, and full implementation of CMP monitoring for this ESU with estimated cost is shown in Tables 1 and 2.

At Redwood Creek, CDFW currently operates the only LCM station at the population scale with a significant CC Chinook Salmon population. The survey components at Redwood Creek consist of spawning surveys for three salmonid species, including CC Chinook Salmon, an outmigrant trap, and a DIDSON counting station below all spawning habitat. Additionally, a second DIDSON in the middle reach provides counts of adults of all three salmonid species in the upper basin. There are currently three years of adult escapement data paired with juvenile recruitment estimates at this LCM station. At Mad River, CDFW began operating two DIDSONs in 2013/14. At both Redwood Creek and the Mad River, CDFW proposes to continue monitoring contingent on funding.

Due to the large drainage area of the Eel River, California's third largest watershed, and the significant proportion of overall CC Chinook Salmon ESU production that it potentially represents, it would be ideal for CDFW to create a field office at a strategic location (e.g., Willits) from which monitoring crews could deploy to cover the middle to upper watershed areas. An additional facility would complement field staff and equipment working from the existing CDFW office in Fortuna which effectively accesses the lower watershed's major forks. Since 2010, CDFW has monitored South Fork Eel River adult CC Chinook salmon, Steelhead, and Coho Salmon spawning via a survey design focused on the spatial and temporal boundaries of Coho Salmon spawning. In 2013/14 and 2014/15 spawning years, additional mainstem South Fork Eel River CC Chinook Salmon spawning areas were added. Identification of project funding to continue complete monitoring of South Fork Eel River CC Chinook salmon spawning is a priority.

A LCM station is proposed on Sproul Creek, tributary to the South Fork Eel River, which could provide insight into adult to redd ratios for walkable stream reaches, as well as recruit per spawner estimates of freshwater productivity. Currently, CDFW conducts CC Chinook Salmon spawning surveys at index reaches downstream of Van Arsdale Dam and counts fish at the dam's fish ladder within the upper Eel River sub-basin. CDFW will be working with statisticians to determine how we can tie current and past index data to GRTS-based sample data to obtain comparable status and trend information. Areas of the watershed prioritized for spawner surveys include the South Fork Eel River and the Upper Eel River watershed, followed by the Lower Eel River/ Van Duzen River.

At the Mattole River, CDFW proposes to expand the existing sampling frame, currently only covering Coho Salmon spawning areas, to include CC Chinook Salmon spawning reaches starting in 2015/16. At five streams in Mendocino County (Ten Mile, Big, Albion, Navarro, and Garcia Rivers), CDFW is already monitoring all three salmonid species. In this plan, CDFW proposes to improve precision by increasing the GRTS-sampling rate in the CC Chinook Salmon space. At the Noyo River, spawning surveys are currently being conducted at an appropriate rate (50% GRTS-sampling rate). Therefore, no additions to monitoring are proposed there.

At the Russian River LCM station, two DIDSON units are paired with video cameras at Mirabel Dam count CC Chinook Salmon adults, and a rotary screw trap counts out-migrating smolts. Annual, one-pass, spawner surveys on the main-stem Russian River, which do not conform to CMP adult survey protocols (Adams et al. 2011), provide limited data with which to evaluate status and trend in the basin. At this time, no additional monitoring is proposed for the Russian River watershed. However, reliability and accuracy of status and trend information could be improved in this watershed by employing CMP protocols for CC Chinook Salmon spawner surveys (i.e., repeated surveys using GRTS-based sample locations, rather than single-pass annual surveys) and by expanding adult monitoring to include fish that spawn in main-stem reaches and tributaries downstream of Mirabel Dam.

Limitations of CMP methods — The CMP was designed primarily to obtain data for evaluation of status and trend of populations and for assessing ESU recovery. As such, it is uniquely tuned for broad scale population and ESU-level surveys of adult numbers (and derived productivity) and geospatial distribution. Data from CMP monitoring will provide useful information in the areas for which it was designed.

Although CMP will be used to estimate CC Chinook Salmon status and trends in abundance, spatial structure, diversity, and marine/freshwater survival, we reiterate that these data will not provide age-specific abundance or survival estimates suitable for development of fishery targets, nor will it provide sufficient detail to manage fisheries directly. Except for the possible use of LCM stations on specific streams, information necessary for the development of cohort reconstruction models and for fisheries harvest will largely need to be developed separately.

Achieving complete coastwide application of the CMP is likely to take a long time. CDFW envisions an incremental approach to eventually include all coastal watersheds and the three species of anadromous coastal salmonids. Lack of a consistent and sufficient funding source and staffing are the largest constraints to implementation at all levels from maintaining existing monitoring projects to full CMP implementation.

Other known complications include obtaining necessary landowner permission to access sampling sites in the GRTS sample draws, difficulties accessing large areas repeatedly both over a spawning season and across years, and detecting redds in larger main-stem riverine systems with high discharge and turbidity. Phased expansion to larger watersheds will be implemented as technical solutions are found to overcome their unique challenges. These challenges include large portions of the watershed being inaccessible to survey teams (e.g. North Fork Eel River, the main-stem Eel River between the confluence of the North and Middle Forks) and high flows that create dangerous working conditions and make it difficult to see redds and adult fish.

OCEAN HARVEST MANAGEMENT

Background — Similar to that for freshwater, marine and ocean fishery data for CC Chinook Salmon are very limited. No hatchery in the ESU is currently producing CC Chinook salmon. Therefore, there are no opportunities to tag and mark fish, making cohort reconstruction approaches to harvest management impossible. In the 1980s, coded wire tagged (CWT) juvenile

CC Chinook Salmon were released in the Eel River to compare their ocean distribution with stocks outside of the ESU (Klamath-Trinity and Central Valley Chinook Salmon; NOAA Fisheries 2000). However, since the NOAA Fisheries Biological Opinion (NOAA Fisheries 2000), only eight groups of CWT juvenile CC Chinook Salmon, ranging in number from 2,300 to 73,000 have been released (O'Farrell et al. 2012). Issues with sampling methods used in these studies (e.g., low number of CWT recoveries, lack of accounting for differences in fishing effort, and no accounting for temporal differences in spatial distribution) have complicated our ability to draw conclusions based on them. Further research is needed to elucidate ocean spatial distribution at a level that could be helpful for fisheries management.

From 2010 to 2012, Genetic stock identification (GSI) data were collected by commercial fishermen off of the coasts of California and Oregon (Satterthwaite et al. 2014). These data, along with age estimates from scales, described the proportion of CC Chinook Salmon in the commercial catch and identified similarities and differences in ocean distribution of CC Chinook Salmon and Klamath Age-4 Chinook Salmon.

Harvest management goal — The goal for harvest management is to manage fish harvest to protect the CC Chinook Salmon ESU while simultaneously allowing commercial and sport fishing on the mixed stocks that contain this and other listed ESUs. Currently, the Pacific Fishery Management Council uses a surrogate stock to set limits on the fishery (see description in O'Farrell et al 2012). The CDFW and NOAA Fisheries will continue to explore ways to improve the data used to manage CC Chinook Salmon by either replacing the surrogate with abundance and age-structure estimates from within the CC Chinook Salmon ESU or further validating the surrogate approach. The ultimate goal is to collect data sufficient to enable abundance-based fishery management (ABM) using data representing the entire CC Chinook Salmon ESU.

Monitoring Options — Availability of a marked hatchery stock within the CC Chinook Salmon ESU could provide a useful index stock on which to base direct abundance-based ocean harvest monitoring. However, there are no plans to restart any hatchery programs for CC Chinook Salmon and the feasibility of restarting or establishing such a program is not known. Also, CDFW acknowledges that there are potential impacts associated with producing large numbers of hatchery fish on natural runs that would have to be addressed before undertaking a new hatchery program. Therefore, the authors do not see this as a viable option.

LCM stations in streams that are potentially major producers of CC Chinook Salmon could provide locations for implementation of wild stock marking programs. Theoretically, by tagging a large number of outmigrating CC Chinook Salmon smolts and subsequently recapturing them in a fishery, one could directly evaluate harvest rates and time-area distribution of marked fish. However, whether it is possible to mark enough natural-origin fish and whether they could be recaptured in the fishery in sufficient numbers is unknown. Also, because of the broad latitudinal scale of the ESU, it is not known whether any one marked population would be sufficiently representative of the ESU as a whole. Capture, handling, marking, and recovery of natural-origin fish would be costly and, at the proposed scale, could potentially impact this federally threatened species. However, since LCM stations are already an essential part of CMP monitoring, it is reasonable to explore use of these stations for natural-origin stock marking.

An evaluation of the usefulness of available data and monitoring programs and possible monitoring options to provide this information are thoroughly explored in O'Farrell et al. (2012). We feel that the evaluation and options presented in that report, along with additional recommendations in this one, should provide the basis for further discussion of how to address the fishery management issues. For convenience, the main conclusions of O'Farrell et al. (2012) are summarized below with comments from the authors of this paper.

a. Low levels of sampling and lack of random sample site selection in existing and historical data sources make aggregate escapement estimates infeasible. Available methods and data are not likely representative of the ESU as a whole, and are therefore of limited value in assessing population abundance. Implementation of the CMP will improve status and trend estimation for the CC Chinook Salmon ESU and its populations.

b. GSI methods apportion fish to stock based on population genetic structure relationships (see Figure 2). GSI may be able to estimate proportions of CC Chinook Salmon in the ocean catch. However, there are many uncertainties that complicate use of GSI for direct management (see Satterthwaite et al. 2014 for details). Current methods and levels of genetic distinction within the ESU are only able to apportion catch into two reporting groups: Russian River and Eel River plus all others. This may not provide sufficient stock specificity to implement effective direct management for CC Chinook salmon. Also, the low expected proportion of CC Chinook Salmon in the ocean catch is likely to result in inaccurate stock proportion estimates for these less abundant populations.

c. Development of escapement estimates and maturation schedules for index streams in the ESU has been suggested as a possible approach. However, cohort reconstruction is currently not possible due to a lack of age-structured escapement and harvest data spanning the entire ESU. The only current location in the ESU for which this approach might be developed is the Russian River at the southern extent of the ESU. However, the authors of this report think that it should be possible to tailor the design of LCM stations at selected locations in the ESU to collect data that would allow us to develop an index stream management approach.

d. It may be possible to infer CC Chinook Salmon abundance using data for other adjacent stocks (Satterthwaite et al. 2014). CMP may provide data allowing better inferences about the coordination of abundance and distribution of CC Chinook Salmon and neighboring stocks. However, any inferences based on surrogate stocks could have the same (or different, but just as serious) limitations as the currently employed surrogate age-4 Klamath fall-run Chinook salmon. The authors of this paper think that additional research may further legitimize a surrogate approach, which might be the easiest option for the foreseeable future.

e. The current consultation standard for CC Chinook Salmon is a cap on the projected ocean harvest rate of surrogate age-4 Klamath fall-run Chinook (0.16). However, the appropriate exploitation rate that would allow for conservation and recovery of CC Chinook Salmon is not known.

f. Indicator stocks might be established using wild stock tagging. Complications include limitations on the number of out-migrating juveniles that could be tagged, recovery and estimation complications due to scarcity of CC Chinook Salmon in the ocean catch, and concerns about whether any given tagged stock is representative of the ESU as a whole. The authors of this paper think that wild stock tagging could potentially be experimentally implemented at LCM stations with appropriate funding.

NOAA Fisheries/CDFW Workshop — Science staff and managers from NOAA Fisheries and CDFW participated in a workshop convened in Santa Rosa, California, on September 3-4, 2014, entitled *"California coastal Chinook Salmon (CC-Chinook) fishery management: future prospects."* The workshop's goals were to determine the level of data needed to implement ABM and whether that level of data could be feasibly collected for CC Chinook salmon. The results of this workshop are documented in a NOAA Fisheries Technical Memorandum (O'Farrell et al. 2015) and are summarized below.

The workshop explored the path forward to collect better data for ocean fishery management, including discussion of the following topics (among others):

a. Feasibility of obtaining credible total escapement estimates for appropriate index watersheds, including *i*) efficacy of spawner surveys to estimate large watershed Chinook escapement, *ii*) potential to scale up parent progeny genetic mark recapture to an Eel River-size basin, and *iii*) use of scale analysis for age structuring escapement estimates;

b. Feasibility of marking and tagging juveniles in sufficient number for stock assessment;

c. Potential for recovery of a sufficient number of marked/tagged adults in spawner surveys;

d. Uses and capabilities of LCM stations; and

e. Potential for estimating ocean harvest of CC Chinook salmon.

Workshop participants concluded that collecting sufficient data to implement ABM for CC Chinook Salmon would be difficult. The data required are currently not being collected, and the most comprehensive sampling plan for the region, the CMP, even when fully implemented, will not collect data that will enable ABM. There are substantial technical challenges associated with estimating ESU-wide spawner abundance and new ocean harvest programs would likely be needed.

In the future, CDFW and NOAA Fisheries will move forward by 1) addressing the challenges of CMP implementation for evaluating status and trend of CC Chinook Salmon, and expanding CMP to cover all coastal salmonid streams, 2) exploring pilot CC Chinook Salmon marking/tagging studies to assess the feasibility of obtaining sufficient data for cohort reconstruction, and 3) working to identify and obtain stable funding.

CARCASS RECOVERY POTENTIAL IN THE EEL RIVER

Estimates of abundance, maturation rates, harvest, and harvest rates are necessary for development of ABM for CC Chinook Salmon (O'Farrell et al. 2012, and this report). Cohort reconstructions based on Coded Wire Tag (CWT) recoveries are currently used to manage Klamath River Chinook Salmon populations, and represent a potential model that might be applied to the Eel River as an important index population within the CC Chinook Salmon ESU.

In order to implement ABM for the Eel River, CDFW envisions the need to 1) design and implement a natural-origin CWT program targeting CC Chinook Salmon, 2) develop annual estimates of age-specific escapement and harvest, and 3) recover a sufficiently large sample of CWTs from both freshwater returns and marine landings to estimate harvest rates.

There are critical uncertainties about the feasibility of obtaining the data needed for cohort reconstruction. First, we do not know whether a natural stock CWT-tagging program is feasible; the number of natural-origin juvenile CC Chinook Salmon that would need to be captured and marked to give sufficient returns is not known. However, modeling in O'Farrell et al. (2015; Appendix A) suggests that a release size of 200,000 CWTed juveniles may be minimally sufficient if certain assumptions are valid. Ultimately, these issues can only be resolved in the field. Second, because the basin is large, and parts of it present logistical difficulties to sampling, it is unclear whether current CMP spawner estimation protocols will accurately estimate CC Chinook Salmon escapement across the Eel Basin. Lastly, we do not know whether enough CC Chinook Salmon carcasses can be found in the Eel River for us to recover sufficient CWTs to enable cohort reconstruction or to use genetic-based escapement estimation methods (e.g., Rawding et al 2014).

Cohort reconstruction, the foundation of the ABM approach, relies on the ability to estimate escapement and recover CWTs from a significant number of carcasses on the spawning grounds. Current CMP spawner estimation protocol calls for 10-50% of spawning reaches (depending on the total number of reaches in the sample frame) to be sampled every 14 days in order to estimate total number of redds. While carcasses are encountered as part of this protocol, this sampling fraction and return interval is unlikely to recover enough carcasses for CWT recovery (A. Renger, S. Harris, and S. Ricker personal communication).

Similarly, the parent-progeny Mark-Recapture Estimator of Rawding et al. (2014) is largely constrained by the number of adult genotypes collected. For example, for a hypothetical escapement of 20,000 animals approximately 5% (or 1,000) carcasses and 5,000 juvenile progeny would need to be genotyped to achieve an escapement estimate with 20% precision (S. Ricker, unpublished data). Whereas, it seems reasonable that tissues from 5,000 juveniles might be collected during a juvenile trapping operation designed to deploy CWTs, it is unknown whether 1,000 carcasses could be collected, making carcass recovery the primary limitation.

Since its inception, the CMP has implemented spawning ground surveys as the principal technique to estimate the number of redds deposited by species. To estimate Coho Salmon escapement, the estimated number of redds is expanded using the relationship between redds and escapement gathered at small scale Coho Salmon-focused LCM sites. It remains unclear whether the protocols implemented so far in smaller streams to estimate the number of Coho Salmon is transferrable to larger river systems like the Eel River and when applied to Chinook salmon. Chinook Salmon are known to have a spawning distribution lower in the drainage making redd observation more difficult, and requiring longer return intervals.

CDFW proposes a step-by-step approach to evaluation of these critical uncertainties in the South Fork Eel and Upper Mainstem Eel River populations of CC Chinook Salmon. The first component will be application of the CMP spawner survey protocol augmented with a separate targeted carcass survey applied to the South Fork Eel River. Currently, the Pacific States Marine Fisheries Commission (PSMFC) is funded via the Fisheries Restoration Grants program to implement CMP spawning ground surveys in Coho Salmon spawning space. We will leverage these efforts to evaluate the CMP spawner survey protocols for estimating CC Chinook Salmon redd abundance in large rivers. The second component will be a targeted carcass recovery survey to count carcasses and take tissue and scale samples. This effort will be extended to areas that are not within the CMP sample draw funded by PSMFC and Sport Fish Restoration Act, and will use a return interval intended to maximize carcass recovery.

CDFW proposes to develop the sample frame necessary for application of CMP design-based sampling in the Upper mainstem Eel River above Dos Rios. Contingent on funding, CDFW will implement CMP spawner survey protocols for CC Chinook Salmon in this portion of the basin augmented with an additional targeted carcass recovery effort.

The outcome of these efforts will provide information to address critical uncertainties in methodologies to estimate escapement, and provide the basis for a rigorous evaluation as to whether CWT-based cohort reconstruction is possible for the Eel River CC Chinook Salmon population. If only a small fraction of the escapement can be recovered as carcasses, then the potential for a CWT-based cohort reconstruction approach would be low unless a very large proportion of the naturally produced juveniles were marked with CWTs.

Remaining Information Gaps and Complications

Even with expanded CMP coverage of the CC Chinook Salmon ESU, there are still some areas of uncertainty. Some of these are described below.

a. Not all watersheds within the CC Chinook Salmon ESU are included in the monitoring expansion proposed in this document. However, any estimate that contains the Eel, Mad, Russian, and Mattole Rivers, Redwood Creek, and additional tributaries will estimate what we think is likely a substantial portion of CC Chinook Salmon in the ESU.

b. We think that the Eel River is a key producer of CC Chinook Salmon. Therefore, we are proposing to expand CMP to specifically target CC Chinook Salmon in that watershed. However, there remain substantial logistical difficulties with expanding CC 0Chinook Salmon monitoring in the Eel River. These include very high and turbid flows (especially in the North Fork Eel) that affect both redd visibility and field-worker safety, and inaccessibility of much of the watershed. The CMP Science Team, made up of members from CDFW, the National Marine Fisheries Service, and the Southwest Fisheries Science Center, is in the process of addressing these issues. That group will be proposing possible solutions and implementation recommendations.

c. The CMP Science Team is currently exploring details of how to carry out sampling and estimation processes to evaluate targets in NOAA Fisheries recovery plans for CC Chinook salmon.

d. Expansion of monitoring beyond that which is described in this report will require additional funding that is not yet secured. Personnel needs for expanded data gathering, analysis, and reporting need to be explored by the participating agencies.

e. Some possible expansion methods may be compatible with existing CMP methodology. However, some likely will not be. We propose that these issues be resolved through the CMP Science Team, which is the only established group containing the expertise to address these complex issues.

ADDITIONAL RESEARCH NEEDS AND INCORPORATION OF EMERGING TECHNOLOGY

DIDSON technology, which focuses sonar onto high resolution sensor arrays, produces images of fish at ranges of 15 to 40 m. Since 2009, Sound Metrics, Inc.'s DIDSON cameras have been deployed throughout California to enumerate salmonids as part of CMP and for other purposes. These units are being used as fixed counting stations for adult Steelhead in the CMP Southern Monitoring Area as described in Adams et al. (2011) and are also being used at some LCM stations (Atkinson et al. 2016). Additionally, DIDSON units are currently operated in the Northern Monitoring Area (including the CC Chinook Salmon ESU) to enumerate (and to measure length of) adults (Atkinson et al. 2016). We envision that DIDSONs will be especially useful in locations where trapping is infeasible, where high stream flows impede human access, where turbidity impedes visual redd observations, where un-obtrusive techniques are otherwise desirable, or during nighttime hours when video cameras are unable to record images. The CDFW is finding that this technology meets our needs for enumeration and measurement of adult salmonids. We are also finding that a primary limitation of this technology is the difficulty differentiating among salmonid species with similar size and body form where multiple species are present. Maintaining operation, or accounting for non-operation, under high flows is also challenging. In addition to using knowledge of the stream, species presence, and time of year, biologists statewide are employing other methodologies to validate DIDSON counts. Validation methodologies currently in use include redd surveys, paired DIDSON and digital video cameras, trapping, hook and line sampling, and seining.

Recently, CDFW purchased adaptive resolution imaging sonar (ARIS), the latest generation of sonar technology (Sound Metrics, Inc.). Researchers will soon be deploying these units to enumerate salmonids and to determine whether image quality has improved enough to reliably differentiate similar-appearing salmonid species. Sound Metrics, Inc., states that they are working toward improving fish species identification through development of algorithms based on species differences in swimming behavior (e.g., tail movement patterns).

CDFW is also interested in expanding use of manned and unmanned ("drone") aircraft and associated technologies to conduct spawning surveys (redd and adult fish counts) as part of CMP. CDFW currently conducts weekly manned air surveys of CV Chinook Salmon redd distribution in the Sacramento River. Unmanned aircraft technologies might be employed in places that are difficult to access due to high flows, steep canyons, or during high turbidity conditions when visual surveys of redds and fish are impractical. Idaho Power Company's Environmental Department reported that University of Alaska, Fairbanks, researchers successfully used the Aeryon Scout with a Photo3S™ high resolution camera to count Chinook Salmon redds on the Snake River in narrow, remote canyons under varying wind and weather conditions. However, due to power limitations and FAA regulations, they were only able to survey accessible reaches where the craft was in line-of-sight of its operators. This limited survey duration to less than 15 minutes at a time. Use of unmanned aircraft was reported to be safer for biologists when compared to helicopter surveys, and unmanned aircraft have provided sufficiently high resolution images to observe redd superimposition. We expect this technology to improve greatly in the near future and will continue to investigate using it for monitoring CC Chinook salmon.

The CDFW would also like to explore the use of genetic-based parentage methods to estimate adult escapement using juvenile genetic data (Rawding et al. 2014). Research is needed to determine how to scale these techniques for large basins like the Eel River. A project to evaluate this method is being carried out by CDFW on Freshwater Creek and is proposed for Sproul Creek (South Fork Eel River) for 2016/17.

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FIGURE 1. California Coastal Salmonid Monitoring Plan monitoring locations within the California Coastal Chinook Salmon Evolutionary Significant Unit.

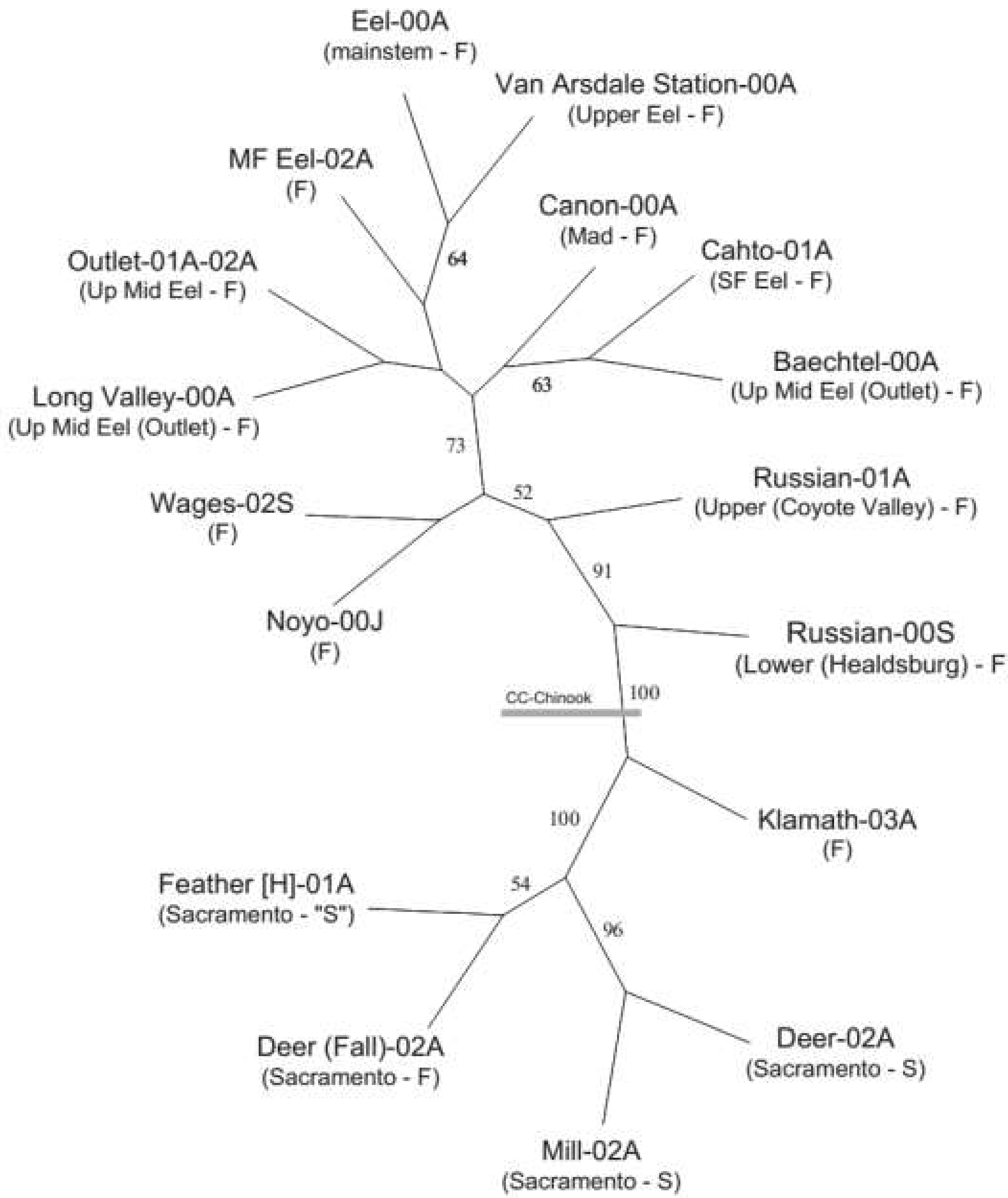

FIGURE 2. Bootstrap consensus tree showing genetic relationships among California Chinook Salmon from Bjorkstedt et al. (2005). Consensus tree based on trees constructed using the neighbor-joining algorithm in Saitou and Nei (1987) and chord distance measures (Cavalli-Sforza and Edwards 1967). Genetic data are for 19 microsatellite loci. Numbers adjacent to branches are proportion (>50%) of trees in which the indicated node appeared. Age abbreviations: A = adult; S = smolt or outmigrating juvenile. Run abbreviations: F = Fall-run; S = Spring-run; "S" = Spring-run produced at Feather River Fish Hatchery.

FIGURE 3. California Coastal Salmonid Monitoring Plan watersheds showing the status of sampling frame development.

Table 1. Current CDFW population monitoring within the California Coastal Chinook Salmon ESU.

Watershed	Description of Life Cycle Monitoring (LCM) and/or counts at fixed stations	Description of spawning surveys
Redwood Creek[a]	One rotary screw trap. Target species and life stages: adult and smolt Chinook Salmon, Coho Salmon, and Steelhead.	GRTS[b] spawning surveys within sampling frames for Coho and Chinook Salmon (and part of that for Steelhead). Spawning ground surveys for Chinook Salmon begin on November 01 and end March 15. Approximately 75% of Chinook Salmon spawning area is covered.
Little River (Humboldt Co)	None at this time.	None at this time.
Mad River	One DIDSON[c] unit is in operation, beginning in 2013-14. Surveys for adult Chinook Salmon begin on October 15 and end on June 01. The entire Chinook Salmon sampling space is covered.	Index spawning surveys occur on Canon Creek, tributary to Mad River.
Humboldt Bay tributaries	Mark- recapture at Freshwater Creek LCM weir for Coho Salmon and Steelhead adults / smolts. Also, uncalibrated weir counts for adult Chinook Salmon. Surveys for Chinook Salmon begin on November 01 and end on June 01. The entire Chinook Salmon space is covered.	GRTS spawning surveys for the Chinook Salmon in sampling frame of tributaries to Humboldt Bay.
Eel River Watershed		
Lower Eel River /Van Duzen River	None at this time.	Index spawning surveys on Van Duzen River.
South Fork Eel River	None at this time.	GRTS spawning surveys only for Coho and Chinook Salmon sampling frames. Monitoring within entire Chinook Salmon sampling space began in 2013-2014 season. Surveys occur from mid-November through March. Index spawning surveys on Sproul Creek.
North Fork Eel River / Middle Fork Eel River	None at this time.	Only spawning surveys index reach on Middle Fork Eel River

Watershed	Description of Life Cycle Monitoring (LCM) and/or counts at fixed stations	Description of spawning surveys
Middle Mainstem Eel River (from South fork Eel confluence to Middle Fork Eel R. confluence)	None at this time.	None at this time.
Upper Mainstem Eel River (from confluence of Middle Fork Eel River to Scott Dam / Lake Pillsbury)	Although Van Arsdale ladder is not a LCM, there is a complete census of adult anadromous salmonids counts starting in November through April.	Index spawning surveys on mainstem Eel River downstream of Van Arsdale ladder. Also, index spawning surveys on Outlet Creek. PG&E consultants Steiner Environmental Consulting conducts spawning surveys at index reaches on Tomki Creek.
Bear River	None at this time.	None at this time.
Mattole River	None at this time.	GRTS spawning surveys only for Coho Salmon sampling frame. There is no current monitoring for Chinook Salmon.
Usal Creek, Cottaneva Creek, DeHaven Creek, Wages Creek	NA	NA
Ten Mile River	None at this time.	GRTS spawning surveys for all three salmonid species' sampling frames.
Pudding Creek	NA	NA
Noyo River	Mark- recapture at weir on South Fork Noyo River (only for Coho Salmon and Steelhead adults / smolts). No monitoring occurs for Chinook Salmon.	There are GRTS spawning surveys for all three salmonid species' sampling frames for entire watershed. Not all Chinook Salmon reaches are surveyed. The Department surveyed eight of 16 in 2013 and would like to add at least four more reaches. Spawning surveys begin after first rains that allow fish access and end in early April.
Hare Creek and Jaspar Creek	NA	NA
Big River	None at this time.	GRTS spawning surveys for all three salmonid species' sampling frames.

Watershed	Description of Life Cycle Monitoring (LCM) and/or counts at fixed stations	Description of spawning surveys
Albion River	None at this time.	GRTS spawning surveys for all three salmonid species' sampling frames.
Big Salmon Creek	NA	NA
Navarro River	None at this time.	GRTS spawning surveys for all three salmonid species' sampling frames.
Garcia River	None at this time.	GRTS spawning surveys for all three Salmonid species' sampling frames.
Gualala River	NA	NA
Russian River	Salmonid adults and juveniles are counted at the Water Agency's seasonally-operated inflatable dam at Mirabel on mainstem Russian River (river km: 39.7) and in Dry Creek (a tributary entering mainstem Russian approximately 12.3 km upstream of Mirabel). Two DIDSONs at Mirabel operate along with underwater video cameras in order to enumerate adult Chinook Salmon and provide partial counts of adult Coho Salmon and steelhead. This location works as a LCM station for Chinook Salmon based on timing of this species' migration in the Russian as well as on dam operation. Immediately downstream of the dam, Chinook Salmon smolt abundance is estimated annually at rotary screw traps using mark-recapture. On Dry Creek near the mouth (river km: 0.4), staff operate one DIDSON paired with a digital video camera to aid in providing estimates of adult Chinook Salmon, Coho Salmon, and steelhead. Prewinter snorkeling and electrofishing surveys in conjunction with year-round operation of a PIT antenna array near the mouth of Dry Creek (river km: 0.3) and seasonally-operated out-migrant traps on Dry Creek (river km: 3.3) and Mill Creek (river km: 2.0, Mill Creek is a tributary entering Dry Creek near the mouth of Dry Creek downstream of the Dry Creek rotary screw trap) provide estimates of Coho Salmon and steelhead smolts. In addition to Dry Creek and Mill Creek, out-migrant traps (rotary screw traps, funnel traps, or pipe traps depending on the site) are operated annually at	Spawning surveys occur annually on mainstem Dry Creek and reaches of tributaries to Dry Creek containing anadromous salmonid habitat (Mill, Grape, Wine, Pena creeks. Additionally, Sonoma County Water Agency staff conduct annual spawner surveys (using protocols outside of CMP) on the mainstem Russian River from Ukiah downstream to Mirabel Dam in order to estimate reach-specific spawner distribution.

Watershed	Description of Life Cycle Monitoring (LCM) and/or counts at fixed stations	Description of spawning surveys
	locations downstream of Mirabel on Mark West, Dutch Bill and Austin creeks. A PIT antenna is being operated seasonally on Austin Creek coincidental to and just downstream of the out-migrant trap in order to address questions related to movements of juvenile steelhead into the Russian River estuary.	

[a]Bold/Italicized streams are CDFW's highest focus/highest priority for CC Chinook Salmon monitoring.
[b]GRTS: Generalized Random Tessellation Stratified.
[c]DIDSON: Dual Frequency Identification Sonar.
[d]NA: Not applicable. Refers to streams that have minimal (if any) habitat (either present or historic) for this species.

TABLE 2. Near-future monitoring and full-implementation of CMP monitoring within the California Coastal Chinook Salmon ESU.

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
Redwood Creek[a]	Deploy DIDSON[b] in lower Redwood Creek estimate Chinook Salmon escapement. Juvenile outmigrant trapping to assess smolt abundance. In combination, this could allow stock recruitment analysis.	Three technicians ($13.5K/year =$41k), gasoline ($2.5K), and hard drive ($1k). Total cost is $44.5k	"Near-future implementation" = "Full-implementation"	"Near-future implementation" = "Full-implementation"
Little River (Humboldt Co)	None at this time.	None at this time.	This river is considered a low priority for Chinook Salmon monitoring due to this species' extremely low abundance. Potential methodologies include using one or more methods in combination of the following: spawning surveys by foot, boat, manned and unmanned aircraft technology; and DIDSON cameras.	NA[c]
Mad River	None at this time. Existing DIDSON operation and analysis of imagery could use additional funding and staffing.	Two technicians ($13.5K/year =$27k), gasoline ($1.5k), and hard drives ($1K). Total cost is $29.5k.	Implement protocol-level GRTS[d] spawning surveys in the entire Chinook Salmon sampling space and time.	Eight technicians and one crew lead (approx $40k), four vehicles ($120k), operational expense of computers, gas, etc ($8k). Total cost is $168k,

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
				including initial cost of vehicle purchase.
Humboldt Bay tributaries	None at this time.	None at this time.	We are at full-implementation.	Not applicable.
Eel River Watershed				
Lower Eel River /Van Duzen River	The Department expects to conduct feasibility analysis of sampling methodologies to implement CMP for Chinook Salmon. Potential methodologies include spawning ground surveys by foot and boat.	Four technicians over four months using existing facilities, vehicles, and survey gear. Total cost is $20k .	Potential methodologies will be based on feasibility analysis and test runs of employing methods in the field. These include using one or more methods in combination of the following: spawning surveys by foot and boat.	Eight technicians over four months ($40k)and one crew leader over six months ($12k), two trucks ($60k), facilities ($20k/ yr), survey gear, computers, and facilities ($8k). Total cost is $140k, including initial cost of vehicle purchase.
South Fork Eel River	Sproul Creek (tributary to South Fork Eel River) LCM could potentially occur in 2017/2018 and is contingent on funding.	Four fisheries technicians for four months ($24 k) and one fisheries biologist ($35k), plus PIT tags, antennas, readers, survey gear, and genetic analysis ($90k). Total cost is $149k/yr.	GRTS along with LCM could potentially be considered full-implementation at this river.	Not applicable.

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
North Fork Eel River / Middle Fork Eel River	None at this time. This tributary is considered lower priority based on expected lower productivity of Chinook Salmon and on access issues (very remote location with few roads) for sampling.	None.	"Near-future implementation" = "Full-implementation"	"Near-future implementation" = "Full-implementation"
Middle Mainstem Eel River (from South fork Eel confluence to Middle Fork Eel R. confluence)	The Department should conduct feasibility analysis of sampling methodologies to implement CMP for Chinook Salmon. Potential methodologies: spawning surveys by foot and boat.	Four technicians over four months using existing facilities, vehicles, and survey gear. Total cost is $20k .	Potential methodologies will be based on feasibility analysis and test runs of employing methods in the field. These include using one or more methods in combination of the following: spawning surveys by foot and boat.	Eight technicians over four months ($40k)and one crew leader over six months ($12k), two trucks ($60k), facilities ($20k/ yr), survey gear, computers, and facilities ($8k). Total cost is $140k, including initial cost of vehicle purchase.
Upper Mainstem Eel River (from confluence of Middle Fork Eel River to Scott Dam / Lake Pillsbury)	The Department expects to conduct feasibility analysis of sampling methodologies to implement CMP for Chinook Salmon. Potential methodologies: spawning surveys by foot and boat.	Four technicians over four months using existing facilities, vehicles, and survey gear. Total cost is $20k .	Potential methodologies will be based on feasibility analysis and test runs of employing methods in the field. These include using one or more methods in combination of the following: spawning surveys by foot and boat.	Eight technicians over four months ($40k)and one crew leader over six months ($12k), two trucks ($60k), facilities ($20k/ yr), survey gear, computers, and facilities ($8k). Total cost is $140k, including initial cost of vehicle purchase.

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
Bear River	None at this time. This river is considered to be a low priority due to possible local extirpation / very low abundance.	None.	This river is considered to be a low priority due to possible local extirpation / very low abundance. Potential methodologies will be based on future feasibility analysis and test runs of employing methods in the field. These include using one or more methods in combination of the following: spawning surveys by foot, boat.	NA
Mattole River	Expand spawning surveys to include Chinook Salmon sampling space and time.	Extend staffing for Mattole Watershed Council for additional field work. One biologist ($40k), six technicians ($15k), and three vehicles to rent ($16k). Equipment needs include handheld data loggers, waders and boots, misc. survey gear ($3k). Total cost is $74k. If BLM funding is available cost may be reduced by $30K. Operated out of Petrolia in cooperation with the Mattole Salmon	"Near-future implementation" = "Full-implementation"	"Near-future implementation" = "Full-implementation"

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
		Group.		
Usal Creek, Cottaneva Creek, DeHaven Creek, Wages Creek	NA	NA	NA	NA
Ten Mile River	Increase GRTS sampling rate from 29% to 50% (12 of 24 reaches) in Chinook Salmon space. To do this from October through March, additional funding and staffing is needed.	One biologist ($71k), three technicians ($78k), two trucks to rent ($8k) or purchase ($60k), and two quad to purchase ($17.5k), fuel and maintenance ($12k), over-time, travel, training ($20k). Total cost is $258.5k, including initial cost of vehicle purchase. Note: this includes staff and equipment cost for seven rivers (Ten Mile, Noyo, Big, Albion,	"Near-future implementation" = "Full-implementation"	"Near-future implementation" = "Full-implementation"

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
		Navarro, and Garcia) in coastal Mendocino County.		
Pudding Creek	NA	NA	NA	NA
Noyo River	Increase GRTS sampling rate from 50% to 75% (12 of 16 reaches) in Chinook Salmon space. To do this from October through March, additional funding and staffing is needed. In order to include a LCM, downstream trapping could be done along with a census of spawning reaches.	One biologist ($71k), three technicians ($78k), two trucks to rent ($8k) or purchase ($60k), and two quad to purchase ($17.5k), fuel and maintenance ($12k), over-time, travel, training ($20k). Total cost is $258.5k, including initial cost of vehicle purchase. Note: this includes staff and equipment cost for seven rivers (Ten Mile, Noyo, Big, Albion, Navarro, and Garcia) in coastal Mendocino County.	"Near-future implementation" = "Full-implementation"	"Near-future implementation" = "Full-implementation"

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
Hare Creek and Jaspar Creek	NA	NA	NA	NA
Big River	Increase GRTS sampling rate in Chinook Salmon space from 12% to 50% for a total of 16 (out of 32) reaches sampled. To do this from October through March, additional funding and staffing is needed.	One biologist ($71k), three technicians ($78k), two trucks to rent ($8k) or purchase ($60k), and two quad to purchase ($17.5k), fuel and maintenance ($12k), over-time, travel, training ($20k). Total cost is $258.5k, including initial cost of vehicle purchase. Note: this includes staff and equipment cost for seven rivers (Ten Mile, Noyo, Big, Albion, Navarro, and Garcia) in coastal Mendocino County.	"Near-future implementation" = "Full-implementation""	"Near-future implementation" = "Full-implementation"

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
Albion River	Increased GRTS sampling rate from 30 to 90% in Chinook Salmon space for a total of 5 (out of six) reaches sampled. To do this from October through March, additional funding and staffing is needed.	One biologist ($71k), three technicians ($78k), two trucks to rent ($8k) or purchase ($60k), and two quad to purchase ($17.5k), fuel and maintenance ($12k), over-time, travel, training ($20k). Total cost is $258.5k, including initial cost of vehicle purchase. Note: this includes staff and equipment cost for seven rivers (Ten Mile, Noyo, Big, Albion, Navarro, and Garcia) in coastal Mendocino County.	"Near-future implementation" = "Full-implementation"	"Near-future implementation" = "Full-implementation"
Big Salmon Creek	NA	NA	NA	NA

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
Navarro River	Increased GRTS sampling rate in Chinook Salmon space from 26% to 50% for a total of 11 of 23 reaches sampled. In 2014, an LCM will be implemented on the North Fork Navarro River in which all reaches in this stream surveyed for redds and a screw trap operated for smolts at the mouth of the stream. To do this from October through March, additional funding and staffing is needed.	One biologist ($71k), three technicians ($78k), two trucks to rent ($8k) or purchase ($60k), and two quad to purchase ($17.5k), fuel and maintenance ($12k), over-time, travel, training ($20k). Total cost is $258.5k, including initial cost of vehicle purchase. Note: this includes staff and equipment cost for seven rivers (Ten Mile, Noyo, Big, Albion, Navarro, and Garcia) in coastal Mendocino County.	"Near-future implementation" = "Full-implementation"	"Near-future implementation" = "Full-implementation"
Garcia River	Increase GRTS sampling rate in Chinook Salmon space from 27% (conducted in 2013) to 55% for a total of six out of 11. To do this from October through March, additional funding and staffing is needed.	One biologist ($71k), three technicians ($78k), two trucks to rent ($8k) or purchase ($60k), and two quad to purchase ($17.5k), fuel and maintenance ($12k), over-time, travel, training ($20k). Total cost is $258.5k, including initial cost of vehicle purchase. Note: this includes staff and equipment cost for	"Near-future implementation" = "Full-implementation"	"Near-future implementation" = "Full-implementation"

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
		seven rivers (Ten Mile, Noyo, Big, Albion, Navarro, and Garcia) in coastal Mendocino County.		
Gualala River	NA	NA	NA	NA

	Near-future Monitoring		Monitoring with full-implementation of Coastal Monitoring Plan	
Watershed	Proposed additional work to be done	Budget for additional work	Proposed additional work to be done	Budget for additional work
Russian River	None at this time.	Not applicable	**<u>Spawning surveys</u>**: Fully implement CMP by conducting spawning surveys in GRTS reaches throughout the Chinook Salmon sampling space (includes mainstem Russian River, Maacama Creek, mainstem Dry Creek, Pena Creek, Santa Rosa Creek, Austin Creek) and time. **<u>Smolt survival in lower Russian River</u>**: Improve marine survival estimates by correcting for potentially significant loss of outmigrating salmon smolts between traps at Mirabel Dam (as well as from downstream tributaries) and the mouth of the Russian River. **<u>Ocean harvest (CWT tagging):</u>** A large portion of the fish in Dry Creek and Mirabel Dam could be CWT-tagged (if water temperatures were below stressful levels).	SCWA staff would use existing gear and staff for counting adult salmonids and out-migrant trapping so there would be no cost for to continue those specific efforts. **<u>Spawning surveys</u>**:. Proposed work would add to existing staffing in order to implement GRTS spawning surveys for Chinook Salmon. Total cost is ~$38K. **<u>Smolt Survival Lower River:</u>** Proposed work would add to existing work by PIT-tagging up to ~2,000 smolts at Mirabel smolt trap. Total cost is $33.4k.**<u>Ocean Harvest (CWT tagging):</u>** Using the same staff identified for PIT-tagging (above), CWT tagging would be conducted at Dry Creek and Mirabel out-migrant traps. Total cost is $31k.

[a]Bold/Italicized streams are CDFW's highest focus/highest priority for CC Chinook Salmon monitoring.
[b]DIDSON: Dual Frequency Identification Sonar.
[c]NA: Not applicable. Refers to streams that have extremely minimal (if any) habitat (present / historic) for this species.
[d]GRTS: Generalized Random Tessellation Stratified.