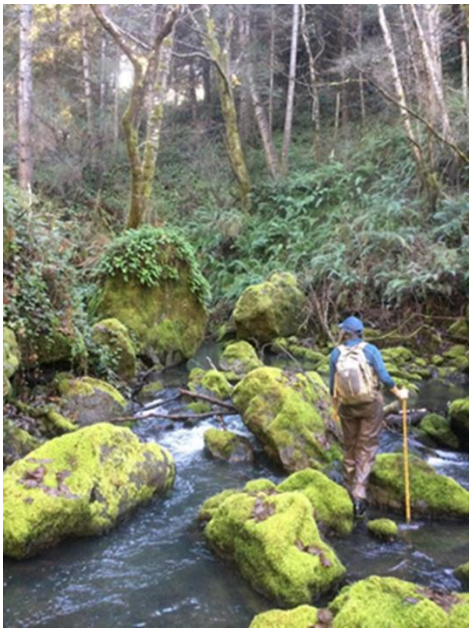
Coastal Mendocino County Salmonid Life Cycle and Regional Monitoring Project: 2019–2020 and 2020–2021 Final Report



Pacific States Marine Fisheries Commission in partnership with California Department of Fish and Wildlife, Lyme Redwood Forest Company, and Mendocino Redwood Company

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INTRODUCTION

Recovery of salmon and steelhead listed under the Endangered Species Act (ESA) primarily depends on increasing the abundance of adults returning to spawn (Good et al. 2005), thus both spawner escapement and trends in spawner escapement are two primary measures of recovery. In coastal Mendocino County, CA watersheds, the Central California Coast (CCC) Coho Salmon (*Oncorhynchus kisutch*) Evolutionarily Significant Unit (ESU), California Coastal (CC) Chinook Salmon (*Oncorhynchus tshawytscha*) ESU, and Northern California (NC) steelhead (*Oncorhynchus mykiss*) Distinct Population Segment (DPS) are listed as either threatened or endangered under Federal or state ESA (70 FR 37160 2005, CDFW 2019). Recovery of these distinct units of salmon and steelhead will depend on if important populations have reached abundance thresholds, and if biological recovery criteria being met (NMFS 2012, NMFS 2016a, Spence et al. 2008).

In 2005, the California Department of Fish and Wildlife (CDFW) and the National Marine Fisheries Service (NMFS) developed an Action Plan to monitor California's coastal salmonids (Boydstun and McDonald 2005). This plan outlined a strategy to monitor salmon and steelhead status and trends at different spatial scales and provide population estimates. This approach was implemented during a three-year pilot study in coastal Mendocino County watersheds (Gallagher et al. 2010 a-b) and findings from this work helped develop methods for the California Coastal Salmonid Monitoring Plan–CMP (Adams et al 2011).

Beginning in 2008, we began monitoring salmon and steelhead in the Mendocino Coast region following Adams et al. (2011) using a two-stage approach to estimate escapement. Under this scheme, first stage sampling is comprised of regionwide spawning ground surveys to estimate escapement based on redd counts, collected in stream reaches under spatially balanced probabilistic rotating panel design using the Generalized Random Tessellation Stratified (GRTS) technique (Stevens and Olson 2004) at a survey level of 15% of available habitat each year (Gallagher et al. 2010b). Second stage sampling provides escapement estimates from life cycle monitoring stations (LCMs) through either census counts or mark-recapture studies. The second-stage estimates represent true adult escapement, which are then used to establish spawner: redd ratios and calibrate first stage redd surveys. Annual estimates of smolt abundance, growth, and survival at various life stages are derived from juvenile monitoring at LCMs and provide measures of freshwater and marine influence on observed trends in abundance.

An additional component of the 2020–2021 monitoring season included the evaluation of a pilot Coho Salmon captive rearing project in two coastal Mendocino watersheds, where juveniles were captured in the wild then released as adults. The use of recovery/conservation hatcheries has been identified as a recovery action in both state and federal Coho Salmon recovery plans (CDFG 2004, NMFS 2012) and conservation hatcheries currently supplement several populations within the southern range of CCC Coho Salmon ESU (CDFW 2017). The Mendocino captive rearing project was initiated in 2018 in response to low Coho Salmon adult abundance estimates in the Garcia River to reduce the risk of extirpation in the Navarro -Gualala Point Diversity Strata (PACT 2019). The project involved capturing juvenile Coho Salmon from the Garcia River and Navarro River for three summers, rearing them in captivity to maturity at Don Clausen Fish Hatchery (DCFH) in Geyserville, CA, then releasing them as adults back to their natal rivers to spawn with ocean returning Coho Salmon. The first release of adults to the Garcia River and Navarro River occurred in December 2020. We provide preliminary monitoring findings from the first adult release of the captive rearing project.

This report provides population estimates for major portions of the CC Chinook Salmon ESU, CCC Coho Salmon ESU, and the NC steelhead DPS for spawning seasons 2019–2020 and 2020–2021,

completing thirteen years of CMP status and trend monitoring in coastal Mendocino County watersheds, and the continuation of long-term juvenile and adult datasets at existing LCMs.

METHODS

Study area

The study area includes coastal watersheds in Mendocino County, CA, extending from Usal Creek in the north to Schooner Gulch in the south (Figure 1). Watershed drainage areas range from approximately 15 km^2 up to 820 km^2 and the region is dominated by coastal redwood forest. Watersheds are rainfall and groundwater fed, with peak flows occurring during winter and receding through spring and summer. Streamflow is largely unregulated, and rivers enter directly into the Pacific Ocean. In some watersheds, bar-built estuaries close to the ocean during low-flow periods, restricting both adult and juvenile salmonid migration until flows increase and sand bars breach.

Adult salmonid upstream migration timing begins in the late fall/early winter, usually following the first significant rain events. Coho Salmon and Chinook Salmon typically return and spawn from late October through February, while steelhead return and spawn from late December through early May. Salmon and steelhead abundance and productivity data are commonly indexed by brood year, which typically refers to the year adult fish return to spawn, and eggs are deposited. Adult returns and spawning for all three species typically span two calendar years, and we define brood year as the second year, which is generally when the eggs first hatch and alevins emerge (e.g., brood year 2020 are the progeny of adults returning to spawn between October 2019 and May 2020).

Mendocino Coast sample frame

Spawning ground surveys were conducted under the context of a fixed sample frame. The sample frame included potential anadromous salmonid spawning habitat in coastal Mendocino County watersheds (Gallagher and Wright 2009) divided into a spatially balanced probabilistic GRTS design. The sample frame consisted of 339 reaches, with each reach ranging in length from 0.1–4.2 kilometers. The entire sample frame was designated as both Coho Salmon and steelhead habitat, with 146 reaches also designated as Chinook Salmon habitat.

Reaches were selected annually according to a GRTS rotating panel design. A sample size of 41 reaches or 15% of available habitat, was determined to have adequate precision and sufficient statistical power to detect regional trends in salmonid populations for the Mendocino Coast (Gallagher 2010b). If a reach was unavailable due to access restrictions, it was replaced by the next reach in GRTS order until the required sample size was filled. A minimum of six reaches were selected in Ten Mile River, Noyo River, Big River, Albion River, Navarro River, and Garcia River to generate redd abundance and salmonid population estimates with 95% confidence intervals. If fewer than six reaches were selected following the rotating panel design in these watersheds, additional reaches were added in GRTS order. A spawning survey census was conducted at LCMs.

Life cycle monitoring stations

There are six established LCMs nested within the regional sample frame (Figure 2). South Fork Noyo River, Little River, and Caspar Creek LCMs began monitoring adult and smolt abundance in 2000. Pudding Creek life cycle monitoring station (LCM) was established in 2006, and North Fork Navarro River LCM was established in 2014. These watersheds are studied in partnership with

landowners Lyme Redwood Forest Company and Mendocino Redwood Company (MRC), respectively. In spawning season 2020–2021, the South Fork Ten Mile River LCM was added through partnership with The Nature Conservancy (TNC) (Stillwater 2019). Annually, the level of monitoring at each LCM has varied and was dependent on logistics and funding. The metrics collected during the reporting years are presented in Table 1.

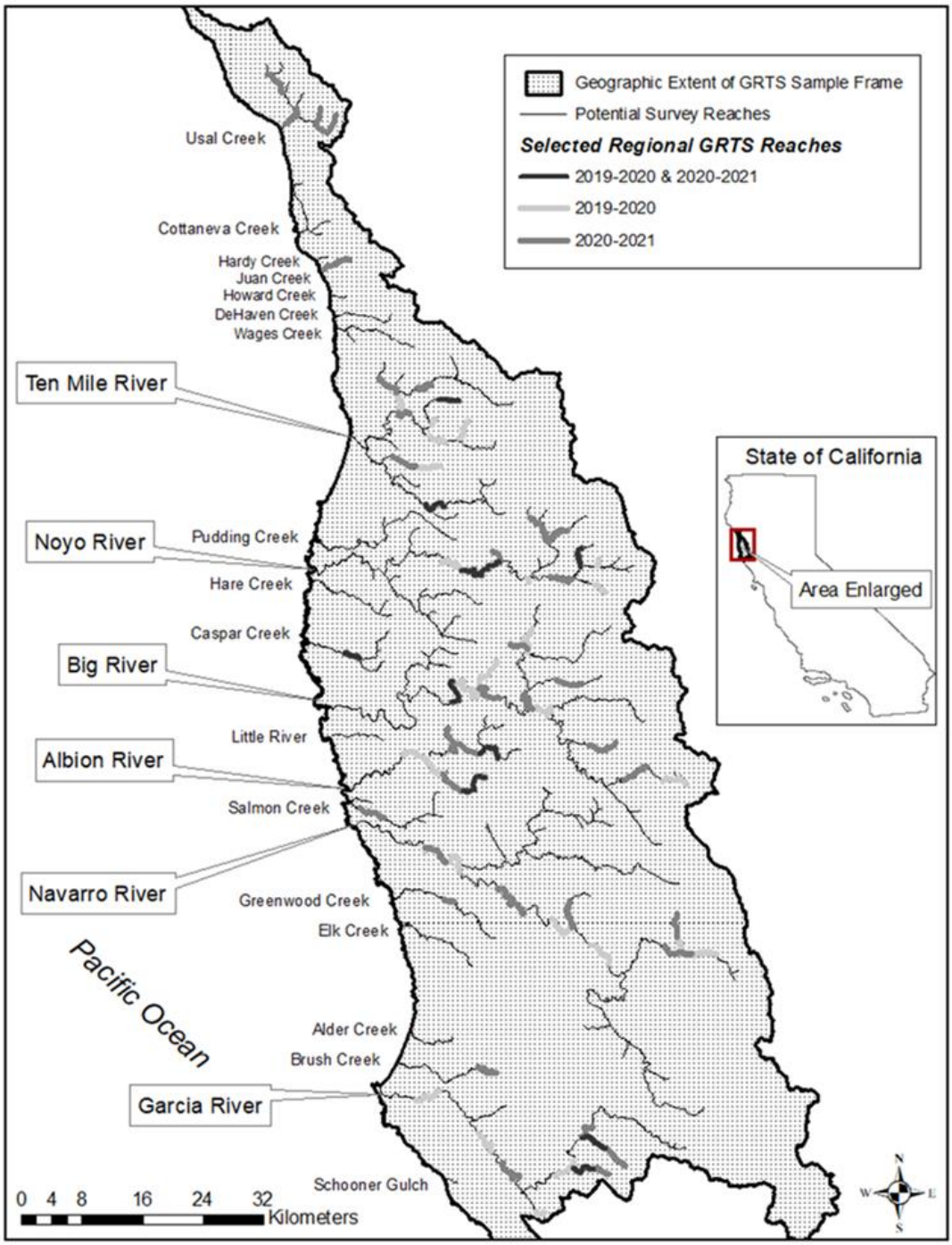

Figure 1. Map of study area sample frame and selected spawning survey reaches for the Coastal Mendocino County Salmonid Life Cycle and Regional Monitoring Program, 2019–2020 and 2020–2021 spawning seasons.

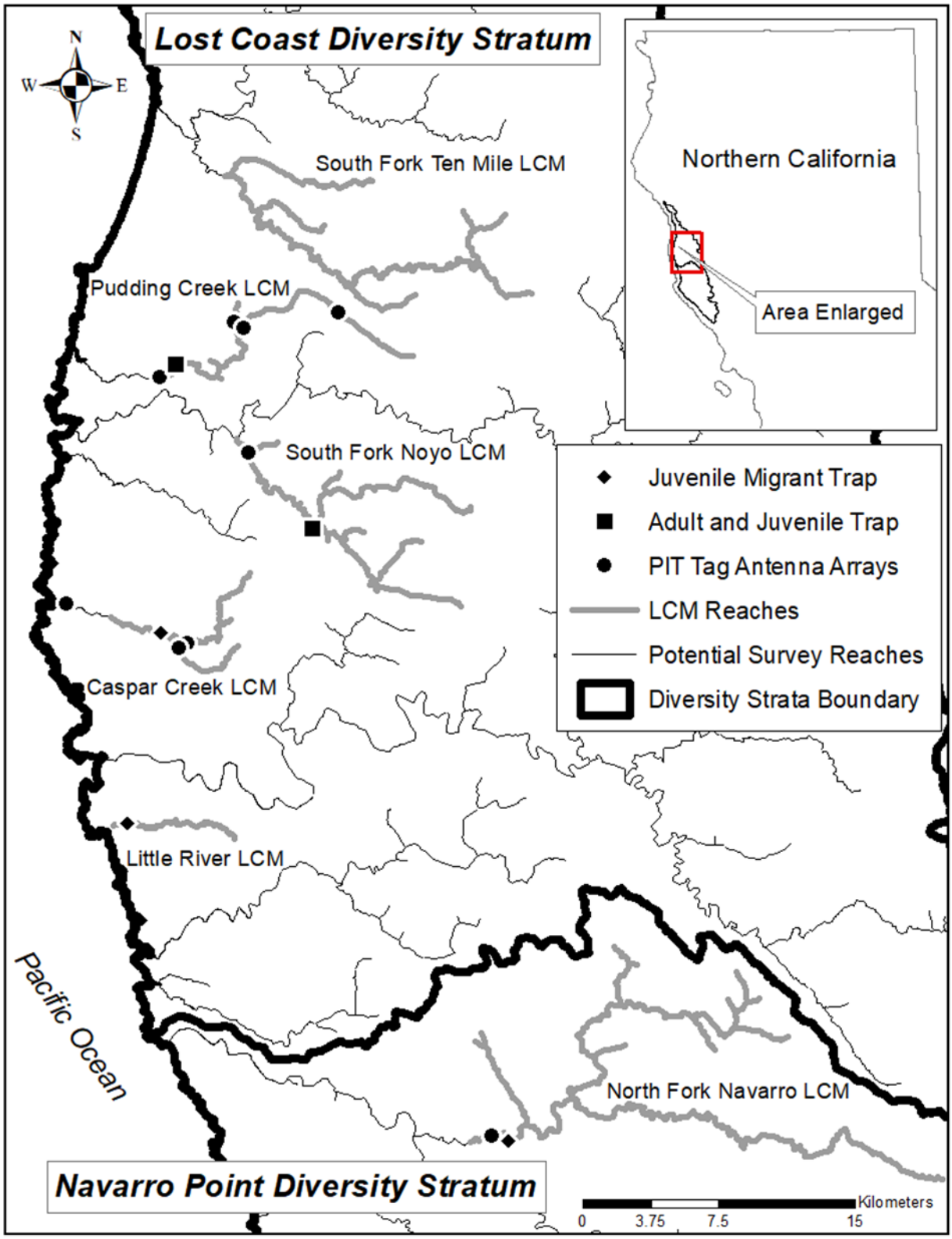

Figure 2. Map showing each life cycle monitoring station (LCM) within the Coastal Mendocino County Salmonid Life Cycle and Regional Monitoring Program, 2019–2020 and 2020–2021. Caspar Creek LCM was not operated in 2020–2021.

Table 1. Summary of life cycle monitoring station (LCM) metrics collected for the Coastal Mendocino County Salmonid Life Cycle and Regional Monitoring Program for 2019–2020 and 2020–2021. Location refers to either kilometers (km) from the ocean to a fixed capture site, or sample frame reach selection type. GRTS= generalized random tessellation stratified. RST=rotary screw trap. PIT= passive integrated transponder.

LCM	Life-stage	Method	Location	2019–2020	2020–2021
South Fork Ten Mile River	Adult/redd	Spawner census	GRTS reaches		x
Pudding Creek	Adult	Mark/recapture weir	6.6 km	x [a]	x [a]
	Adult/redd	Spawner census	GRTS reaches	x	x
	Smolt	Mark/recapture RST/fyke	6.6 km	x	x
	Juvenile	Depletion electrofishing/ PIT tags	GRTS subsample	x	x[b]
	Adult/juvenile	PIT tag arrays	5.5 km	x	x
South Fork Noyo River	Adult	Mark/recapture weir [a]	16.0 km	x	x
	Adult/redd	Spawner census	GRTS reaches	x	x
	Smolt	Mark/recapture RST/fyke	16.0 km	x	x
	Adult/juvenile	PIT tag arrays	10.5 km		x
Caspar Creek	Adult/redd	Spawner census	GRTS reaches	x	
	Smolt	Mark/recapture RST/fyke	2.5 km	x	
	Juvenile	Depletion electrofishing/PIT tags	GRTS subsample	x	
	Adult/juvenile	PIT tag arrays	0.8 km	x	x
Little River	Adult/redd	Spawner census	GRTS reaches	x	x
North Fork Navarro River	Adult/redd	Spawner census	GRTS reaches	x	x
	Smolt	Mark/recapture RST/fyke	18.5 km	x	x
	Juvenile	Electrofishing/PIT tags	GRTS subsample		x
	Adult/juvenile	PIT tag array	18.0 km	x	x

[a] Coho Salmon only.

[b] Electrofishing for PIT tagging only.

Spawning ground surveys

Spawning surveys occurred annually with a targeted survey interval of two weeks at LCM reaches, and in reaches selected from the GRTS sample frame. Methods followed Gallagher et al. (2014) and Gallagher et al. (2007). Field staff worked in pairs and surveyed reaches by walking or kayaking. New redds were identified to species, flagged, measured, and assigned a GPS location. Redds from previous surveys were reexamined to avoid double counting, and to assess redd loss between surveys. Over and under-counting errors in redd counts were reduced following Gallagher and Gallagher (2005). Live adult salmonids were counted, identified to species and sex, estimated to size, and inspected for Floy® T Bar Anchor Tags (Floy tags) and other secondary marks. A Floy tag and operculum punch was applied to adult salmonids captured at the South Fork Noyo River LCM and Pudding Creek LCM (see **Adult abundance** section**)**. Additionally, Floy tags and passive integrated transponder (PIT) tags were applied to Coho Salmon that were released on the North Fork Navarro River and Garcia River (see **Mendocino Coho Salmon captive rearing project** section). Carcasses were identified to species and sex, inspected for marks and tags, measured to fork length, and marked with a unique identifying jaw tag.

Redd abundance

Individual redds were classified to species and estimates of total redds per reach were generated following Ricker et al. (2013). Total redd construction was calculated using resighting of known redds in an open mark-recapture model to calculate between-survey-interval redd survival, which was then used to expand the raw count of known redds to estimated number of redds. The K-nearest neighbor (kNN) algorithm assigned a species attribute to any redd that was identified in the field without a live fish occupying the redd by using a majority vote of the three nearest known redds or live fish in time using Julian date, and in space using the GPS coordinate.

We followed Adams et al. (2011) and Ricker et al (2013) to estimate redd abundance at basin scales, where the estimated average number of redds from sampled reaches was multiplied by the total number of reaches in the sample frame. Redd abundance for the Mendocino Coast region, diversity strata, and individual watersheds were derived from reaches in the annual GRTS draw. We estimated 95% confidence intervals (CI) using bootstrap with replacement and 1000 iterations (Ricker et al. 2013). Reach level and population space redd abundance was estimated for all streams in which we surveyed six or more reaches (the minimum number needed for using the bootstrap to estimate 95% CI). Population abundance was generally not estimated in watersheds with fewer than two reaches sampled.

Adult abundance

Life cycle monitoring stations.— We estimated escapement at the South Fork Noyo River LCM and Pudding Creek LCM using Lincoln-Petersen mark-recapture method (Krebs 1989). Both LCMs have traps to capture adult salmonids as they migrate upstream to spawn. Adult salmonids were captured, marked, and released with time-specific externally visible Floy tags (Szerlong and Rundio 2008). Each fish was examined for external marks and scanned for PIT tags implanted as juveniles. Recaptures were live-fish observations made during census spawning ground surveys. To evaluate tag loss, fish were marked with weekly stream-specific operculum punches. During spawning surveys, all carcasses were inspected for Floy tags, operculum punches, or other marks to estimate tag loss and residence time. Residence time (rt) for Coho Salmon was estimated based on the time elapsed between

initial capture and recovery as a fresh carcass (Gallagher et al. 2010a). Observer efficiency (OE) was calculated following Szerlong and Rundio (2008) where the average number of Floy tags observed during spawning ground surveys was divided by the total known Floy tags available for resighting. Annually, we used either the multiyear average OE from Gallagher et al. 2010a, or the year specific average annual OE from LCMs. For 2020, OE was also estimated on the North Fork Navarro River LCM using observations of the Floy tagged adult Coho Salmon released for the captive rearing project

We used the area under the curve (AUC) methods described in Gallagher et al. (2010a) at LCMs without adult traps to estimate spawner abundance. Live fish counts from each spawning survey census were summed each survey interval and converted to "fish-days" by multiplying the number of days between surveys and the moving two-week average fish count. Fish-days were then summed for all intervals and divided by the OE derived from mark recapture, and multiyear, multi-stream average rt (Gallagher et al. 2010a). Spawner: redd ratios were derived at each LCM by either (1) dividing the mark recapture estimate by the redd estimate, or (2) dividing the AUC estimate by redd estimate. If escapement could not be calculated by mark recapture or AUC at a LCM, it was estimated using the annual spawner: redd ratio.

Regional spawning surveys. —We used the average spawner:redd ratio derived annually from all available LCMs to convert redd abundance to adult abundance (Gallagher et al. 2010a). The average was used for both Coho Salmon and steelhead adult estimates for the Mendocino Coast, diversity strata, and individual watersheds, except for in watersheds where the LCM is located within a subbasin. We applied the basin-specific spawner:redd ratio in Ten Mile River, Noyo River, Navarro River. Similarly, a basin-specific spawner:redd ratio was used to estimate adult abundance for the entire South Fork Noyo River and all of Pudding Creek to include survey reaches downstream of adult traps.

Fall electrofishing juvenile abundance

We performed electrofishing surveys in the late summer/fall at select LCMs to (1) estimate juvenile abundance of rearing parr, and/or (2) apply PIT tags for recapture at the outmigrant traps to evaluate seasonal growth and survival rates. Juvenile abundance electrofishing surveys were performed in October 2019 in Pudding Creek and Caspar Creek. In fall of 2020, electrofishing was conducted in the Navarro River and Pudding Creek in selected reaches only to implant PIT tags.

To estimate juvenile abundance, all GRTS reaches were habitat typed in Caspar Creek and Pudding Creek following Bouwes et al (2014) and Holloway et al. (2016). Three-pass depletion electrofishing described in Reynolds (1996) was conducted in a systematic sample of 50 habitat units in Caspar Creek, and 50 habitat units in Pudding Creek (Gallagher et al. 2014). Juvenile abundance was estimated in each unit using the jackknife estimator (Pollock and Otto 1983) and total sampled length was used to estimate total abundance for each stream (Särndal et al. 1992).

All captured salmonids were anesthetized using diluted tricaine mesylate (MS 222), identified to species, measured to fork length, weighed, and examined for previously applied marks/PIT tags. Any untagged salmonid ≥60 mm was surgically implanted with a PIT tag. All fish were released back to the unit from which they were captured after fishing was complete.

Downstream migrant trap smolt abundance

We used fixed downstream migrant traps (rotary screw traps and/or fyke net traps) to estimate smolt abundance using mark-recapture methods at Pudding Creek, South Fork Noyo River, North Fork Navarro River, and Caspar Creek LCMs. For trap locations, see Table 1 and Figure 2. The South Fork

Noyo River trap was not operated in spring 2020 because of working restrictions associated with the pandemic, and the Caspar Creek trap was not operated in spring 2021 due to lack of dedicated funding.

Traps were placed in the streams annually in late-February and sampled daily through early June. Data collection followed the methods in Barrineau and Gallagher (2001) with PIT tags used as the primary mark to estimate trap efficiency weekly for fish ≥ 70 mm and week-specific fin clips for salmonids between 45 mm and 69 mm. To assess tag loss, all PIT tagged smolts were marked with a secondary maxillary clip. Individuals less than 45mm were identified to species, counted, and released downstream of the traps. We examined all salmonids ≥45 mm for marks each day. Those without marks were marked, then released at least 150 m above the traps. Recaptured fish were released at least 150 m below the traps.

Annual smolt abundance and capture probability was estimated using Darroch Analysis with Rank Reduction and a one-trap design (Bjorkstedt 2003) for each age/size class by species. For both species 70–120 mm were one-year-old (Y+), and for steelhead only, >120 mm were two-year-old or older (Y++). Coho Salmon and steelhead < 70 mm captured before fry were first observed in spring were assumed to be Y+ (hatched the previous spring).

Point estimates for Coho Salmon includes one-year-old (Y+) smolts and a smaller portion of two-year-old (Y++) smolts. These age/size classes were developed based on Neillands (2003), Gallagher (2000), and Shapovalov and Taft (1954), and per discussion with local biologists. Young-of-the year (YOY) were assumed not to be migrating to the ocean, therefore only total capture was reported.

Estimation of overwinter growth

Juvenile Coho Salmon and steelhead were implanted with PIT tags at LCMs to evaluate overwinter growth rates. Growth rates were calculated as growth per day (millimeters) from initial capture during fall electrofishing surveys to recapture at the outmigrant trap.

Estimation of survival

We estimated apparent Coho Salmon (1) egg-to-smolt (freshwater) survival, and (2) smolt-to-adult (marine) survival at LCMs annually. We did not include steelhead in our survival estimates because their flexible cohorts and multiple age classes complicate survival computations. Egg-to-smolt survival was the proportion of smolt abundance to egg abundance. To estimate egg abundance, we multiplied the total estimated number of females by averaged fecundity, as estimated from fork length-fecundity relationships described in Shapovalov and Taft (1954). For South Fork Noyo River LCM and Pudding Creek LCM, the estimated number of females was the proportion of female spawners collected at the adult traps multiplied by spawner abundance. Average fork length was calculated from females captured at the traps. In Caspar Creek LCM and North Fork Navarro River LCM, we used total number of females and average estimated fork length observed during spawning ground surveys. Smolt-to-adult survival was the estimated abundance of returning adults divided by the estimated abundance of smolts migrating to the ocean in spring approximately 18 months earlier (Adams et al. 2011).

PIT tag antenna arrays

PIT tag antenna arrays were installed and maintained in Caspar Creek, Pudding Creek, South Fork Noyo River, and North Fork Navarro River LCMs (Figure 2) to detect movement of juvenile and adult salmonids. Detections of tagged Coho Salmon and steelhead on arrays were used to interpret estimates of marine and freshwater survival and evaluate migration timing and life history diversity.

Because our previous analysis has shown very limited movement of salmonids over summer when flows are low, arrays were only operated from fall through early summer.

Mendocino Coho Salmon captive rearing project

Project methods. — The Mendocino Coho Salmon captive rearing project was piloted in cooperation with the Russian River Coho Salmon Captive Broodstock Program (RRCSCBP) at DCFH, established due to the near extirpation of several populations within the southern range of the CCC Coho Salmon ESU (CDFW 2017). The hatchery and genetic management plan (HGMP) for the RRCSCBP included provisions for collecting, rearing, and releasing Coho Salmon from streams outside of the Russian River to support ESU-wide recovery efforts (CDFW 2017). Implementation of the Mendocino project was guided by a technical advisory committee including staff from NFMS, CDFW, United States Army Corps of Engineers (USACE), the North Coast Regional Water Quality Control Board, MRC, The Conservation Fund (TCF), and TNC. The project scope was limited in scale by available tank space for rearing adults at DCFH and funding.

Project methods included collection of 250 juvenile Coho Salmon annually from the Navarro River and Garcia River combined, for three summers in 2018, 2019, and 2020. Juveniles were transported to DCFH immediately after capture, raised in captivity to maturity, to be released to either the Garcia River or Navarro River just prior to spawning in winter 2020, 2021, and 2022. Each fish was genotyped, implanted with a PIT tag, and marked with a Floy tag prior to release. The release strategy included the use of a genetic/sex ratio scheme and multiple release site options to increase genetic diversity and accommodate variable instream flows to help maximize dispersal after release.

Adult release and monitoring. —The first release of ten jacks occurred in December 2019. With so few jacks released, there was no evaluation of spawning success in the first year. The first release of three-year-old adults occurred in December 2020. The two remaining release groups (brood year 2018 and 2019) will rear at DCFH until release in December 2021 and 2022.

Genetic analysis revealed relatedness at the sibling level, therefore some Garcia River origin Coho Salmon were released into the North Fork Navarro River and vice versa, to reduce chances of inbreeding. Over two days, on December 23 and 23, 121 adult Coho Salmon were released into the mainstem Garcia River (70 female). The Garcia River fish were split into two groups and released at two locations (Eureka Hill Bridge and Voorhees Grove). On December 29, 77 (42 female) Coho Salmon adults were released to the North Fork Navarro River in two groups at two different locations: the confluence of the South Branch North Fork Navarro, and near the mouth of Flynn Creek.

We used spawning ground survey observations to document evidence of spawning by project fish and interactions with ocean returning Coho Salmon during spawning season 2020–2021. Floy tags distinguished project fish from ocean returning Coho Salmon. Following the spawning season, we collected genetic samples from offspring to provide information on parental contribution and reproductive success. The tissue sample collection strategy for the Garcia River was to obtain approximately 200 samples from young of the year juvenile Coho Salmon in summer 2021 from multiple locations distributed throughout the watershed by electrofishing or seining. In June 2021, CDFW and partners performed snorkel surveys in the Garcia River to obtain general juvenile Coho salmon abundance and distribution and inform genetic sample collection. For the Navarro River, tissue samples are planned to be collected from smolts at the at the North Fork Navarro River outmigrant trap in spring 2022.

RESULTS

Sample frame draw

Spawning season 2019–2020. —Due to reduced project funding, we excluded Coho Salmon dependent population watersheds from the regional sample draw, and focused survey efforts in the six independent population watersheds. Therefore, there was no estimate for Mendocino Coast regional or diversity strata. A total of 38 reaches were selected in GRTS order. Access was denied in four reaches in the original draw and replaced with reaches within the same watershed selected in GRTS order. Nine GRTS selected reaches were at LCMs. Seven additional reaches were selected in GRTS order in the Noyo River, Albion River, Garcia River, Navarro River to obtain a minimum of six reaches in each watershed. In addition, six reaches were added to the Ten Mile River to increase sampling precision and support partner interest. Two additional reaches (one in Big River and one in Noyo River) were added due to their closeness to selected reaches and ease of access.

Surveys occurred from November 2019 through June 2020. The COVID-19 pandemic impacted monitoring in spring 2020 resulting in reduced spawning surveys in the regional space and monitoring at the South Fork Noyo LCM from March through May. Spawning surveys and smolt trapping continued at other LCM stations by CMP partners, and redds remained visible due to persistent low flow conditions during this period. As a result, we conducted a spawning survey in June in the regional space at the South Fork Noyo LCM to complete the redd count for the season and estimate steelhead abundance.

Spawning season 2020–2021. —A total of 44 reaches were selected in GRTS order from the sample frame, eight of which were at LCMs. Seven additional reaches were selected from the Albion River, Garcia River, and Navarro River in GRTS order to obtain a minimum of six reaches in each watershed. One additional reach was selected and surveyed in Noyo River due to proximity to other selected reaches and ease of access. In addition to the independent population watersheds, our sample draw included reaches in Usal Creek, Juan Creek, Caspar Creek, Big Salmon Creek, Greenwood Creek, and Brush Creek. The sampling fraction was 13% (44 of 339 reaches) for Coho Salmon and steelhead, and 14% (21 of 146 reaches) for Chinook Salmon. Surveys occurred from December 2020 through June 2021.

Redd and adult abundance estimates

Spawning season 2019–2020. — The Coho Salmon average annual spawner:redd ratio was 2.62 (95% CI = 2.20–3.50) derived from South Fork Noyo River, Pudding Creek, and North Fork Navarro River LCMs. The Coho Salmon average annual OE was 0.16, calculated from Pudding Creek and South Fork Noyo River LCMs.

The Coho Salmon mark-recapture adult population estimate was 84 for South Fork Noyo River LCM, and 359 for Pudding Creek LCM (Table 2). The Coho Salmon adult population estimate for all South Fork Noyo River was 175, and 551 for all Pudding Creek (Table 2). The Coho Salmon AUC adult population estimate was 138 for North Fork Navarro River LCM (Table 2). The Coho Salmon adult population estimate was 180 for Caspar Creek LCM, and 5 for Little River LCM–each estimate was derived from redd expansion and not AUC because there were too few live adult observations (Table 2). Coho Salmon adult population estimates for individual watersheds ranged from 44 in the Garcia River to 1,198 in Big River (Table 2). For individual basins, percent of sampled reaches ranged from 10–33% (Table 2).

There were no observations of Chinook Salmon adults or redds during the spawning season. Chinook salmon redd and adult population estimates are zero for Ten Mile River, Noyo River, Big River, Albion River, Navarro River, and Garcia River.

Table 2. Coho Salmon redd and adult population abundance estimates with 95% confidence intervals (lower–upper) in coastal Mendocino County, CA, for spawning season 2019–2020. Basin estimates include their respective life cycle monitoring station (LCM) or tributary. Pudding Creek LCM is upstream of the adult trap. South Fork Noyo River LCM is upstream of the Noyo Egg Collecting Station (ECS).

Population	Sample	Coho Salmon redd	Coho Salmon adult
Ten Mile River	29%	116 (32–202)	303 (70–703)
Pudding Creek	census	149 (143–156)	551 (426–770)
Pudding Creek LCM	census	97 (91–104)	359 (271–513)
Noyo River	17%	213 (112–387)	358 (142–1,129)
South Fork Noyo River	census	104 (94–115)	175 (119–336)
South Fork Noyo River LCM	census	50 (41–61)	84 (52–178)
Caspar Creek. LCM	census	69 (65–73)	180 (143–254)
Big River	10%	458 (58–858)	1,198 (127–2,988)
Little River LCM	census	2 (0–2)	5 (4–7)
Albion River	33%	140 (41–298)	366 (90–1,038)
Navarro River	14%	78 (58–126)	192 (136–327)
North Fork Navarro River LCM	census	56 (55–57)	138 (129–148)
Garcia River	23%	17 (4–52)	44 (9–181)

Steelhead annual spawner:redd ratio was 1.78 (95% CI = 1.49–2.23) calculated using North Fork Navarro River LCM. This ratio was used for all watersheds to estimate adult abundance. Adult abundance was not estimated by mark-recapture or AUC at South Fork Noyo LCM, or AUC at Caspar LCM, or Little River LCM due to the gap in survey dates caused by work restrictions resulting from the pandemic. Mark-recapture or AUC methods were not used at Pudding Creek LCM because too few steelhead were observed on spawning ground surveys. Steelhead adult abundance for North Fork Navarro River LCM was estimated by AUC using the multiyear average OE and rt from Gallagher et al. (2010a).

The steelhead adult population estimate was 48 for South Fork Noyo River LCM, and 71 for Pudding Creek LCM (Table 3). The steelhead adult population estimate for all South Fork Noyo River was 93, and 114 for all Pudding Creek (Table 3). The AUC steelhead adult population estimate was 600 for North Fork Navarro River LCM (Table 3). The steelhead adult estimate was 94 for Caspar Creek LCM, and 7 for Little River LCM. Steelhead adult estimates ranged from 7 in Little River to 1,926 in the Navarro River (Table 3).

Table 3. Steelhead redd and adult population estimates with 95% confidence intervals (lower–upper) in coastal Mendocino County, CA, for spawning season 2019–2020. Basin estimates include their respective life cycle monitoring station (LCM) or tributary. Pudding Creek LCM estimate is upstream of the adult trap. South Fork Noyo River LCM is upstream of the Noyo Egg Collecting Station (ECS).

Population	Sample	Steelhead redd	Steelhead adult
Ten Mile River	29%	302 (121–483)	538 (180–1,078)
Pudding Creek	census	64 (61–67)	114 (91–150)
Pudding Creek LCM	census	40 (37–43)	71 (55–96)
Noyo River	17%	335 (106–564)	596 (157–1,259)
South Fork Noyo River	census	52 (49–55)	93 (73–123)
South Fork Noyo River LCM	census	27 (26–28)	48 (39–62)
Caspar Creek LCM	census	53 (50–56)	94 (74–125)
Big River	10%	866 (518–1,214)	1,542 (769–2,710)
Little River LCM	census	4 (4–4)	7 (6–9)
Albion River	33%	26 (8–69)	46 (12–154)
Navarro River	14%	1,082 (710–1,454)	1,926 (1,054–3,246)
North Fork Navarro River LCM	census	337 (334–340)	600 (496–759)
Garcia River	23%	719 (272–1,166)	1,280 (404–2,603)

Spawning season 2020–2021.— Average Coho Salmon spawner:redd ratio was 2.35 (95% CI = 2.18–2.54) calculated from South Fork Noyo River, Pudding Creek, North Fork Navarro River, and South Fork Ten Mile River LCMs. Estimated OE for Coho Salmon was 0.19 for South Fork Noyo River LCM. The North Fork Navarro River LCM estimated OE (0.13) was calculated using observations of marked adult Coho Salmon released for the pilot conservation rearing project. Pudding Creek LCM OE was comparatively high (0.43) and unique due to a condensed adult migration and spawning run timing coupled with low clear water on subsequent spawning ground surveys. The Pudding Creek OE was therefore not used to calculate annual average OE. Average OE for Coho Salmon was 0.16.

Coho Salmon mark recapture adult population estimates were 130 for South Fork Noyo River LCM, and 303 for Pudding Creek LCM (Table 4). The Coho Salmon adult population estimate for all South Fork Noyo River was 373, and 399 for all Pudding Creek (Table 4). The Coho Salmon AUC adult population estimate was 409 for North Fork Navarro River LCM (0.13 OE) and 729 (0.16 OE) for South Fork Ten Mile River LCM (Table 4). The Little River LCM Coho Salmon adult estimate (21) was calculated using average spawner:redd ratio (Table 4).

For 2020–2021, the Mendocino Coast regional Coho Salmon redd estimate was 3,855 and the adult population estimate was 9,070 (Table 4). This is the highest reported estimate for since monitoring was initiated (A1). The Lost Coast DS Coho Salmon redd estimate was 2,775 and the adult population estimate was 6,529 (Table 4). The Navarro Point DS Coho Salmon redd estimate was 951, and the adult population estimate was 2,237 (Table 4). Coho Salmon adult population estimates ranged from 21 in Little River to 2,479 in the Ten Mile River (Table 4). For individual basins, percent of sampled reaches ranged from 11% to 40% (Table 4). Coho Salmon were observed in Caspar Creek and Big Salmon Creek; however, population estimates were not generated in these watersheds because fewer than six reaches were sampled.

Chinook Salmon were not observed during spawning surveys in 2020–2021. Chinook salmon redd and adult population estimates are zero for Ten Mile River, Noyo River, Big River, Albion River, Navarro River, and Garcia River.

Table 4. Coho Salmon redd and adult abundance estimates with 95% confidence intervals (lower–upper) in coastal Mendocino County, for spawning season 2020–2021. Basin estimates include their respective life cycle monitoring station (LCM) or tributary. Pudding Creek LCM estimate is upstream of the adult trap. South Fork Noyo River LCM is upstream of the Noyo Egg Collecting Station (ECS). DS=diversity stratum. NA=not available.

Population	Sample	Coho Salmon redd	Coho Salmon adult
Mendocino Coast	13%	3,855 (2,314–3,855)	9,070 (5,054–13,731)
Lost Coast DS	14%	2,775 (1,515–4,035)	6,529 (3,308–10,268)
Usal Creek	40%	0 (NA)	0 (NA)
Juan Creek[a]	census	4 (NA	9 (NA)
Ten Mile River	14%	952 (371–1,734)	2,479 (914–4,797)
South Fork Ten Mile River LCM	census	280 (277–283)	729 (682–783)
Pudding Creek	census	253 (252–254)	399 (346–469)
Pudding Creek LCM	census	192 (191–193)	303 (262–357)
Noyo River	17%	557 (203–916)	1,541 (527–2,690)
South Fork Noyo River	census	135 (133–137)	373 (345–402)
South Fork Noyo River LCM	census	47 (47–47)	130 (122–138)
Big River	12%	368 (44–723)	866 (96–1,840)
Little River LCM	census	9 (9–9)	21 (20–23)
Albion River	33%	62 (21–181)	146 (46–461)
Navarro Point DS	11%	951 (110–1919)	2,237 (240–4,883)
Navarro River	14%	210 (172–288)	517 (396–757)
North Fork Navarro River LCM	census	166 (166–167)	409 (382–439)
Garcia River	23%	135 (32–326)	318 (70–830)

[a] Only one reach therefore confidence intervals cannot be calculated

Average steelhead spawner:redd ratio was 1.71 (95% CI =1.43–2.14) calculated from North Fork Navarro LCM and South Fork Ten Mile LCM. Steelhead adult population abundance was not estimated by mark-recapture or AUC methods at South Fork Noyo LCM or Pudding LCM because adult traps were opened to facilitate passage through much of the steelhead run due to low flow conditions, and/or because very few steelhead were observed on spawning ground surveys, and instead estimated using average spawner:redd ratio. Steelhead adult population abundance was 10 for South Fork Noyo LCM, 48 for Pudding LCM, and 5 for Little River LCM (Table 5). The AUC steelhead adult estimate was 754 for the North Fork Navarro LCM, and 415 for the South Fork Ten Mile LCM (Table 5) using the multiyear averages of OE and rt from Gallagher et al. (2010a).

We estimated 5,264 steelhead redds, and 9,013 adult steelhead in coastal Mendocino County during 2020–2021 (Table 5). This is the highest reported estimate since monitoring was initiated in 2011 (A15). The North Central Coastal DS steelhead redd estimate was 2,877 and 4,926 adults (Table 5). The Central Coast DS steelhead redd estimate was 2,508 and 4,294 adults (Table 5). For individual watersheds, adult steelhead estimates ranged from a low of 5 in Little River to 1,411 in the Navarro River (Table 4). Sample rates ranged from 11% to 40% for each population space (Table 5). Steelhead

were observed in Caspar Creek, Big Salmon Creek, Brush Creek, and Greenwood Creek, however, population estimates were not generated in these watersheds because fewer than six reaches were sampled.

Table 5. Steelhead redd and adult abundance estimates with 95% confidence intervals (lower–upper) in coastal Mendocino County, for spawning season 2020–2021. Basin estimates include their respective life cycle monitoring station (LCM) or tributary. Pudding Creek LCM estimate is upstream of the adult trap. South Fork Noyo River LCM is upstream of the Noyo Egg Collecting Station (ECS). DS=diversity stratum. NA=not available.

Population	Sample	Steelhead redd	Steelhead adult
Mendocino Coast	13%	5,264 (3,911–6,617)	9,013 (5,579–14,224)
North Central Coastal DS	14%	2,877 (2,096–3,658)	4,926 (2,990–7,863)
Usal Creek	40%	144 (NA)	247 (NA)
Juan Creek[a]	census	31 (NA	53 (NA)
Ten Mile River	14%	769 (433–1,105)	1,375 (646–2,478)
South Fork Ten Mile River LCM	census	232 (230–234)	415 (343–525)
Pudding Creek	census	35 (35–35)	60 (50–75)
Pudding Creek LCM	census	28 (28–28)	50 (40–60)
Noyo River	17%	479 (141–817)	820 (201–1,756)
South Fork Noyo River	census	19 (19–19)	33 (27–41)
South Fork Noyo River LCM	census	6 (6–6)	10 (9–13)
Big River	12%	594 (145–1,043)	1,017 (207-2,242)
Little River LCM	census	3 (3–3)	5 (4–6)
Albion River	33%	80 (26–180)	137 (37–387)
Central Coastal DS	11%	2,508 (1,269–3,747)	4,294 (1,810–8,055)
Navarro River	14%	862 (567–1,157)	1,411 (772–2,380)
North Fork Navarro River LCM	census	461 (458–464)	754 (624–954)
Garcia River	23%	768 (405–1,131)	1,315 (578–2,431)

[a] Only one reach therefore confidence intervals not calculated.

Fall electrofishing juvenile abundance estimates

The fall 2019 Coho Salmon juvenile abundance estimate was 18,391 (95% CI =10,936–25,845) in Pudding Creek, and 6,983 (95% CI = 4,049–9,916) in Caspar Creek. The fall 2019 steelhead juvenile abundance estimate was 16,316 (95% CI = 12,074–20,557) in Pudding Creek, and 6,748 (95% CI = 4,612–8,884) in Caspar Creek.

Downstream migrant trapping smolt abundance estimates

Traps were operated from late February/early March through late-May/early June. A motor was required to keep rotary screw trap cones spinning for most of the outmigration period, or a fyke trap was installed in low flows. Coho Salmon smolt abundance estimates for spring 2020 and 2021 are shown in Table 6. Steelhead smolt abundance estimates for spring 2020 and 2021 are shown in Table 7. Capture probabilities varied among LCMs for both species, ranging from 0.04 to 0.56 (Table 6 and Table 7).

Table 6. Coho Salmon smolt abundance estimates at each life cycle monitoring station (LCM) in coastal Mendocino County, 2020 and 2021. Young-of-the year (YOY) are counts. Point estimates consist of one-year-old (Y+) smolts and a smaller portion of two-year-old (Y++) smolts. Estimates include 95% confidence intervals (CI) and mark recapture probabilities. NA=not available. South Fork Noyo LCM was only operated for approximately two weeks in 2020.

Life stage	YOY	Y+				
LCM	Total captured	Total captured	Low 95% CI	Point estimate	High 95% CI	Capture probability
2020						
Pudding Creek	5,337	4,222	12,571	13,345	14,119	0.41
South Fork Noyo River	NA	103	NA	NA	NA	NA
Caspar Creek	535	3,329	3,954	4,113	4,272	0.56
North Fork Navarro River	13	1,446	32,892	55,312	77,732	0.06
2021						
Pudding Creek	21,245	4,257	9,444	9,847	10,249	0.42
South Fork Noyo River	5,576	321	2,009	3,187	4,366	0.13
North Fork Navarro River	6,211	373	1,734	2,813	3,892	0.20

Table 7. Steelhead juvenile abundance estimates at each life cycle monitoring station (LCM) in coastal Mendocino County, 2020 and 2021. Young-of-the year (YOY) are counts. Point estimates include one-year-old (Y+) and two-year-old and older (Y++) juveniles. Estimates include 95% confidence intervals (CI) and mark recapture probabilities. NA=not available. South Fork Noyo LCM was only operated for approximately two weeks in 2020.

Life stage	YOY	Y+ and Y++				
LCM	Total captured	Total captured	Low 95% CI	Point estimate	High 95% CI	Capture probability
2020						
Pudding Creek	151	766	2,395	2,938	3,482	0.36
South Fork Noyo River	0	34	NA	NA	NA	NA
Caspar Creek	219	426	1,208	1,588	1,968	0.35
North Fork Navarro River	2,830	1,732	42,456	61,609	80,762	0.04
2021						
Pudding Creek	1,619	150	418	687	956	0.24
South Fork Noyo River	14	85	323	1,445	2,567	0.05
North Fork Navarro River	1,427	262	1,550	2,793	4,036	0.09

Estimation of overwinter growth

In 2019, PIT tags were applied to 307 Coho Salmon and 269 steelhead juveniles in Pudding Creek LCM, and 351 Coho Salmon and 228 steelhead in Caspar Creek LCM. Crews applied PIT tags to 407 Coho Salmon and 113 steelhead in Pudding Creek LCM in fall 2020. In summer 2020, crews applied PIT tags to 73 Coho Salmon in the North Fork Navarro River LCM. Due to small sample sizes, growth rates were not estimated for steelhead in Caspar or Pudding, nor for either species in the North Fork Navarro River LCM.

Based on smolt recaptures in 2020, average Coho Salmon overwinter growth per day in Pudding Creek LCM (0.12 mm) (n=43) was slightly higher than Caspar Creek LCM (0.10 mm) (n=70) (Table 8). In 2021, average growth per day of smolt recaptures was 0.15 mm (n=98) in Pudding Creek LCM, an increase from 2020 (Table 8).

Table 8. Overwinter growth rates (average millimeters per day) with 95% confidence intervals of juvenile Coho Salmon in Caspar Creek and Pudding Creek, coastal Mendocino County, CA, 2019–2020 and 2020–2021. NA=not available.

Smolt year	Caspar Creek			Pudding Creek		
	Low 95% CI	Point Estimate	High 95% CI	Low 95% CI	Point Estimate	High 95% CI
2020	0.089	0.098	0.107	0.106	0.123	0.140
2021	NA	NA	NA	0.134	0.147	0.159

Estimation of survival

Coho Salmon egg-to-smolt survival ranged from 0.03 to 0.07 for brood year 2019, and from 0.04 to 0.12 for brood year 2020 (Table 9). Coho Salmon smolt-to-adult survival for brood year 2017 ranged from 0.01–0.07 (Table 10). Coho Salmon smolt-to-adult survival for brood year 2018 was 0.03 for Pudding Creek LCM, and 0.02 for South Fork Noyo River LCM (Table 10). Average smolt-to-adult survival (0.03 for brood year 2017, and 0.02 brood year 2018) was slightly below the long-term average but improved from the extremely poor years from 2003 to 2007 (Figure 3). Average number of smolts per adult for brood year 2019 ranged from 18 to 69, and for brood year 2020 ranged from 18 to 38 (Table 11). Appendices 2-13 include survival estimates for all LCMs for previous years for comparison. Coho Salmon recruits-per-spawner ratios for brood year 2017 (spawning season 2019–2020 adult returns) were greater less than 1, except in Caspar Creek LCM (Table 12). For brood year 2018 (spawning season 2020–2021 adult returns), recruit-per-spawner ratios were less than 1, except for North Fork Navarro River LCM (Table 12).

Table 9. Coho Salmon egg-to-smolt survival (freshwater) with 95% confidence intervals (lower–upper) for brood year 2019 (2020 smolts) and 2020 (2021 smolts) for each life cycle monitoring station (LCM), coastal Mendocino County, CA. NA=not available. Smolts were not estimated at South Fork Noyo River LCM in 2020, or Caspar Creek LCM in 2021.

	Egg-to-smolt survival (freshwater)	
Brood year	2019	2020
LCM	Estimate (95% CI)	Estimate (95% CI)
Pudding Creek	0.03 (0.027–0.032)	0.04 (0.038–0.041)
South Fork Noyo River	NA	0.12 (0.070–0.160)
Caspar Creek	0.05 (0.048–0.052)	NA
North Fork Navarro River	0.07 (0.046–0.110)	0.06 (0.035–0.078)

Table 10. Coho Salmon smolt to adult (marine) survival rates with 95% confidence intervals (lower–upper) for brood year 2017 (2018 smolts to 2019–2020 adults) and 2018 (2019 smolts to 2020–2021 adults) for each life cycle monitoring station (LCM), coastal Mendocino County, CA. NA=not available Smolts were not estimated in North Fork Navarro River LCM and Little River LCM in 2019. Adult escapement was not estimated in Caspar Creek LCM in 2021.

	Smolt-to-adult survival (marine)	
Brood year	2017	2018
LCM	Estimate (95% CI)	Estimate (95% CI)
Pudding Creek	0.037 (0.032–0.048)	0.028 (0.026–0.030)
South Fork Noyo River	0.009 (0.009–0.014)	0.016 (0.010–0.020)
Caspar Creek	0.073 (0.072–0.087)	NA
Little River	0.005 (0.005–0.007)	NA
North Fork Navarro River	0.025 (0.014–0.172)	NA

Table 11. Coho Salmon smolt per adult estimate with 95% confidence intervals (lower–upper) for brood years 2019 (2020 smolts from 2018–2019 adults) and 2020 (2021 smolts from 2019–2020 adults) for each life cycle monitoring station (LCM), coastal Mendocino County, CA. NA=not available. Smolts were not estimated at South Fork Noyo River LCM in 2020. Adult escapement was not estimated in Caspar Creek LCM in 2021.

	Smolt per adult	
Brood year	2019	2020
LCM	Estimate (95% CI)	Estimate (95% CI)
Pudding Creek	18 (11–24)	18 (13–22)
South Fork Noyo River	NA	38 (25–39)
Caspar Creek	46 (44–47)	NA
North Fork Navarro River	69 (41–97)	20 (13–28)

Table 12. Coho Salmon recruit per spawner ratios with 95% confidence interval (lower–upper) for brood year 2017 (2016–2017 adults to 2019–2020 adults) and 2018 (2017–2018 adults to 2020–2021 adults) for each life cycle monitoring station (LCM), coastal Mendocino County, CA. NA= Not available. Adult escapement was not estimated in Caspar Creek LCM in 2021.

	Recruit per spawner ratio	
Brood year	2017	2018
LCM station	Estimate (95% CI)	Estimate (95% CI)
Pudding Creek	0.96 (0.89–1.08)	0.8 (0.75–0.84)
South Fork Noyo River	0.07 (0.05–0.13)	0.35 (0.30–0.38)
Caspar Creek	3.00 (2.55–3.97)	NA
Little River	0.16 (0.13–0.21)	0.72 (0.73–0.69)
North Fork Navarro River	0.47 (0.47–0.47)	1.78 (1.78–1.79)

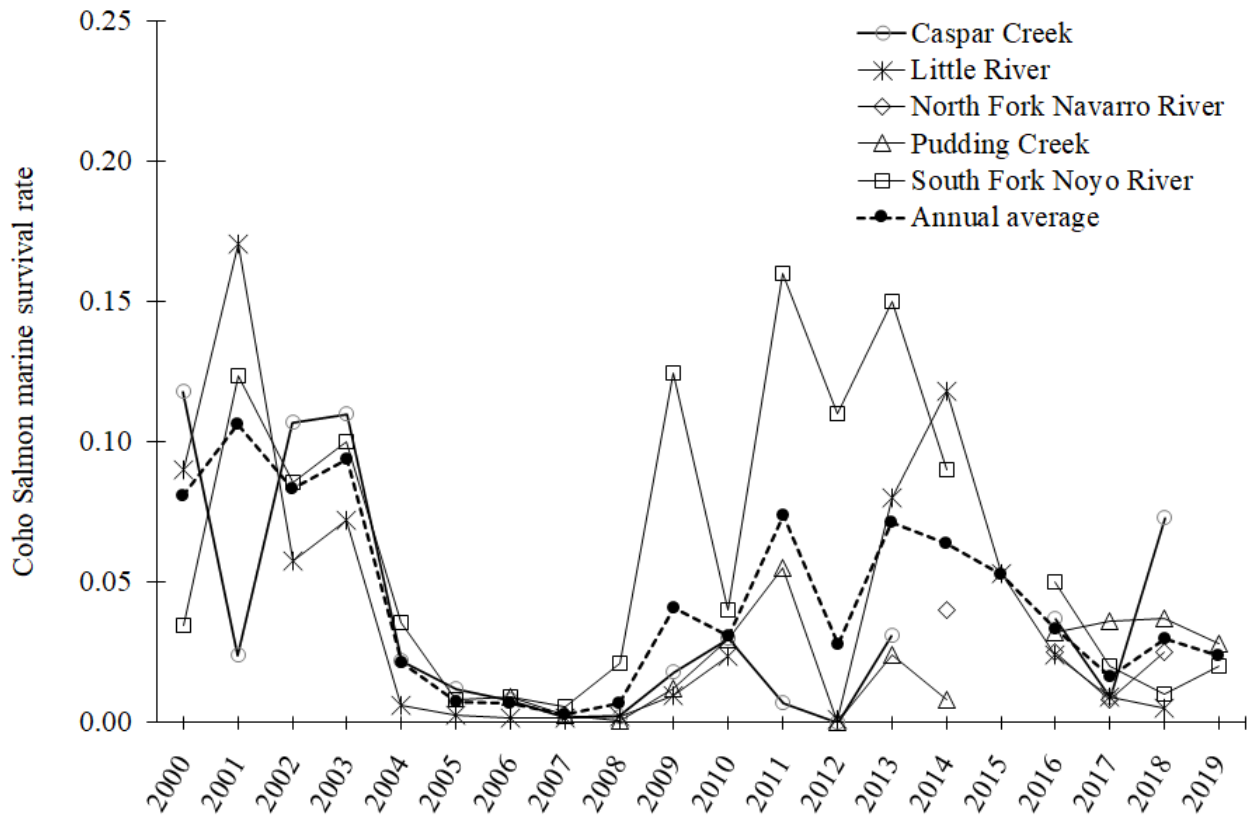

Figure 3. Coho Salmon marine survival (smolt to adult return) at coastal Mendocino life cycle monitoring stations, 1999-2019. Year is smolt year. (Eg.1999 brood year, 2000 smolt year, 2002 returning adults.)

Mendocino Coho Salmon captive rearing project

On the North Fork Navarro River, Floy tagged project fish were observed constructing redds during spawning ground surveys. Five of the 26 observations of female Coho Salmon on redds (20%) were Floy tagged project fish. Five Floy tagged project males were observed on redds. The total project fish released (77) was 18-20% of the North Fork Navarro River adult population estimate 409 (95% CI 382–439). If each mature project female constructed a redd (assuming one redd per female, no prespawn mortality, and none left the basin prior to spawning), project fish contributed up to 34 redds, which is 20% of the North Fork Navarro River redd estimate (166). The PIT tag array detected 18 of the released adults, indicating downstream movement within the North Fork Navarro River. It is unknown if these adults moved back upstream or spawned downstream.

On the Garcia River, the total number of project fish released (121) was 15–38% of adult population estimate 318 (95% CI=70–830). The range does not include the lower bound of the CI because it was lower than the number of project fish. Approximately 68 redds may have been constructed by female project fish, representing 21-50% of the redd estimate 135 (32–326). Two Floy tagged adults were observed on spawning ground surveys, comprising 6% of the total live Coho Salmon observations for the season. One female was observed in a pool with several other wild Coho Salmon, about five miles upstream of the Vorhees Grove release site.

During the summer snorkel surveys in the Garcia River, hundreds of juvenile Coho Salmon were observed at most snorkel survey locations except for the North Fork Garcia River, which had long

portions of dried habitat and flow disconnection. Using general patterns of abundance and distribution from the selected snorkel sites, crews collected tissue samples from 199 juvenile Coho Salmon. Genetic analysis results are pending. The abundant numbers of juvenile Coho Salmon distributed throughout the Garcia River in June 2021 during snorkel surveys matched the above average adult spawning population estimate. During a similar snorkel survey effort to collect juveniles for the project in summer 2020, few juvenile Coho Salmon were found in the Garcia River, which was expected with the low adult escapement estimate that year.

DISCUSSION

Long term population abundance and trend information is essential for assessing the viability and recovery of listed salmonids (Williams et al. 2016, Spence et al. 2008, Spence and Williams 2011). The 2020–2021 monitoring season completes 13 years of CMP implementation in coastal Mendocino watersheds, resulting in regional, diversity strata, and independent watershed level population estimates for Coho Salmon, Chinook Salmon, and steelhead. Though populations remain below recovery targets, Coho Salmon populations on the Mendocino Coast are some of the strongest within the ESU.

Coho Salmon independent populations in the Lost Coast Diversity Stratum continue to be more robust than those in the Navarro Point. Steelhead estimates were above average in most watersheds in both spawning seasons. Coho Salmon returns in 2019–2020 were above average in Pudding Creek, Caspar Creek, Albion River, and Big River, and below average in Ten Mile, Noyo, Navarro, and Garcia rivers. Coho Salmon adult estimates in most watersheds were average or slightly above average in 2020–2021, except for in Albion River and South Fork Noyo River, which were likely lower than average due to low flow conditions that limited access into upper watersheds. In 2020–2021, the Mendocino Coast regional estimate for both Coho Salmon and steelhead was the highest recorded since the CMP began. Notably, the Ten Mile Coho Salmon estimate exceeded previous estimates this year (A1). Observations of fish and redds in the GRTS draw reaches where the Mendocino captive rearing project fish were released were used to expand estimates to larger population spaces. This may have led to an overestimate or underestimate of Coho Salmon population abundance for the Navarro River, Navarro Point Diversity Stratum, and Mendocino Coast.

Coho Salmon adult returns in both years were progeny of relatively strong cohorts (brood years 2017 and 2018). Juveniles experienced generally good in-river conditions during incubation, rearing, and outmigration to the ocean. Average smolt-to-adult survival estimates for brood year 2017 was 3%, and 2% for brood year 2018. Since 2016, the Pacific Decadal Oscillation (PDO) has continued a 5-year trend of decreasing values associated with cooler temperatures and high productivity (Harvey et al. 2021). Despite the marine heat wave that began in late 2014 and that continues to persist, nearshore conditions have remained relatively favorable due to strong upwelling in the California Current Ecosystem (Harvey et al. 2021).

Adult migration and spawning under drought conditions

Unfortunately, the strong Coho Salmon and steelhead returns of 2020–2021 coincided with regionwide severe and exceptional drought (A12). Low river flows impacted run timing, and spawning distribution. Coastal watersheds experienced below average rainfall totals resulting in reduced magnitude and duration of peak stream flows, and lower seasonal base flows (A13 and A14). Abnormally dry conditions began in early winter 2019, transitioned to severe drought beginning in spring 2020, and extreme drought by spring 2021 (A12). Mean monthly flows in both the Navarro River and Noyo River were well below long-term averages (A13).

The timing and magnitude of instream flows influence migration timing and spawning in coastal Mendocino watersheds. Most rivers initially require 6-7 inches of rain in the late fall and early winter to increase flows to (1) break bar build estuaries that create seasonal barriers to the ocean, and (2) allow upstream passage and distribution to spawning grounds. In 2020–2021, late arriving rains and low seasonal rainfall totals delayed the opening of bar-built estuaries. The Navarro River estuary bar did not open until January 5, 2021, and intermittently opened and closed throughout the winter. While Coho Salmon were observed spawning in the North Fork Navarro soon after it opened, the delayed opening may have prevented some adult Coho Salmon from entering the river. In Pudding Creek, the estuary bar initially opened on December 17, 2020, for several days, however flows were insufficient for upstream passage until it reopened on January 4. Ten Mile River first opened December 14 and remained open through spring. In watersheds with open estuaries (Noyo River, Garcia River, Albion River), we observed Coho Salmon in mid-December in the lower portions of watersheds. Delayed and shortened estuary bar opening can lead to reduced run size, or even run failure as we observed in 2013–2014 when most estuary bars did not open until early February.

Low flows throughout the 2020–2021 spawning season restricted upstream passage of both Coho Salmon and steelhead adults into the upper portions of many watersheds, condensing spawning to lower mainstem reaches and larger tributaries. Adult steelhead were concentrated in the lower mainstem Noyo River, with very few in South Fork Noyo River (Table 5). Many smaller tributaries remained completely dry through the entire spawning season. Low flows can restrict spawning distribution by creating low flow passage barriers. Spawning survey observations indicated that a large jam on the Albion River passable at normal winter flows was impassible to Coho Salmon under the low flow conditions. Similarly, the most upstream three survey reaches in Pudding Creek did not have Coho Salmon spawning due to low flow barriers.

While both Coho Salmon and steelhead may experience delayed migration, redd dewatering, and restricted spawning distribution due to low flows, steelhead may be more vulnerable when drought conditions occur in the spring. In 2021, coastal watersheds experienced extremely dry conditions from late winter through spring. Crews observed steelhead redd dewatering during spawning surveys, and by mid-March, schools of adult steelhead were observed holding in the Noyo, Garcia, Navarro, and Ten Mile rivers in large pools, either waiting for increased flows to move upstream to spawn or return to the ocean. By early summer, many steelhead were trapped due to surface flow disconnection, most notable in the Navarro River and the Garcia River. Based on spawning survey observations, there were likely hundreds of steelhead in this condition. Steelhead observed in the Navarro River estuary in mid-June were found to be stressed and perishing. While it is likely that survival of the adults through the summer was poor, under similar conditions in coastal CA, Barnett and Spence (2011) found 40% of trapped adult steelhead kelts survived through summer until fall rains. We may expect variability in survival this year depending on the connectivity and water quality at individual locations. With the predicted increased frequency of drought, steelhead adult stranding may become more common. We recommend increased monitoring and evaluation of stranding in subsequent years to determine prevalence and develop strategies for management.

Juvenile abundance and life history during drought

In spring 2021, large numbers of Coho Salmon YOY were captured at all LCM outmigrant traps, and high densities were observed along the stream margins during spawning surveys. While it is not unusual to capture YOY in the outmigrant traps, the high densities may have been due to the low stream flows that concentrated spawning lower in the watersheds. During spring 2020 and 2021, stream flows

were low during peak smolt emigration and peak steelhead spawning and egg incubation. Stream flows receded rapidly through the spring, prematurely closing bar-built estuaries, and decreasing opportunities for smolts to migrate to the ocean. In 2021, both Pudding Creek and the Navarro River mouths closed in early April. Pudding Creek reopened temporarily for a few days on May 11, which may have provided additional window for smolts to enter the ocean. For Coho Salmon, especially in systems with bar-built estuaries, temporal restrictions of migrating adults and smolts due to climate change will be at least as important as changes in temperature, if not more (Osterback et al. 2018).

Findings from our LCM data show that annually, a portion of Coho Salmon juveniles remain in freshwater for two summers. Under drought conditions, this life history pattern may be more prevalent. In spawning season 2013–2014, adult Coho Salmon could not access Ten Mile River, Pudding Creek, Caspar Creek, Albion River, or the Navarro River due to low flows and/or closed estuary bars, which resulted in zero juvenile production for brood year 2014. This provided a unique opportunity to estimate the contribution of Y++ Coho Salmon in these watersheds, and the importance of this life history strategy under drought conditions. Similarly, low flow conditions and early sand bar closure during the outmigration period in spring 2020 and 2021 likely delayed or blocked outmigration for both Coho Salmon and steelhead smolts, causing them to remain another year in freshwater, or potentially perish.

It can be difficult to distinguish the one- and two-year-old Coho Salmon by size alone during summer or fall. To detect presence of Y++ in Pudding Creek, we collected and measured a sample of Coho Salmon in June 2021, during a period when age class is more easily discerned by length. We randomly selected sites within our GRTS sample frame from four reaches upstream of the rotary screw trap site within Coho Salmon spawning locations from the last two years. All captured Y++ Coho Salmon were measured and tagged, and a systematic sample of YOY were measured. Seventy-seven Y++ were tagged from 34 pool habitat units. Coho Salmon identified as Y++ were found in all selected sample locations, suggesting that there was some upstream migration of juveniles in spring of 2020 and/or winter 2021. Average Y++ fork length was 91mm, compared to average YOY fork length of 48mm. Seven Coho Salmon Y++ (average fork length 89 mm) were recaptured during this effort, each of which were first tagged as Y+ during fall electrofishing in 2020 or during outmigrant trapping in 2021. Recaptures at different life stages will continue to provide insight into survival and growth, and annual contribution of the Y++ in coastal Mendocino Coho Salmon populations.

The two-year freshwater life history strategy for Coho Salmon may be important for population diversity, and resilience to drought conditions and poor ocean conditions, spending two years in freshwater may be a risky strategy under multiple years of drought. Some habitat units in Pudding Creek were already disconnected by low flow conditions by early summer in 2021.

Low flows during the spawning season concentrated redds lower in the watersheds condensing multiple age classes of rearing juvenile salmonids during 2020. With less habitat availability, steelhead YOY may have a disadvantage due to their smaller size. While both Coho Salmon and steelhead can survive in disconnected pools for long periods, dissolved oxygen levels and water level decrease with days of disconnection (Woelfle-Erskine et al. 2017). We observed surface flow and habitat disconnection in several watersheds by fall of 2020. While smolt abundance and egg-to-smolt survival rates indicated brood year 2020 survived the drier than normal fall and summer rearing conditions, we are concerned that habitat fragmentation and drying pools will decrease juvenile survival in summer 2021. In the larger watersheds that extend further inland (e.g., Big River, Navarro River, Garcia River), water temperatures will likely cause thermal stress and decrease survival. In an evaluation of oversummer survival of juvenile salmonids under drying stream conditions, Vander Vorste et al. (2021)

found that while habitat disconnection had the greatest influence on oversummer survival, some pools had more resistance to drought, and serve as refuges.

While expansive spawning distribution is important for life history diversity, spawning in the lower mainstem in the larger rivers may have provided improved rearing conditions under drought conditions. While juveniles do move from smaller tributaries to larger mainstems as conditions start to deteriorate, rearing habitat in the lower and mainstream reaches of some rivers retained water, stayed cooler, and less prone to habitat fragmentation in 2021. In many watersheds, surface flow disconnection occurred in the most upstream spawning reaches beginning in early spring. In the North Fork Navarro River, in early summer, juvenile Coho Salmon were observed at typical known spawning and rearing locations, but upper tributaries and watersheds were dry by early June. By late August, almost the entirety of Flynn Creek was dry. During snorkel surveys in the Garcia River in 2021, we observed more disconnected surface flows and fewer salmonids in the upper mainstem where water temperatures normally exceed thresholds for survival by late summer 2021, compared to spring. In the lower Garcia River, water temperatures remained cool through the summer where hundreds of Coho Salmon juveniles were present.

With drought conditions expected to be more frequent and severe due to climate change, it will be important to undertake evaluations to determine extent of habitat fragmentation, assess juvenile salmonid survival rates, and identify juvenile salmonid refugia annually to help inform management actions to further protect these areas, or improve resiliency with habitat restoration

Coho Salmon dependent populations

The Mendocino Coast regional sample frame includes survey reaches in both dependent and independent populations for both Coho Salmon and steelhead. The sample design was developed to generate population estimates at the diversity strata and regional level with options to increase sample size for individual watersheds. Generally, there are not enough GRTS drawn sample reaches to generate population estimates in dependent population streams outside of LCMs. Though the current sample selection rate does not usually provide dependent population estimates, spawning surveys observations provide presence and distribution information annually in these smaller watersheds.

Dependent population watersheds outside of LCMs were not surveyed in 2018–2019 or 2019–2020 due to budget constraints but reincorporated during the 2020–2021. Spawning survey crews observed Coho Salmon and steelhead in Big Salmon Creek, Caspar Creek, and Juan Creek. Only steelhead were observed in Brush Creek, Greenwood Creek, and Usal Creek.

In Usal Creek, Coho salmon have not been observed during surveys since 2014, and only very few were observed during spawning surveys from 2008–2014. Like other watersheds in the region with bar-built estuaries, delayed opening of the sandbar associated with reduced rainfall may restrict Coho Salmon from entering Usal Creek. In 2021, the bar did not open until early January. Access restriction coupled with already depressed populations may have contributed to the potential extirpation of this population in Usal Creek.

Coho Salmon continue to persist in many of the smaller watersheds, even if not documented during spawning surveys. In January 2021, a local resident shared video footage of five adult Coho Salmon spawning in Wages Creek. We have not performed spawning surveys in Wages Creek since 2013–2014, and Coho Salmon have not been observed in Wages Creek since the CMP began.

Chinook Salmon

Since the initiation of CMP in 2008–2009, Chinook Salmon annual regional adult abundance estimates have ranged from 0 to 857 in coastal Mendocino watersheds. While abundance is generally low, we have made estimates in all independent watersheds within the region, with the highest annual estimate occurring in Ten Mile River in 2016–2017 (662).

For the past two spawning seasons, Chinook Salmon redd estimates were zero, though we have some evidence adult returns in both years. In December 2019, a live adult was observed in the Garcia River within a reach outside of our selected spawning reach. Five smolts were captured at the South Fork Ten Mile downstream migrant trap in 2020, indicating a small number of redds may have been missed during spawning surveys. On July 29, 2021, a 50 mm juvenile Chinook Salmon was captured on the Ten Mile River during an electrofishing survey for the restoration monitoring project, also indicating some successful spawning in 2020–2021. While these observations confirm Chinook Salmon have persisted in some basins, populations are likely at very low abundance in coastal Mendocino tributaries. Due to their earlier run timing, Chinook Salmon may be more sensitive to the late arriving and/or decreased fall precipitation conditions that occurred.

Our monitoring design also likely underestimates Chinook Salmon populations. There are fewer sample reaches specific to Chinook Salmon, and while we sampled 14% of the space during the past two survey years, Lacy et al (2016) recommends increasing this sampling rate in coastal Mendocino County for improved estimates. Overlap in spawn time with Coho Salmon coupled with low abundances likely cause underestimates. With so few spawners, live observations may be missed or masked by Coho Salmon observations, and the nearest neighbor predictor may predict zero redds as Chinook Salmon redds. For improved estimates, we recommend increasing sampling rates in the Chinook Salmon habitat space.

Mendocino Coho Salmon captive rearing project

In the Garcia River and Navarro River, natural returns of Coho Salmon were above average in 2020–2021. This provided project fish an opportunity to interbreed with ocean returning fish and increase diversity. The release strategy of placing adults in the lowest portions of the watersheds timed with storm events to allow for upstream distribution and match the ocean returning salmon migration timing was difficult due to the low flow conditions at the time of the release. The TAC selected two release locations in each river to improve distribution under these conditions. Logistically, the release sites worked well, and the adults were transported and released successfully without mortality. While most project adults dispersed upstream and downstream immediately after release, a large proportion held in a pool at the Eureka Hill Bridge for several days until rains increased flow and turbidity. This location may be a vulnerable for fish due to public accessibility and visibility from the bridge. Under the low flow conditions upstream migration was likely delayed or restricted at all sites. In the Navarro River, the captive reared released fish were the only adult Coho Salmon present for a week until the estuary bar opened to the ocean on January 5, 2021.

Floy tagged adults were observed on redds with ocean returning Coho Salmon in both the Garcia River and North Fork Navarro River, providing some indication of spawning success. In both rivers, escapement was equal or greater than the number of project adults released. Because spawning surveys were only conducted on a sample of the Garcia River (compared to the census in the North Fork Navarro River) there was more uncertainty around the population estimate, and fewer opportunities to view Floy tagged project fish. As a result, estimating the contribution of the project fish to the natural escapement may be better evaluated using juvenile genetic analysis. The pending genetic analysis of the offspring will provide further insight into parental contribution and reproductive successful.

Populations in the Navarro Point DS are below recovery targets and less robust than populations of Coho Salmon in the Lost Coast DS. Captive rearing may be an important method for sustaining or improving populations of Coho Salmon while restoration actions continue improve freshwater habitat. This pilot project was initiated opportunistically within existing infrastructure at the hatchery, and partner support. Further planning for extending the captive rearing project beyond the pilot phase should consider results of the genetic and spawning survey evaluation and resources available. We will continue to monitor the adult releases and juveniles through 2023 to help inform future efforts.

Observer error estimates

For the 2020–2021 spawning season, OE for Coho Salmon in Pudding Creek was unusually high. The late opening of estuary sand bar following the first high flow event resulted in most of the population entering Pudding Creek over a short period of time. Adults were trapped at the weir and tagged over two days. They spawned almost immediately and were recovered as carcasses by the next survey interval resulting in an unusually high proportion of tagged adults and carcasses observed. Since these circumstances were unique to Coho Salmon spawning in Pudding Creek, we decided it was not appropriate to transfer the OE to other locations. This same year, we were provided a unique opportunity to estimate OE in the North Fork Navarro LCM using the captive rearing project adult Coho Salmon marked with Floy tags. The second interval of OE had a changed ratio of Floy tagged to untagged fish, which suggested residence time of hatchery reared adults was longer than ocean returning adults. With ten percent of the project fish immature, overall residence time may have increased. The North Fork Navarro LCM OE (13%) was lower than Gallagher et al. (2010a) estimated mean OE of 19% for Coho Salmon from 2004–2008.

In both survey years, we were not able to calculate OE for steelhead for the Pudding Creek LCM or the South Fork Noyo LCM due to low adult returns and reduced sightings under low flow conditions. In 2020–2021, although,16 steelhead were Floy tagged in Pudding Creek only one was resighted despite good visibility throughout the season. More frequent and persistent droughts that cause low flows and delay estuary bar openings, may impacting spawn timing in future years and it may be necessary to reevaluate the application of OE on estimates.

Conclusion

This report completes thirteen years of population monitoring information for Coho Salmon, Chinook Salmon, and steelhead for the Mendocino coastal region, and continues long term datasets at established LCMs. Particularly this year, our monitoring illuminated some different effects of drought for each species and life stage. This monitoring program has been used to guide recovery efforts by providing a framework for studies to inform habitat and restoration work throughout the region (e.g., Pudding Creek BACI study and Ten Mile River Restoration project) and used to initiate and assess the pilot Coho Salmon captive rearing project in the Garcia River and Navarro Rivers. The CMP will be important for continued long-term status and trend monitoring, which is core for recovery, assessment, and planning at the federal and state levels for listed species of salmonids.

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APPENDICES

A1. Coho Salmon adult abundance estimates in coastal Mendocino County, 2009–2021. Adult returns and spawning period span two calendar years and brood year refers to the second year (e.g., brood year 2009 is spawning season 2008–2009). Mendocino Coast is the regional estimate from watersheds selected annually from the GRTS sample frame. DS= diversity stratum. LCM=life cycle monitoring station. The Gualala River is located within the Navarro Point DS but not included. NS=not sampled.

Brood year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Population													
Mendocino Coast	887	898	1,427	2,845	3,365	869	8,577	8,206	2,785	6,747	NS	NS	9,070
Lost Coast DS	672	1,059	1,212	2,756	4,646	869	7,991	6,657	2,599	6,139	NS	NS	6,529
Ten Mile River[1]	0	190	395	1,127	440	3	1,654	241	336	1,011	1,045	303	2,479
S. Fork Ten Mile LCM	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	729
Pudding Creek LCM [2]	50	9	199	415	283	0	539	135	572	497	754	551	399
Noyo River [3]	294	286	411	228	784	723	3,468	5,112	2,637	2,043	1,015	358	1,541
S. Fork Noyo LCM [4]	19	63	39	38	398	305	616	1,047	1,195	375	244	84	130
Caspar LCM [5]	6	5	27	20	10	0	40	56	60	131	90	180	NA
Big River	80	134	160	269	519	155	1,344	744	250	963	NS	1,198	866
Albion River	8	0	162	66	894	0	467	137	165	56	NS	366	146
Little River LCM	4	2	8	2	2	2	65	15	34	30	13	5	21
Navarro Point DS	158	513	542	250	578	2	586	591	0[6]	685	NS	NS	2,237
Navarro River[7]	70	452	420	244	354	0	423	178	291	229	NS	192	517
N. Fork Navarro LCM [8]	NS	NS	NS	NS	140	0	124	217	291	229	798	138	409
Garcia River	69	9	90	0	211	3	163	170	73	399	NS	44	318

[1] South Ten Mile LCM estimate added.
[2] Mark-recapture estimate. Adult trap was moved upstream in 2018. Estimate includes reach downstream of the adult trap in 2018–2021.
[3] South Fork Noyo River estimate added.
[4] Mark-recapture estimate upstream of the Noyo Egg Collecting Station (ECS).
[5] Mark recapture estimate (2009; 2012–2014). Area under curve estimate (2010–2011; 2017–2019). Redd expansion estimate (2020). No census in 2021.
[6] Reaches selected for DS estimate had zero Coho Salmon observations. At minimum, estimate was the same as the Navarro River.
[7] North Fork Navarro LCM estimate added.
[8] AUC estimate 2013–2021.

A2. Summary of Coho Salmon adult returns, smolts produced, smolt per adult ratios, smolt-to-adult survival, and recruit:spawner ratios by brood year for the Pudding Creek life cycle monitoring station, 2001–2021.

Brood Year	Adults			Smolts [2]			Smolt per Adult [3]			Estimated Smolt to Adult Survival [4]			Recruit:Spawner Ratio		
	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI
2001 [1]	ND	276	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2002 [1]	484	524	564	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2003 [1]	351	367	383	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2004	1067	1204	1600	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.36	ND
2005	899	1167	1773	21862	25656	29450	17	22	24	0.007	0.009	0.015	1.86	2.23	3.14
2006	588	709	888	15313	17609	19905	22	25	26	0.0021	0.0028	0.0048	1.68	1.93	2.32
2007	295	401	601	10842	11390	11938	20	28	37	0.0004	0.0008	0.0023	0.28	0.33	0.38
2008	153	228	450	14367	16309	18251	41	72	94	0.011	0.012	0.015	0.17	0.20	0.25
2009	32	50	96	12748	13920	15092	157	278	398	0.027	0.030	0.035	0.05	0.07	0.11
2010	4	9	27	4860	5181	5502	204	576	1215	0.04	0.05	0.07	0.01	0.02	0.04
2011	153	199	270	23951	26668	29385	109	134	157	NA	0.0	NA	0.60	0.87	1.00
2012	341	415	527	20361	22635	24909	47	55	60	0.023	0.024	0.026	5.49	8.30	10.66
2013	214	283	396	14755	16564	18373	46	59	69	0.007	0.008	0.012	14.67	31.44	53.50
2014 [5]	ND	0	ND	5040	5154	5268	NA	NA	NA	0.09	0.11	0.14	NA	NA	NA
2015	459	539	653	14934	15691	16448	25	29	33	0.027	0.032	0.038	1.24	1.30	1.35
2016	97	135	222	18722	21154	22420	101	157	193	0.03	0.04	0.06	0.45	0.48	0.56
2017	478	572	712	13444	14710	15976	22	26	28	0.032	0.037	0.048	NA	NA	NA
2018	410	497	625	13059	14272	15485	25	29	32	0.026	0.028	0.030	0.89	0.92	0.96
2019	527	754	1236	12571	13345	14119	11	18	24				5.43	5.59	5.57
2020	426	551	770	9444	9847	10249	13	18	22				0.89	0.96	1.08
2021	346	399	469										0.75	0.80	0.84

[1] Adult escapement based on one redd per female

[2] Smolt data by brood year: 1999 brood year smolted in spring 2000.

[3] By brood year: ie. 1999 adults produced 2000 smolts.

[4] By brood year: ie. 1999 adults produced 2000 smolts and 2002 returning adults.

[5] Complete run failure in 2014, no adults returned because it didn't rain and flows never got high enough to allow fish into the river. All smolts assumed to be two-years old

A3. Summary of Coho Salmon female:male ratios, estimated number of females and eggs, average female fork length, redd counts, spawner:redd ratios, and freshwater survival by brood year for the Pudding Creek life cycle monitoring station, 2001–2021.

Brood Year	Female:Male Ratio	Estimated Number of Females	Average Female Fork Length	Estimated Number of Eggs	Redd Count	Estimated Spawner:Redd Ratio			Egg to Smolt Survival		
						Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI
2001 [1]	ND	127	64.9	311046	138	ND	2.00	ND			
2002	1.09:1.00	286	66.4	750374	244	1.98	2.15	2.31			
2003	1.25:1.00	229	67.6	635810	184	1.91	1.99	2.08			
2004	1.00:1.04	602	60.3	1193970	519	2.06	2.32	3.08			
2005	0.85:1.00	496	60.2	975563	436	2.06	2.68	4.07	0.022	0.026	0.030
2006	0.68:1.00	241	67.6	667163	76	7.74	9.33	11.68	0.023	0.026	0.030
2007	0.65:1.00	96	66.2	249691	110	2.68	3.65	5.46	0.043	0.046	0.048
2008	1.26:1.00	144	61.8	305451	113	1.35	2.02	3.98	0.047	0.053	0.060
2009	0.91:1.00	23	67.0	61379	40	0.80	1.25	2.40	0.208	0.227	0.246
2010	3.50:1.00 [2]	7	66.6	18556	14	0.29	0.64	1.93	0.262	0.279	0.297
2011	0.91:1.00	58	66.3	151724	68	2.25	2.93	3.97	0.158	0.176	0.194
2012	0.98:100	203	66.1	527244	146	2.34	2.84	3.61	0.039	0.043	0.047
2013	1.73:1.00	188	63.7	437218	109	1.96	2.60	3.63	0.034	0.038	0.042
2014 [3]	NA	0	NA	0	0	NA	NA	NA	NA	NA	NA
2015	0.80:1.00	216	64.6	518741	312	1.49	1.73	2.04	0.029	0.030	0.032
2016	1.00:1.00	68	61.2	139546	73	0.67	1.85	3.04	0.134	0.152	0.161
2017	1.29:1.00	322	55.6	502369	219	2.76	2.61	2.69	0.027	0.029	0.032
2018	1.40:1.00	290	60.4	576614	122	3.45	4.07	5.00	0.023	0.025	0.027
2019	0.40:1.00	215	62.0	462703	296	1.86	2.55	4.00	0.027	0.029	0.031
2020	0.35:1.00	142	58.0	250868	149	2.98	3.70	4.93	0.038	0.039	0.041
2021	1.05:1.00	204	64.0	481961	253	1.37	1.58	1.85			

[1] No fish observed or captured, female to male ratio assumed to be 1.00.

[2] Seven females captured and tagged at dam. Four fish observed in spawning surveys three females and one male, one of the females was not tagged.

[3] Complete run failure in 2014, no adults returned because it didn't rain and flows never got high enough to allow fish into the river.

A4. Summary of Coho Salmon adult returns, smolts produced, smolt per adult ratios, smolt-to-adult survival, and recruit:spawner ratios by brood year for the South Fork Noyo River life cycle monitoring station, 2001–2021.

Brood Year	Adults			Smolts [4]			Smolt per Adult [5]			Estimated Smolt to Adult Survival [5]			Recruit:Spawner Ratio		
	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI
1999	ND	ND	ND	2102	2763	3424	ND	ND	ND	0.030	0.035	0.040	ND	ND	ND
2000 [1]	ND	190	ND	1596	4152	6708	ND	22	ND	0.080	0.124	0.290	ND	ND	ND
2001 [2]	289	323	357	5994	7562	9130	21	23	26	0.080	0.086	0.090	ND	ND	ND
2002 [2]	86	96	106	4789	5357	5925	56	56	56	0.057	0.100	0.144	ND	ND	ND
2003 [2]	462	514	566	7289	7975	8661	15	16	16	0.024	0.036	0.068	ND	2.71	ND
2004	530	647	706	9261	13727	18193	17	21	26	0.008	0.008	0.011	1.83	2.00	1.98
2005	272	536	854	4760	5980	7200	8	11	18	0.003	0.009	ND	3.16	5.58	8.06
2006	178	285	588	3212	3488	3764	6	12	18	ND	0.005	ND	0.39	0.55	1.04
2007	76	114	202	2829	2971	3113	15	26	37	0.015	0.021	0.036	0.14	0.18	0.29
2008	16	54	∞	287	313	339	ND	6	18	0.084	0.125	0.319	0.06	0.10	ND
2009 [3]	11	19	46	847	951	1055	ND	50	ND	0.020	0.040	0.076	ND	0.07	ND
2010	42	63	112	1720	2472	3226	29	39	41	0.122	0.157	0.230	0.55	0.55	0.55
2011	24	39	108	2373	3009	3645	34	77	99	0.105	0.101	0.108	ND	0.72	1.50
2012	17	38	80	3656	4078	4500	56	107	215	0.134	0.151	0.184	ND	2.00	ND
2013	209	389	742	9940	11484	13028	18	30	48	0.091	0.091	0.095	4.98	6.17	6.63
2014	249	305	395	2874	3674	4474	11	12	12	0.310	0.325	0.370	3.66	7.82	10.38
2015	490	616	829	5478	7852	10226	11	12	13	0.040	0.048	0.060	10.36	16.21	28.82
2016	909	1047	1235	7226	11087	14948	8	11	12	0.020	0.022	0.030	1.66	2.69	4.35
2017	1056	1195	1377	5808	9273	12738	5	8	9	0.009	0.009	0.014	3.49	3.92	4.24
2018	318	375	454	7316	8382	9448	21	22	23	0.010	0.016	0.020	0.55	0.61	0.65
2019	214	244	272	-	-	-	-	-	-				0.22	0.23	0.24
2020	52	84	178	2009	3187	4365	25	38	39				0.05	0.07	0.13
2021	122	130	138										0.30	0.35	0.38

[1] Total number of fish released above the Egg Collecting Station.

[2] Adult escapement based on one redd per female.

[3] Nineteen fish captured and tagged at the ECS and no recaptures so total count presented.

[4] Smolt data by brood year: 1999 brood year smolted in spring 2000.

[5] By brood year: 1999 adults produced 2000 smolts and 2002 returning adults.

A5. Summary of Coho Salmon female:male ratios, estimated number of females and eggs, female length, redd counts, spawner:redd ratios, and freshwater survival by brood year for the South Fork Noyo life cycle monitoring station.

Brood Year	Female:Male Ratio	Estimated Number of Females	Average Female Fork Length	Estimated Number of Eggs	Redd Count	Estimated Spawner:Redd Ratio			Egg to Smolt Survival		
						Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI
2000 [1]	0.35:1.00	81	59.2	151401	ND	ND	ND	ND	0.01	0.03	0.04
2001	0.79:1.00	128	59.7	244721	123	2.35	2.63	2.90	0.02	0.03	0.04
2002	1.04:1.00	51	64.0	119997	51	1.69	1.88	2.08	0.04	0.04	0.05
2003	0.79:1.00	203	54.3	294473	114	4.05	4.51	4.96	0.02	0.03	0.03
2004	0.96:1.00	320	61.6	675872	391	1.36	1.65	1.81	0.01	0.02	0.03
2005	1.13:1.00	303	56.6	498598	164	1.66	3.27	5.21	0.01	0.01	0.01
2006	0.44:1.00	63	55.9	99314	25	7.12	11.40	23.52	0.03	0.04	0.04
2007	0.53:1.00	30	63.3	68904	50	1.52	2.28	4.04	0.04	0.04	0.05
2008	0.36:1.00	10	58.0	17159	4	4.00	13.50	ND	0.02	0.02	0.02
2009 [2]	0.20:1.00	3	55.6	4677	5	ND	3.80	ND	0.18	0.20	0.23
2010	0.50:1.00	16	63.2	35756	67	0.63	0.94	1.67	0.05	0.07	0.09
2011	0.85:1.00	23	59.0	42697	13	1.85	3.00	8.31	0.06	0.07	0.09
2012	1.10:1.00	21	67.8	58390	11	1.55	3.45	7.27	0.063	0.070	0.077
2013	0.85:1.00	169	65.9	434295	32	6.53	12.16	23.19	0.023	0.026	0.030
2014 [3,4]	0.28:1.00	84	65.9	215863	35	0.81	0.82	1.02	0.013	0.017	0.021
2015	0.39:1.00	173	64.8	422702	284	1.79	2.17	2.87	0.013	0.019	0.024
2016	0.92:1.00	502	57.0	841514	343	2.51	3.05	3.60	0.008	0.013	0.018
2017	0.95:100	582	57.7	1012212	296	3.78	4.04	4.40	0.006	0.009	0.013
2018	1.06:1.00	193	55.6	300845	127	2.52	2.95	3.55	0.024	0.028	0.031
2019	1.00:1.00	122	55.2	186214	132	1.71	1.85	1.96	-	-	-
2020	0.27:1.00	18	56.5	29239	50	1.27	1.68	2.92	0.069	0.109	0.149
2021	0.53:1.00	45	64.2	107431	47	2.60	2.77	2.94			

[1] Total of grilse and hatchery. Only fish considered adults was 0.85:1.00.

[2] Three females and 16 males captured at ECS.

[3] 2014 Only 35 redds and 84 females above ECS, superimposition likely.

[4] Spawner:redd ratio from Noyo River mark recapture

A6. Summary of Coho Salmon adult returns, smolts produced, smolt per adult ratios, smolt-to-adult survival, and recruit:spawner ratios by brood year for the North Fork Navarro life cycle monitoring station.

Brood Year	Adults			Smolts			Smolt per Adult			Estimated Smolt to Adult Survival			Recruit:Spawner Ratio		
	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI
2013	132	140	150	4402	5423	6444	33	39	43	0.036	0.040	0.046	ND	ND	ND
2014	0	0	0	1655	2527	3399	NA	NA	NA	0.092	0.115	0.164	ND	ND	ND
2015	116	124	133	7878	9164	10450	68	74	79	0.024	0.025	0.027	ND	ND	ND
2016	204	217	234	67390	96714	126038	330	446	539	0.007	0.008	0.011	1.5455	1.5500	1.5600
2017	272	291	312	752	5550	10348	3	19	33	0.014	0.025	0.172	NA	NA	NA
2018	215	229	246	-	-	-	-	-	-	-	-	-	1.8468	1.8496	1.8534
2019	747	798	857	32892	55312	77732	44	69	91				3.6618	3.6624	3.6774
2020	129	138	148	1734	2813	3892	13	20	26				0.4742	0.4743	0.4744
2021	382	409	439										1.7767	1.7846	1.7860

A7. Summary of Coho Salmon female:male ratios, number of females, female length, number of eggs and redds, and spawner:redd ratios by brood year for the North Fork Navarro life cycle monitoring station.

Brood Year	Female:Male Ratio	Estimated Number of Females	Average Female Fork Length	Estimated Number of Eggs	Redd Count	Estimated Spawner:Redd Ratio			Egg to Smolt Survival		
						Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI
2013	0.50:1.00	47	51.3	57260	28	5.00	5.00	5.08	0.08	0.09	0.11
2014 [3]	-	0	-	0	0	NA	NA	NA	NA	NA	NA
2015	0.83:1.00	56	52.0	72176	67	1.82	1.85	1.90	0.11	0.13	0.14
2016	1.80:1.00	140	55.0	210665	80	2.62	2.71	2.85	0.32	0.46	0.60
2017	0.25:1.00	58	58.3	104491	7	38.90	41.57	44.57	0.01	0.05	0.10
2018	1.33:1.00	131	62.5	287775	65	3.36	3.52	3.73	-	-	-
2019	1.18:1.00	432	57.4	737699	256	2.99	3.12	3.27	0.04	0.07	0.11
2020	0.58:1.00	51	46.4	46655	56	2.35	2.46	2.60	0.04	0.06	0.08
2021	1.32:1.00	233	63.2	528347	166	2.30	2.46	2.63	-	-	-

[3] Complete run failure in 2014, no adults. Flow never high enough for fish to get into the river.

A8. Summary of Coho Salmon adult returns, smolts produced, smolt per adult ratios, smolt-to-adult survival, and recruit:spawner ratios by brood year for the Caspar Creek life cycle monitoring station for the Caspar Creek life cycle monitoring station.

Brood Year	Adults			Smolts [6]			Smolt per Adult [7]			Estimated Smolt to Adult Survival [8]			RecruIt:Spawner Ratio		
	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI
1999	ND	ND	ND	2889	3259	3629	ND	ND	ND	0.111	0.118	0.128	ND	ND	ND
2000 [1, 2]	41	87	133	3355	3799	4243	32	44	82	0.0238	0.0240	0.0241	ND	ND	ND
2001 [1, 2]	102	106	108	1922	2224	2526	19	21	23	0.105	0.107	0.109	ND	ND	ND
2002 [1,2]	370	386	402	4258	4976	5694	12	13	14	0.101	0.110	0.117	ND	ND	ND
2003 [1,2]	81	91	101	4371	5753	7135	54	63	71	0.011	0.022	0.695	0.76	1.05	1.98
2004 [1,2]	210	238	266	3792	4482	5172	18	19	19	0.007	0.012	0.038	2.06	2.25	2.46
2005 [1,2]	432	548	664	1893	2253	2613	4	4	4	0.003	0.008	ND	1.17	1.42	1.65
2006	48	126	4961	2843	3505	4167	1	28	59	ND	0.002	ND	0.59	1.38	49.12
2007	28	54	196	1786	2134	2491	13	40	64	0.0017	0.0023	0.0036	0.13	0.23	0.74
2008	6	17	∞	1424	2044	2664	ND	120	237	0.017	0.018	0.027	0.01	0.03	NA
2009 [3]	ND	6	ND	545	659	773	ND	110	ND	0.017	0.030	0.235	NA	0.05	NA
2010 [4]	3	5	9	1302	1525	1748	194	305	434	0.003	0.007	0.016	0.05	0.09	0.11
2011 [5]	25	34	73	3418	4086	4754	65	120	137	0.000	0.000	0.000	NA	2.00	4.17
2012	9	20	182	660	1303	1946	11	65	73	0.022	0.031	0.058	-	3.33	-
2013	4	10	28	1859	2753	3647	130	275	465	0.016	0.020	0.028	1.33	2.00	3.11
2014 [9, 10]	0	0	0	-	92	-	NA	NA	NA	ND	0.652	ND	-	0.00	-
2015	38	40	43	2349	3568	4787	62	89	111	0.029	0.037	0.052	0.24	2.00	4.22
2016	52	56	60	7404	9934	12464	142	177	208	0.008	0.009	0.011	2.14	5.60	13.00
2017	56	60	64	1989	2461	2933	36	41	46	0.072	0.073	0.087	NA	NA	NA
2018	122	131	141	4940	5595	6250	40	43	44	-	-	-	3.211	3.275	3.279
2019	85	90	97	3954	4113	4272	44	46	47				1.61	1.62	1.63
2020	143	180	254	-	-	-	-	-	-				2.55	3.00	3.97
2021	-	-	-										-	-	-

[1] Adult escapement based on one redd per female and assumed even male to female ratio.

[2] Adult escapement based on one redd per female.

[3] Total count of fish released above the weir.

[4] No fish tagged, fish observed during spawning surveys: AUC estimate Noyo 2011 observer efficiency and 2001 to 2008 average residence time.

[5] No fish captured, handled, or tagged: fish per redd estimate.

[6] Smolt data by brood year: 1999 brood year smolted in spring 2000.

[7] By brood year: 1999 adults produced 2000 smolts.

[8] By brood year: 1999 adults produced 2000 smolts and 2002 returning adults.

[9] Complete run failure in 2014, no adults. Flow never high enough for fish to get into the river.

[10] Caspar 2015 (BY 2013 but recorded in 2014 above) 53 coho smolt captured. Sh y+ cap prob = 0.27. 53*1-.27+53=9 91.69

A9. Summary of Coho Salmon female:male ratios, number of females, female length, number of eggs and redds, and spawner:redd ratios by brood year for the Caspar Creek life cycle monitoring station.

Brood Year	Female:Male Ratio	Estimated Number of Females	Average Female Fork Length	Estimated Number of Eggs	Redd Count	Estimated Spawner:Redd Ratio			Egg to Smolt Survival		
						Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI
2000 [1, 2]	1.00:1.00	44	64.7	105906	43	0.95	2.02	3.09	0.032	0.036	0.040
2001 [2]	1.00:1.00	53	64.7	129035	53	1.92	2.00	2.04	0.015	0.017	0.020
2002	0.91:1.00	176	64.7	427592	183	2.02	2.11	2.20	0.010	0.012	0.013
2003	1.23:1.00	56	61.7	118501	59	1.37	1.54	1.71	0.04	0.05	0.06
2004	1.30:1.00	155	66.1	401303	133	1.58	1.79	2.00	0.009	0.011	0.013
2005	1.14:1.00	312	61.6	656752	292	1.48	1.88	2.27	0.0029	0.0034	0.0040
2006	1.10:1.00	69	68.0	195294	38	1.26	3.32	130.55	0.015	0.018	0.021
2007	0.80:1.00	22	63.4	49518	45	0.62	1.20	4.36	0.036	0.043	0.050
2008	1.50:1.00	13	67.2	34702	9	0.67	1.89	ND	0.04	0.06	0.08
2009	0.50:1.00	2	64.7	4863	11	ND	0.55	ND	0.11	0.14	0.16
2010 [2]	1.00:1.00	11	64.7	25564	26	0.12	0.19	0.35	0.05	0.06	0.07
2011	1.00:1.00	18	68.0	50726	13	1.92	2.62	5.62	0.07	0.08	0.09
2012 [2]	1.00:1.00	9	64.7	20694	15	0.60	1.33	12.13	0.03	0.06	0.09
2013	4.00:1.00	8	64.5	19300	22	0.18	0.45	1.27	0.10	0.14	0.19
2014 [3]	NA	0	NA	0	0	NA	NA	NA	NA	NA	NA
2015	0.58:1.00	15	61.1	30210	54	0.66	0.80	0.85	0.08	0.12	0.16
2016	1.25:1.00	31	58.5	56327	123	0.42	0.46	0.49	0.13	0.18	0.22
2017	0.75:1.00	26	65.0	63462	24	2.80	2.50	2.06	0.03	0.04	0.05
2018	1:00:1:00	66	55.5	101582	58	2.14	2.26	2.35	0.049	0.055	0.062
2019	1.20:1.00	49	57.1	82769	87	1.01	1.03	1.08	0.048	0.050	0.052
2020 [4]	0.25:1.00	36	63.5	82815	69	2.20	2.61	3.48	-	-	-
2021	-	-	-	-	-	-	-	-			

[1] Expanded Harris (1999-2000) raw redd count of 32, assumed 0.64 Observer Efficiency in redd detection (32*0.36+32).

[2] No fish observed or captured, female to male ratio assumed to be 1.00.

[3] Complete run failure in 2014, no adults. Flow never high enough for fish to get into the river.

[4] Used average female length of previous years due to only one observation.

A10. Summary of Coho Salmon adult returns, smolts produced, smolt per adult ratios, smolt-to-adult survival, and recruit:spawner ratios by brood year for the Little River life cycle monitoring station.

Brood Year	Adults			Smolts [6]			Smolt per Adult [7]			Estimated Smolt to Adult Survival [8]			RecruIt:Spawner Ratio		
	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI
1999	ND	ND	ND	917	975	1033	ND	ND	ND	0.055	0.090	0.122	ND	ND	ND
2000 [1]	0	16	67	259	264	280	∞	17	4	0.162	0.170	0.171	ND	ND	ND
2001 [2]	6	20	33	1441	1575	1709	240	79	52	0.02	0.06	0.09	ND	ND	ND
2002 [2]	50	88	126	1885	2115	2345	38	24	19	0.00	0.07	0.23	ND	ND	ND
2003 [2]	42	45	48	2038	2202	2366	49	49	49	0.000	0.006	0.011	0.72	2.81	∞
2004 [2]	28	91	154	1834	1974	2114	66	22	14	0.002	0.003	0.003	4.55	4.67	4.67
2005 [2]	0	152	535	1176	1294	1412	∞	9	3	0.001	0.002	0.003	0.00	1.73	4.25
2006 [2]	1	14	27	1855	2175	2495	1855	155	92	ND	0.002	ND	0.02	0.31	0.56
2007 [2]	3	5	6	800	863	923	267	173	154	ND	0.002	ND	0.04	0.05	0.11
2008 [2]	1	2	4	698	836	974	517	414	245	ND	0.010	ND	0.007	0.013	∞
2009 [2]	ND	4	ND	41	85	129	ND	21	ND	ND	0.024	ND	ND	0.29	ND
2010 [2]	ND	2	ND	NA	0	NA	ND	0	ND	ND	NA	ND	ND	0.40	ND
2011 [2]	ND	8	ND	1474	1954	2434	ND	244	ND	ND	0.001	ND	ND	3.96	ND
2012 [2]	ND	2	ND	712	778	844	ND	389	ND	ND	0.080	ND	ND	0.50	ND
2013 [2]	ND	2	ND	55	127	199	ND	64	ND	ND	0.118	ND	ND	1.00	ND
2014 [6]	ND	2	ND	506	634	762	ND	317	ND	0.044	0.053	0.068	ND	0.25	ND
2015	ND	62	ND	936	1228	1520	ND	20	ND	0.022	0.024	0.029	ND	31.00	ND
2016	ND	15	ND	1153	1507	1861	ND	100	ND	0.008	0.009	0.010	ND	7.50	ND
2017	34	34	34	621	1039	1457	18	31	43	0.005	0.005	0.007	ND	16.78	ND
2018	27	30	33	-	-	-	-	-	-	-	-	-	ND	0.48	ND
2019	11	13	15	-	-	-	-	-	-				ND	0.85	ND
2020	4	5	7	-	-	-	-	-	-				0.13	0.16	0.21
2021	20	21	23										0.73	0.72	0.69

[1] Adult escapement from Harris 2000 redd counts.

[2] Adult escapement based on one redd per female.

[3] Smolt data by brood year: 1999 brood year smolted in spring 2000.

[4] By brood year: 1999 adults produced 2000 smolts.

[5] By brood year: 1999 adults produced 2000 smolts and 2002 returning adults.

[6] No redds observed, one adult female carcass observed, young-of-the-year captured in traps. Thus assume two adults

A11. Summary of Coho Salmon female:male ratios, number of females, female length, number of eggs and redds, and spawner:redd ratios by

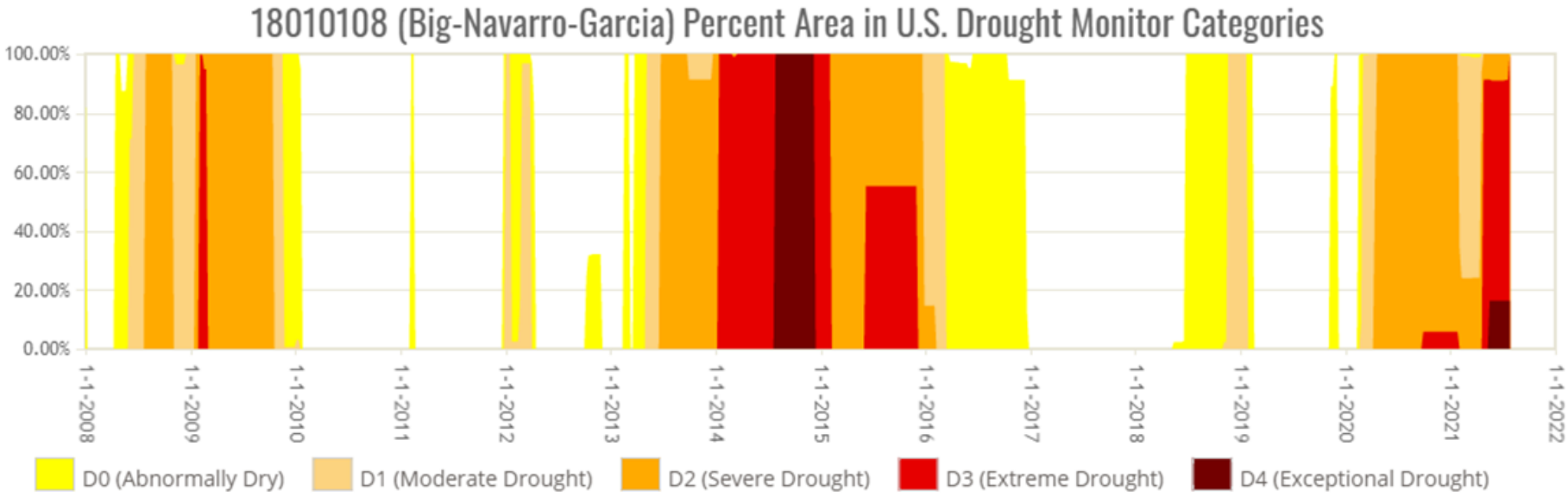
Brood Year	Female:Male Ratio	Estimated Number of Females	Average Female Fork Length	Estimated Number of Eggs	Redd Count	Estimated Spawner:Redd Ratio			Egg to Smolt Survival		
						Lower 95% CI	Estimate	High 95% CI	Lower 95% CI	Estimate	High 95% CI
2000 [1, 2]	1.00:1.00	8	58.7	14630	8	ND	ND	ND	0.018	0.018	0.019
2001 [2]	1.00:1.00	10	58.7	18288	10	0.60	2.00	3.30	0.079	0.086	0.093
2002	1.00:1.00	44	65.6	111564	41	1.22	2.15	3.07	0.017	0.019	0.021
2003	1.25:1.00	23	66.0	58079	27	1.56	1.67	1.78	0.035	0.038	0.041
2004	0.92:1.00	46	58.0	80484	44	0.64	2.07	3.50	0.023	0.025	0.026
2005	1.00:1.00	76	65.2	189267	76	0.00	2.00	7.04	0.006	0.007	0.007
2006 [2]	1.00:1.00	28	56	44585	7	0.14	2.00	3.86	0.042	0.049	0.056
2007 [2]	1.00:1.00	3	45	2511	2	1.50	2.50	3.00	0.319	0.344	0.368
2008 [2]	1.00:1.00	1	55	1510	1	1.35	2.02	3.98	0.462	0.554	0.645
2009 [2]	1.00:1.00	2	58.7	3658	2	ND	2.00	ND	0.011	0.023	0.035
2010 [2]	1.00:1.00	1	58.7	1829	1	ND	2.00	ND	-	0.000	-
2011 [2]	1.00:1.00	4	62.5	8797	3	ND	2.67	ND	0.168	0.222	0.277
2012 [2]	1.00:1.00	1	59.2	1875	1	ND	2.00	ND	0.380	0.415	0.450
2013 [2]	1.00:1.00	1	63.3	2283	1	ND	2.00	ND	0.024	0.056	0.087
2014 [2]	1.00:1.00	1	69.5	3005	1	ND	2.00	ND	0.168	0.211	0.254
2015	1.00:1.00	31	63	69790	54	ND	1.15	ND	0.013	0.018	0.022
2016	1.00:1.00	8	61.5	15730	6	ND	2.50	ND	0.073	0.096	0.118
2017	1.50:1.00	20	55.7	31501	11	3.12	3.05	3.05	0.020	0.033	0.046
2018	1.00:1.00	15	59.8	28445	10	2.68	2.95	3.33	ND	ND	ND
2019	1.00:1.00	9	55.0	12907	6	1.89	2.14	2.58	ND	ND	ND
2020 [3]	1.00:1.00	3	55.0	3949	2	2.20	2.62	3.48	ND	ND	ND
2021	1.00:1.00	11	63.3	24208	9	2.18	2.35	2.54			

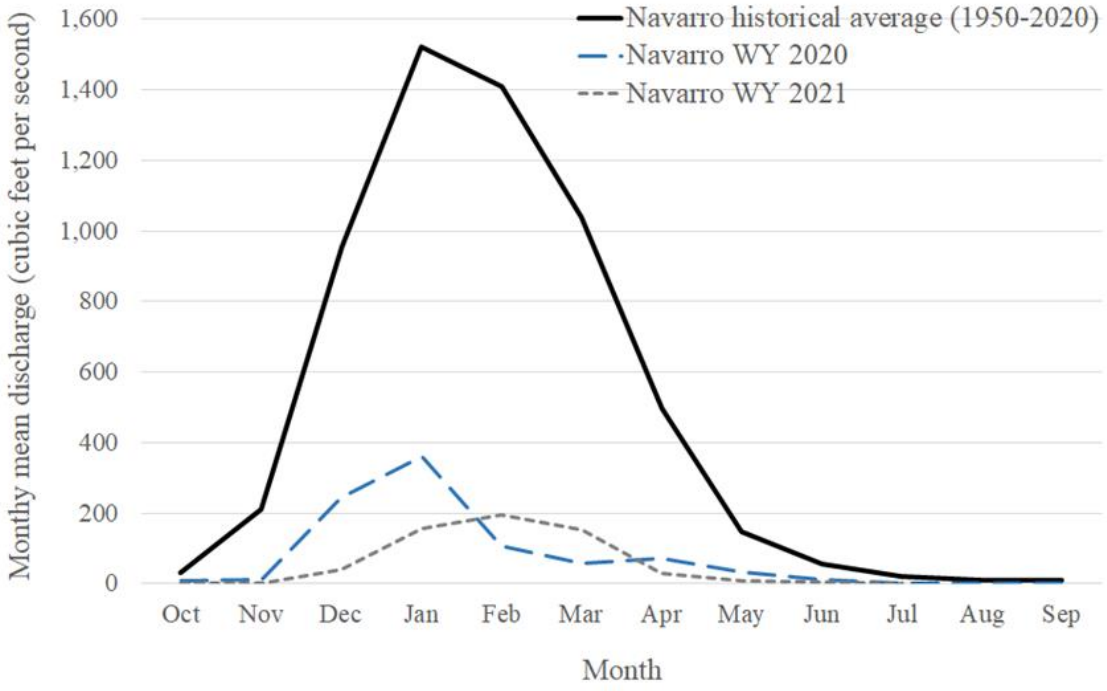
[1] Expanded Harris (1999-2000) raw count assuming 0.64 observer efficiency in redd detection.

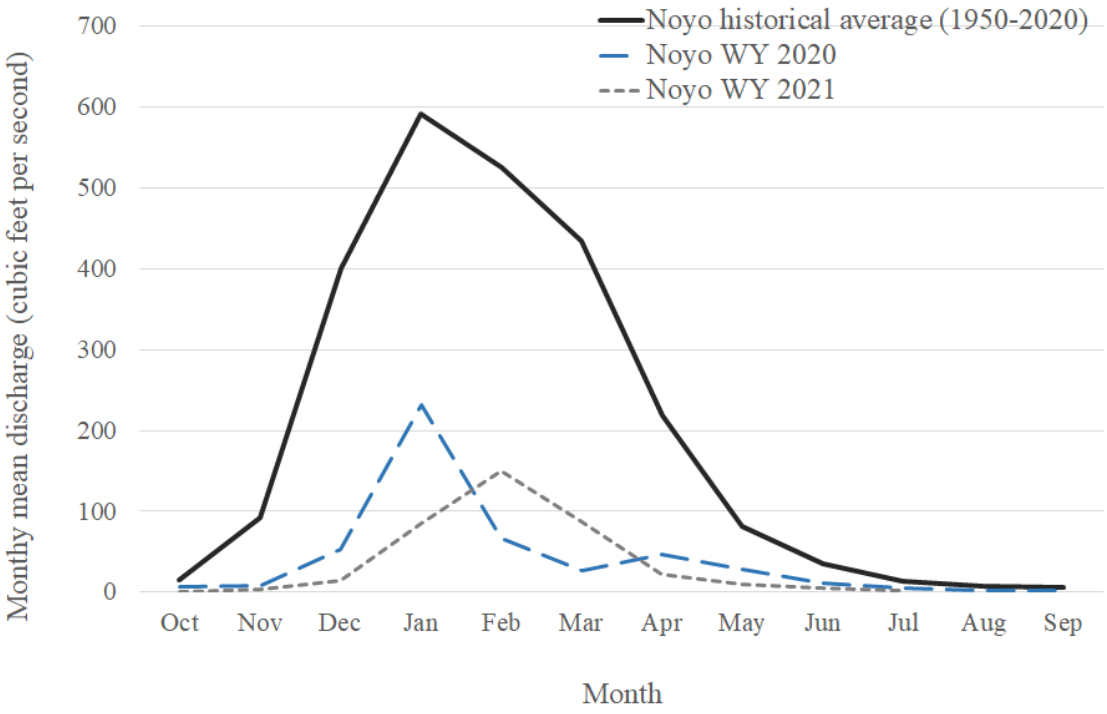
[2] No live fish observed assumed 1.00:1.00.

3 One live fish observed assumed 1.00:1.00.

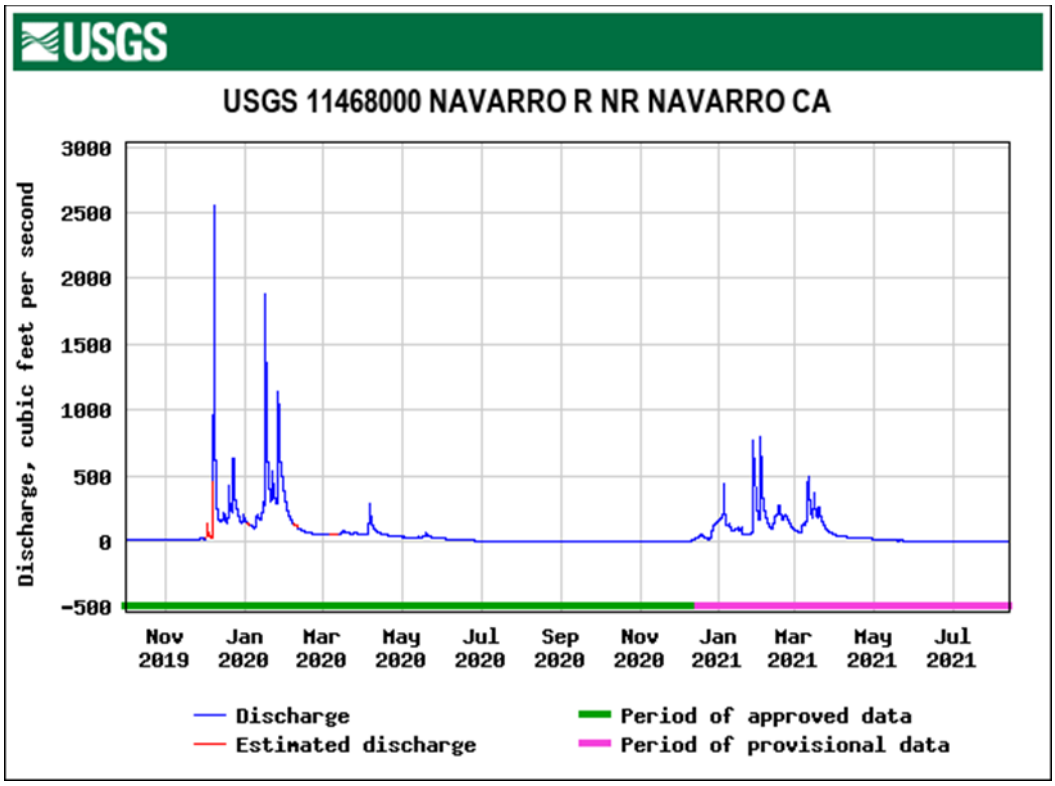
A12. Drought classification between 2008 and 2021 within the Big-Navarro-Garcia watershed areas Source US Drought Monitor. https://droughtmonitor.unl.edu/NADM/Home.aspx

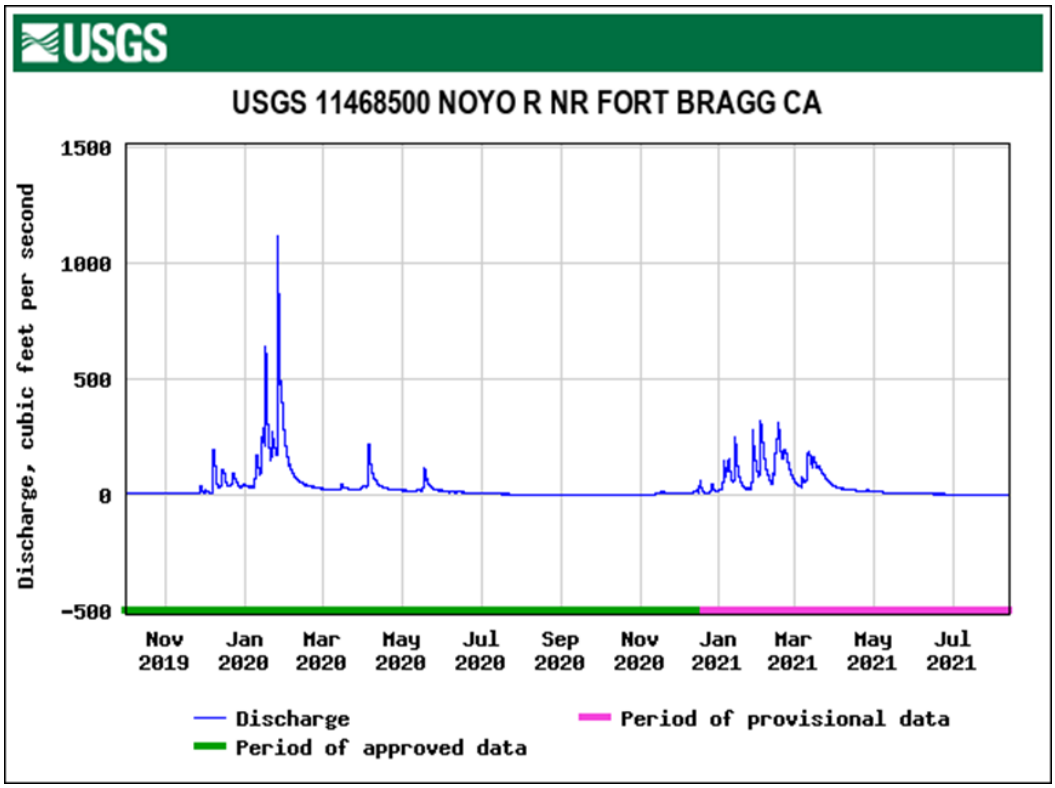






A13. Mean monthly average flow in the Navarro River and Noyo River in water years (WY) 2020 and 2021, compared to historical average.





A14. Flows at Noyo River and Navarro River from October 2019-July 2021.

A15. Steelhead redd and adult abundance estimates in coastal Mendocino County, 2015–2016 through 2016–2017. Mendocino Coast is the regional estimate from GRTS order. DS= diversity stratum. Basin-wide estimates include their respective life cycle monitoring (LCM) station or tributary estimate. South Fork Noyo River is upstream of the Noyo Egg Collecting Station (ECS). Blank spaces are no data or not sampled. Confidence intervals are not provided for individual watersheds if too few reaches were sampled.

Spawning year	2015-2016				2016-2017			
Steelhead Population	Adult	(95% CI)	Redd	(95% CI)	Adult	(95% CI)	Redd	(95% CI)
Mendocino Coast	1720	(1187–2492)	2634	(1830–3438)	1731	(931–2803)	1546	(905–2187)
North-Central Coastal DS	1084	(674–1652)	1659	(1039–2279)	1070	(498–1830)	956	(484–1428)
Usal Creek					37		36	
Cottaneva Creek	11		19					
Juan Creek								
DeHaven Creek								
Wages Creek								
Ten Mile River	207	(125–320)	317	(192–442)	568	(315–907)	507	(306–708)
South Fork Ten Mile River								
Pudding Creek	7	(2–10)	63	(56–70)	72	(60–91)	93	(84–102)
Noyo River	318	(49–652)	487	(75–899)	338	(176–640)	203	(119–320)
South Fork Noyo River	19		63	(57–69)	85	(71–108)	51	(48–54)
Hare Creek								
Caspar Creek	9	(8–11)	34	(20–49)	23	(19–29)	18	(15–22)
Big River	270	(91–497)	413	(140–686)	233	(102–406)	208	(99–317)
Little River	12	(10–28)	19	(16–38)	1	(1–1)	1	(1–1)
Albion River	50	(14–104)	77	(21–143)	0		0	
Big Salmon Creek								
Central Coastal DS	686	(273–1220)	1051	(420–1682)	661	(85–1406)	590	(83–1097)
Navarro River	239	(12–627)	366	(19–865)	188	(152–252)	248	(231–275)
North Fork Navarro River	185	(153–233)	317	(289–345)	183	(151–231)	241	(230–252)
Greenwood Creek								
Elk Creek								
Alder Creek								
Brush Creek	7		11					
Garcia River	240	(128–390)	368	(198–538)	166	(29–383)	148	(28–299)
Schooner Gulch								

A16. Steelhead redd and adult abundance estimates in coastal Mendocino County, 2017–2018 through 2018–2019. Mendocino Coast is the regional estimate from GRTS order. DS= diversity stratum. Basin-wide estimates include their respective life cycle monitoring (LCM) station or tributary estimate. South Fork Noyo River is upstream of the Noyo Egg Collecting Station (ECS). Blank spaces are no data or not sampled. Confidence intervals are not provided for individual watersheds if too few reaches were sampled.

Spawning year	2017-2018				2018-2019			
Steelhead Population	Adult	(95% CI)	Redd	(95% CI)	Adult	(95% CI)	Redd	(95% CI)
Mendocino Coast	4825	(2778–13803)	3896	(2929–4863)				
North-Central Coastal DS	3445	(1909–10082)	2782	(2012–3552)				
Usal Creek	297		269					
Cottaneva Creek								
Juan Creek	31		28					
DeHaven Creek								
Wages Creek								
Ten Mile River	777	(508–1179)	552	(421–683)	201	(47–788)	394	(166–622)
South Fork Ten Mile River	169	(140–214)	120	(116–124)				
Pudding Creek	46	(18–577)	154	(144–164)	60	(27–392)	138	(122–154)
Noyo River	987	(297–5038)	650	(363–937)	632	(70–1748)	870	(563–1177)
South Fork Noyo River	123	(63–457)	81	(77–85)	93	(15–202)	128	(120–136)
Hare Creek								
Caspar Creek	64	(53–81)	63	(57–69)	26	(22–33)	117	(105–129)
Big River	737	(360–2302)	595	(379–811)				
Little River	29	(15–110)	15	(9–46)	13	(11–24)	19	(18–31)
Albion River	53	(21–275)	43	(22–97)				
Big Salmon Creek	0		0					
Central Coastal DS	1412	(512–4939)	1140	(540–1740)				
Navarro River	1013	(630–1587)	519	(379–662)				
North Fork Navarro River	726	(600–918)	372	(361–383)	234	(194–297)	354	(329–379)
Greenwood Creek	36		33					
Elk Creek								
Alder Creek								
Brush Creek	0		0					
Garcia River	518	(160–1893)	418	(169–667)				
Schooner Gulch								

A15 Chinook salmon redd and adult abundance estimates in coastal Mendocino County, 2015–2016 through 2018–2019. Mendocino Coast is the regional estimate from GRTS order. DS= diversity stratum. Blank spaces are no data or not sampled. Confidence intervals are not provided for individual watersheds if too few reaches were sampled.

Spawning year	**2015-2016**		**2016-2017**	
Chinoook Salmon Population	Adult (95% CI)	Redd (95% CI)	Adult (95% CI)	Redd (95% CI)
Mendocino Coast	238 (48–610)	95 (19–244)	858 (185–1530)	343 (74–612)
North-Central Coastal Diversity Stratum	50 (8–143)	20 (3–57)	728 (105–1455)	291 (42–582)
Ten Mile River	23 (8–60)	9 (3–24)	662 (210–1115)	265 (84–446)
Noyo River	0	0	28 (13–60)	11 (5–24)
Big River	0	0	0	0
Albion River	0	0	0	0
Central Coastal Diversity Stratum	178 (5–195)	71 (16–174)	165 (30–348)	66 (12–139)
Navarro River	0	0	0	0
Garcia River	125 (35–240)	50 (14–96)	148 (40–308)	59 (16–123)

Spawning year	**2017-2018**		**2018-2019**	
Chinoook Salmon Population	Adult (95% CI)	Redd (95% CI)	Adult (95% CI)	Redd (95% CI)
Mendocino Coast	138 (20–290)	55 (8–116)		
North-Central Coastal Diversity Stratum	115 (15–278)	46 (6–111)		
Ten Mile River	183 (65–300)	73 (26–120)	40 (5–100)	16 (2–40)
Noyo River	0	0	10 (3–28)	4 (1–11)
Big River	0	0		
Albion River	0	0		
Central Coastal Diversity Stratum	28 (5–88)	11 (2–35)		
Navarro River	0	0		
Garcia River	113 (28–338)	45 (11–135)		