U.S. Fish & Wildlife Service

Arcata Fisheries Data Series Report DS 2026-79

Mainstem Trinity River Chinook Salmon Spawning Survey, 2020-2023

Stephen A. Gough[1], Taylor T. Daley[1], Zac Reinstein[2], Alex Eaton[3], and Brian Krempasky[4]

U.S. Fish and Wildlife Service [1]
Arcata Fish and Wildlife Office
Arcata, California 95521
(707) 822-7201

Yurok Tribal Fisheries Program [2]
Willow Creek, California 95573
(530) 629-3333

Hoopa Valley Tribal Fisheries Department [3]
Hoopa, California 95546
(530) 625-4267

California Department of Fish and Wildlife [4]
Weaverville, California 96093
(530) 623-4016

May 2026

Arcata Fish and Wildlife Office participation in this study was funded by the U.S. Fish and Wildlife Service. Participation of the Yurok Tribal Fisheries Program, Hoopa Valley Tribal Fisheries Department, and California Department of Fish and Wildlife was funded by the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service. Shasta–Trinity National Forest participation was funded by the U.S. Forest Service.

The Arcata Fish and Wildlife Office Fish and Aquatic Conservation Program reports its study findings through two publication series. The **Arcata Fisheries Data Series** was established to provide timely dissemination of data to local managers and for inclusion in agency/tribal databases. **Arcata Fisheries Technical Series** publish scientific findings from single and multi-year studies that have undergone more extensive peer review and statistical testing. Additionally, some study results are published in a variety of professional journals. To ensure consistency with Service policy relating to its online peer-reviewed journals, Arcata Fisheries Data Series and Technical Reports are now completely electronic and made available in the public domain. Paper copies are no longer distributed.

key words: carcass, Chinook Salmon, escapement, hatchery, pre-spawn mortality, redd, restoration, Trinity River

The correct citation for this report is:

Gough, S. A., T. T. Daley, Z. Reinstein, A. Eaton, and B. Krempasky. 2026. Mainstem Trinity River Chinook Salmon Spawning Survey, 2020-2023. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2026–79, Arcata, California.

Table of Contents

List of Tables

page

List of Figures

page

List of Appendices

Mainstem Trinity River Chinook Salmon Spawning Survey, 2020-2023

Stephen A. Gough[1], Taylor T. Daley[1], Zac Reinstein[2], Alex Eaton[3], and Brian Krempasky[4]

[1] *U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office*
1655 Heindon Road, Arcata, California 95521
steve_gough@fws.gov
taylor_daley@fws.gov

[2] *Yurok Tribal Fisheries Program*
P.O. Box 36, Willow Creek, California 95573
zreinstein@yuroktribe.nsn.us

[3] *Hoopa Valley Tribal Fisheries Department*
P.O. Box 417, Hoopa, California 95546
alex.eaton@hoopa-nsn.gov

[4] *California Department of Fish and Wildlife*
80 Nugget Lane, Suite A, Weaverville, California 96093
brian.krempasky@wildlife.ca.gov

Abstract.— Salmon redds and carcasses were surveyed on the mainstem Trinity River, California from Lewiston Dam to the confluence with the Klamath River, during the 2020–2023 spawning seasons to map spawning abundance and distribution, evaluate pre-spawn mortality, and characterize redds by species and spawner origin. These surveys supplemented data that has been collected annually since 2002. Total redd counts were 1,739 in 2020, 1,991 in 2021, 4,203 in 2022, and 3,911 in 2023. Generalized additive models were applied to the spatiotemporal distribution of unmarked and hatchery-marked spawned female salmon carcasses to apportion redd counts by natural- and hatchery-origin Chinook Salmon *Oncorhynchus tshawytscha* and Coho Salmon *O. kisutch*. This methodology only allows for the partitioning of redds constructed by hatchery- and natural-produced female fish. In 2020, an estimated 1,296 redds were constructed by natural-origin Chinook Salmon, 337 by hatchery-origin Chinook Salmon, and 106 were attributed to Coho Salmon. In 2021, an estimated that 1,340 redds were constructed by natural-origin Chinook Salmon, 596 by hatchery-origin Chinook Salmon, and 55 were attributed to Coho Salmon. In 2022, an estimated that 3,725 redds were constructed by natural-origin Chinook Salmon, 357 by hatchery-origin Chinook Salmon, and 121 were attributed to Coho Salmon. In 2023, an estimated that 3,323 redds were constructed by natural-origin Chinook Salmon, 463 by hatchery-origin Chinook Salmon, and 125 were attributed to Coho Salmon. Each year, natural-origin Chinook

Salmon spawned throughout the mainstem river while the distribution of redds constructed by hatchery-origin Chinook Salmon was highly skewed toward Lewiston Dam and the Trinity River Hatchery; between 83.7% and 100.0% of hatchery-origin spawned female carcasses were found annually within 7 km of the dam from 2020 to 2023. Pre-spawn mortality of female Chinook Salmon ranged between 0.9% and 3.1% annually for carcasses in all reaches and between 0.0% and 3.0% within an intensively managed 'restoration reach', which is a focal area for habitat restoration improvements being implemented by the Trinity River Restoration Program (TRRP). Long-term trend analyses from 2002 to 2023 showed no significant change in the abundance of natural-origin Chinook Salmon redds constructed in the mainstem Trinity River, while the number of hatchery-origin Chinook Salmon redds decreased. The annual proportion of total natural-origin Chinook Salmon redds decreased in the reach immediately downstream of Lewiston Dam and increased in some mid-river reaches from 2002 to 2023. The annual proportion of hatchery-origin Chinook Salmon redds, which were almost completely within the two reaches nearest to Lewiston Dam, also decreased in the reach immediately downstream of the dam and increased in the following reach over this time period.

Introduction

The Trinity River once supported large populations of naturally produced anadromous salmonids, including spring- and fall-run Chinook Salmon *Oncorhynchus tshawytscha* (USFWS and HVT 1999). Prior to the construction of Trinity and Lewiston dams, the spawning of spring- and fall-run Chinook Salmon was separated temporally and spatially due to the timing of adult upstream migration of each race and the hydrology of the river. In 1940s, Moffett and Smith (1950) noted that "almost without exception, Trinity River salmon migrating above the South Fork spawn in the 72 miles of river between the North Fork and Ramshorn Creek."

Following construction of Lewiston Dam [river kilometer (rkm) 182.2], spring- and fall-run Chinook Salmon spawning in the mainstem Trinity River exhibited considerable spatial and temporal overlap due to lack of access to historic spawning areas for the spring-run. High redd densities became frequent within the upper-most portions of the river below the dam, where presumably hatchery-origin salmon and their progeny comingled and spawned with naturally produced fish. Trinity River Hatchery (TRH), located at the base of Lewiston Dam, is operated to mitigate for the loss of Chinook Salmon, Coho Salmon *O. kisutch*, and steelhead *O. mykiss* production upstream of the dam. Rogers (1972) documented that in 1970 more than 50% of Chinook Salmon spawned in the two miles (3.2 km) below Lewiston Dam and 80% spawned above Douglas City (around rkm 150.1). Redd surveys in the 1980s and 1990s between North Fork Trinity River (rkm 118.2) and Cedar Flat (rkm 79.1) documented variable spawning use in these reaches, with redd counts ranging from a low of 187 in 1998 to a high of 928 redds in 1997 (USFWS 1986, 1987; Quihillalt 1999). Chamberlain et al. (2012) noted that the mean distance from Lewiston Dam of natural-origin Chinook Salmon redds upstream of Cedar Flat increased from 2002 to 2011. Rupert et al. (2017a) noted that when the mainstem Trinity River was divided into reach-scale sections, natural-origin Chinook Salmon spawning activity decreased near Lewiston Dam and increased in the mid-river sections of the river.

To restore the fishery resources of the Trinity River, the Secretary of the Interior signed the Trinity River Mainstem Fishery Restoration Record of Decision (ROD) in 2000 (USDOI 2000) and the Trinity River Restoration Program (TRRP) was established. The goal of the TRRP is to:

> "…restore and sustain natural production of anadromous fish populations downstream of Lewiston Dam to pre-dam levels, to facilitate dependent tribal, commercial, and sport fisheries' full participation in the benefits of restoration via enhanced harvest opportunities" (TRRP and ESSA 2009).

To achieve this goal, the TRRP implements a suite of actions (flow management, mechanical channel rehabilitation, coarse sediment augmentation, and watershed restoration) to restore riverine habitats and restore habitat-creating alluvial processes (USFWS and HVT 1999; USDOI 2000). Collectively, these actions are intended to increase and maintain salmonid habitats in the 64-km section of the Trinity River from Lewiston Dam downstream to the North Fork Trinity River (restoration reach), which was severely degraded due to the operation of the Trinity River Division (TRD) of the Central Valley Project and other historical anthropogenic impacts. Downstream of the North Fork Trinity River, valley narrowing and accretions of flow and sediment from tributaries attenuate many of the morphological impacts that have occurred in the restoration reach (USFWS and HVT 1999).

The Integrated Assessment Plan (IAP; TRRP and ESSA 2009) sets forth a list of objectives to evaluate the effectiveness of TRRP restoration actions. Salmon spawning surveys are performed to provide data to address Objective 3, specifically sub-objectives 3.1 and 3.3:

> **Objective 3**: Restore and maintain natural production of anadromous fish populations.
>
> > **Sub-objective 3.1**: Increase spawning, incubation, and emergence success of anadromous spawners.
> >
> > **Sub-objective 3.3**: Minimize impacts of predation and genetic interactions between and among hatchery and natural anadromous fish.

The IAP proposes assessing spawning at three spatial scales: system, reach, and site scales. Each of these spatial scales evaluates the effects of restoration efforts on Chinook Salmon spawning at different resolutions. System-scale analysis evaluates the response to all restoration activities combined over time. Reach-scale analysis evaluates the response to management actions within sections of the river that have unique hydrology and sediment supplies. Finally, site-scale analysis provides insight on changes in spawning distribution/abundance within restoration sites and the localized effects of mechanical channel rehabilitation. The IAP also states that "increased spawner success will likely occur within 3–4 brood cycles following completion of channel rehabilitation and subsequent fluvial and geomorphic evolution."

This report details the results from salmon spawning survey data collected from 2020 to 2023 on the mainstem Trinity River. Data from salmon carcasses includes biological information (species, sex, spawn success, origin type, etc.) as well as the location and spawn timing of individual fish. Surveying salmon redds provides the location and spawn timing of individual redds. When analyzed together, each year's data produces a spatially and

temporally explicit set of observed redd locations with each redd having an associated probability of construction by female natural-origin Chinook Salmon, hatchery-origin Chinook Salmon, natural-origin Coho Salmon, and hatchery-origin Coho Salmon. We define 'hatchery-origin' as fish produced and released from Trinity River Hatchery (TRH), and 'natural-origin' as fish that emerge from a redd, regardless of parental origin. These data sets facilitate an array of analyses over a range of spatial and temporal scales, which we use to investigate spawning distribution and abundance. Where applicable, we use the performance measures set forth by the IAP to evaluate changes in spawning as responses to the restoration actions of the TRRP.

Methods

Survey Area and Timing

The Trinity River from Lewiston Dam to its confluence with the Klamath River was delineated into 14 survey reaches ranging in length from 3.3 to 21.3 km (Figure 1, Table 1). Reach breaks were based on river access locations and channel distances that could be surveyed in a day. Two whitewater sections were not surveyed: the 9.7-km Pigeon Point run (Reach 8) and the 15.6-km section that includes the Burnt Ranch Gorge (Reach 11). In 2016, the boundary separating Reaches 5 and 6 was moved from Roundhouse (rkm 135.7) to Evan's Bar (rkm 137.4) because of a change in private landowner permission to use their river access.

Throughout the Chinook Salmon spawning period, from September into December each year, Reaches 1–7 were scheduled to be surveyed weekly and Reaches 9–14 (excluding Reach 11) were scheduled for surveys every other week for salmon carcasses and redds as described in Rupert et al. (2017a). This period was intended to encompass the majority of Chinook Salmon spawning activity.

Redd Identification

Chinook and Coho salmon spawning periods temporally overlap and natural- and hatchery-origin salmon spawn in the same areas in the mainstem Trinity River. Given that redds are not visually distinguishable by these species and origin types, the estimated proportion and spatial distribution of fresh female carcasses of hatchery- and natural-origin Chinook and Coho salmon were used to infer the probability of redd construction by species and origin. Since only female carcasses are used in the hatchery–natural analysis, the estimates of redds constructed by natural-origin females do not account for hatchery-produced males spawning with naturally produced females. Therefore, these estimates should be considered maximum values of natural-origin spawning when not accounting for the hatchery–natural interaction. Generalized Additive Models (GAM) were used with the spatiotemporal distribution of carcasses to estimate the longitudinal gradient in proportional distribution of spawned females by species (Chinook or Coho salmon) and origin (hatchery or natural) along the river channel and over time (Rupert et al. 2017a). Cumulative redd counts were arranged by survey day within reach boundaries and season total estimates of redds by species and origin were calculated by summing predicted probabilities of construction for each species–origin category (Rupert et al. 2017a).

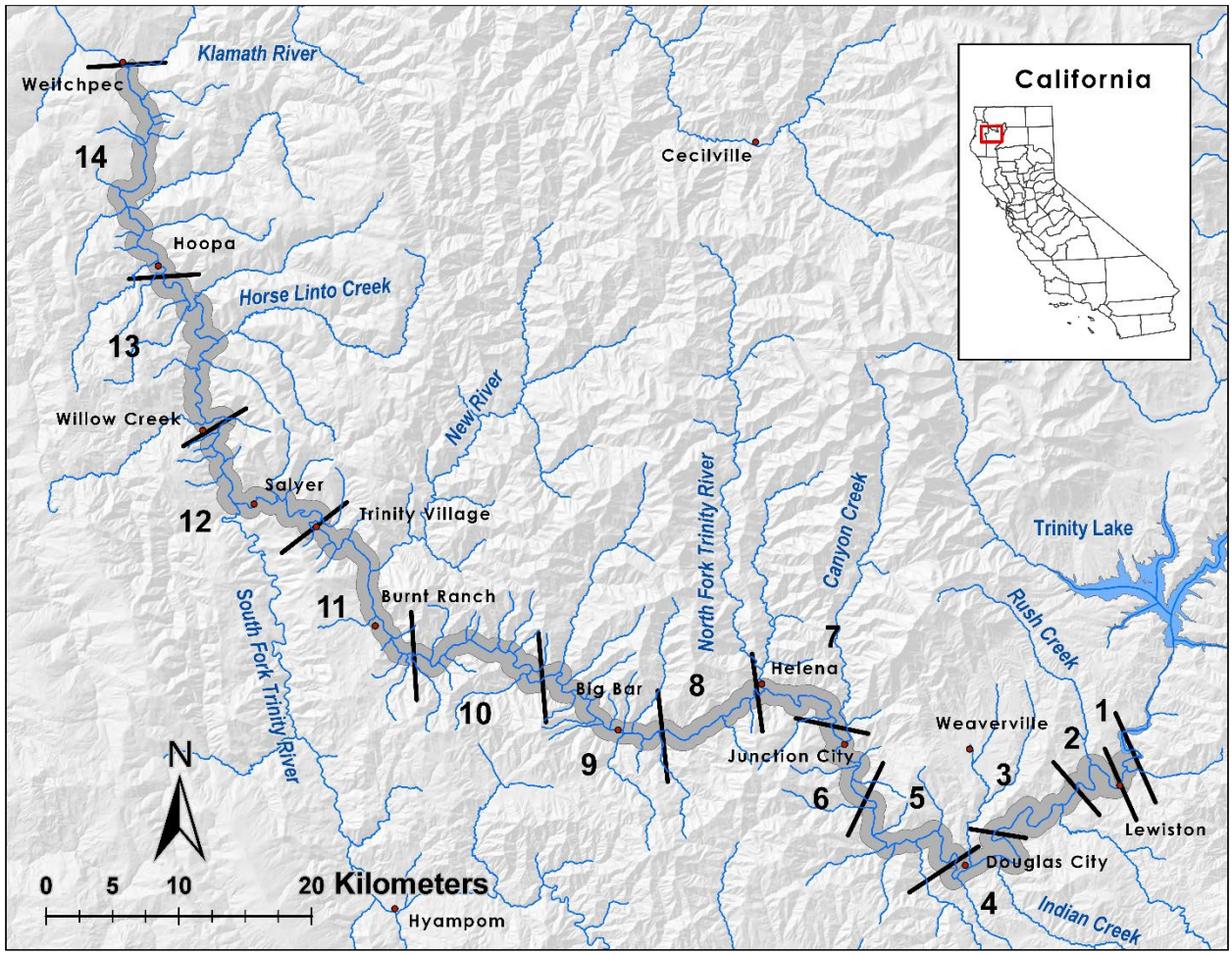


Figure 1. Survey Reaches 1–14 (Lewiston Dam to Weitchpec) on the mainstem Trinity River. Dangerous whitewater conditions precluded surveys in Reaches 8 and 11.

Carcasses Estimation

Carcass abundance estimates for Reaches 1 and 2 were generated via a hierarchical latent variables model as described in Rupert et al. (2017a). This model assumes a latent (unobservable) ecological process interacts with a detection process to produce the observed counts of carcasses (Kery and Schaub 2012). For this survey, the latent process is the true abundance of carcasses. As not all carcasses are observed (imperfect detection), a separate observation process links the unobserved latent process to the observed data. In essence, annual carcass estimates were generated by first estimating weekly detection probabilities. Next, weekly counts of fresh carcasses (those arriving since the prior survey) were assumed to arise from a binomial process, which allows the estimation of weekly abundances. Finally, weekly estimates were summed to create an annual abundance estimate as a derived parameter.

Table 1. Reach boundaries [and river kilometer (rkm)] for the mainstem Trinity River salmon spawning surveys. Agencies involved in data collection include California Department of Fish and Wildlife (CDFW), Shasta–Trinity National Forest (USFS), U.S. Fish and Wildlife Service (USFWS), Yurok Tribal Fisheries Program (YTFP), and Hoopa Valley Tribal Fisheries Department (HVT).

Reach	Boundaries		Surveying agency
	Upstream	Downstream (rkm)	
1	Lewiston Dam (rkm 182.2) [a]	Old Lewiston Bridge (178.7)	CDFW, YTFP
2	Old Lewiston Bridge	Bucktail River Access (171.6)	CDFW, YTFP
3	Bucktail River Access	Steel Bridge River Access (160.7)	CDFW, YTFP
4	Steel Bridge River Access	Douglas City Campground (150.1)	CDFW, YTFP
5	Douglas City Campground	Evan's Bar (137.4) [b]	CDFW, YTFP
6	Evan's Bar [b]	Junction City Campground (127.1)	USFWS, HVT
7	Junction City Campground	Pigeon Point Campground [c] (117.4)	USFWS, HVT
8	Pigeon Point Campground [c]	Big Flat River Access (107.6)	Not surveyed
9	Big Flat River Access	Del Loma River Access (93.8)	USFWS, HVT
10	Del Loma River Access	Cedar Flat River Access (79.1)	USFWS, HVT
11	Cedar Flat River Access	Hawkins Bar (63.4)	Not surveyed
12	Hawkins Bar	Camp Kimtu in Willow Creek (42.6)	USFWS, HVT
13	Camp Kimtu in Willow Creek	Roland's Bar in Hoopa Valley (21.3)	USFWS, HVT
14	Roland's Bar in Hoopa Valley	Weitchpec (Trinity mouth; 0.0)	USFWS, HVT

[a] The spillway and pool directly downstream of Lewiston Dam was not surveyed and presumed to have no redds.

[b] In 2015 and earlier the river access separating Reaches 5 and 6 was at Roundhouse (rkm 135.7).

[c] Pigeon Point Campground access is 0.8 km downstream of the North Fork Trinity River confluence (rkm 118.2). The primary area where Trinity River Restoration Program actively manages to improve channel morphology and salmon habitat are in Reaches 1–7.

Pre-Spawn Mortality

Fresh carcasses were described as spawned (≤1/3 eggs retained), partially spawned (1/3–2/3 eggs retained), or unspawned (≥2/3 eggs retained). These spawning condition data were used to assess levels of pre-spawn mortality. Female carcasses designated as 'spawned' and 'partially spawned' were considered successful spawners. Unspawned carcasses were considered pre-spawn mortalities. Measurement of pre-spawn mortality is limited to occurrence within the time and space of the surveys. Therefore, pre-spawn mortality in the lower Klamath River of Trinity River-bound fish and pre-spawn mortality of spring-run Chinook Salmon prior to the first survey are not reflected in our data and analyses.

Redd–Carcass Relationship

Spawning density was hypothesized to affect the crews' ability to observe redds and carcasses with equal efficiency, especially in the high spawning density areas of Reaches 1 and 2 (Bradford and Hankin 2012). This hypothesis would be supported if the number of redds surveyed in an area was not proportional to the number of spawned female carcasses found in that same area. To determine if this occurred, the estimates of spawned female Chinook Salmon carcasses were compared with corresponding counts of Chinook Salmon redds from Reaches 1 and 2. These values were log-transformed and analyzed using linear regression. These two variables would be considered proportional if the slope of their linear relationship was not significantly different than '1'. A slope that is significantly different than '1' would indicate that these variables are not proportional and some density-dependent observer error could be inferred.

Trends in Redd Abundance and Distribution

Data from 2020 to 2023 were combined with the preceding eighteen years (2002–2019) of mainstem Trinity River redd data from Chamberlain et al. (2012), Rupert et al. (2017a, 2017b), Gough et al. (2019, 2021a, 2021b) for long-term analyses of redd abundance and distribution. Past years' data availability was sometimes limited since not all variables analyzed were previously collected (i.e., spatially explicit redd data are not available for Reaches 12–14 prior to 2007). Redd abundance and distribution were analyzed at three spatial scales: the system (~50–100 km sections), reach (~10–20 km sections), and site (~1–2 km sections) scales.

Changes in redd abundance and distribution at the system scale were evaluated over the entire mainstem as well as separately for the restoration reach (Reaches 1–7) and remaining surveyed river downstream of the restoration reach (Reaches 9–10 and 12–14). Linear models were used to detect trends in redd abundance. Mean distance from Lewiston Dam of natural- and hatchery-origin Chinook Salmon redds built upstream of Cedar Flat were evaluated using linear regression models.

Ten reach-scale sections were used to evaluate long-term trends in natural- and hatchery-origin Chinook Salmon redd abundance (Figure 2, Table 2). These reaches consisted of groups of sites and were intended to evaluate redd abundance at a spatial scale that was an intermediate between the system and site scales. Our reach-scale designations closely resemble those defined by HVT et al. (2011), who partitioned the restoration reach into five 'rehabilitation reaches' that were delineated by differences in hydrology and sediment supply characteristics. Boundaries of the other five river sections downstream of the

restoration reach were set similarly. Changes in spawning abundance within these reaches were analyzed using linear regression analyses of both the annual number and proportion (number of redds in reach / sum of redds in all reaches) of natural- and hatchery-origin Chinook Salmon redds.

For finer resolution spatial analyses, the river was partitioned into individual segments based on morphology referred to as 'riffle units' (Rupert et al. 2017b). A riffle unit is defined as a section of river that corresponds to a singular pool–riffle–pool sequence that typically ranges between 0.1 and 0.5 km in length. These units were delineated by this sequence for redd abundance analyses because Chinook Salmon typically build redds in patches proximate to riffle crests. Therefore, riffle units generally contain an undivided group of redds. Riffle unit designations were based on the 'morphological units' delineated by Gaeuman et al. (2016). Where Gaeuman et al. (2016) used hydraulic controls (i.e., riffles) to delineate morphological units, the deepest locations (i.e., pools) between these hydraulic controls were used to split riffle units. As a result, the morphological units from Gaeuman et al. (2016) were shifted slightly upstream. Aerial photography was used to construct riffle units downstream of the restoration reach (excluding Reaches 8 and 11) because the morphological units developed by Gaeuman et al. (2016) were limited to the restoration reach. In total, the mainstem Trinity River was divided into 482 riffle units.

Contiguous groups of riffle units were combined to create the sections used for the site-scale analysis (Table 3). Site designations in this report are generally based on the TRRP site designations of the SAB units (Buffington et al. 2014). However, the total count of site-scale units was reduced from 57 to 44 by merging the smallest site-scale sections of the SAB dataframe into the most appropriate adjacent site-scale sections. This spatial scale was used to evaluate changes in natural- and hatchery-origin Chinook Salmon redd abundance at a scale similar to TRRP restoration sites or suites of sites. Changes in spawning abundance within these sites was analyzed using linear regression of the annual proportion (number of redds in the site / sum of redds in the restoration reach) of redds.

The riffle unit method described in this report refers to the method used for partitioning the river in Rupert et al. (2017b). In Rupert et al. (2017a), the smallest spatial units were based on contiguous 400-m (and occasionally 200-m) sections of the Science Advisory Board dataframe (SAB units; Buffington et al. 2014). This change in methodology is an improvement over that used in Rupert et al. (2017a) because redd groupings are no longer split and the three spatial scale sections better reflect local spawning habitat and TRRP channel rehabilitation sites or suites of sites. The upstream and downstream site-, reach-, and system-scale section boundaries changed slightly as a result to reflect the newer riffle unit divisions. The complete 2002–2023 data set was analyzed using the newer riffle unit-based divisions at each spatial scale.

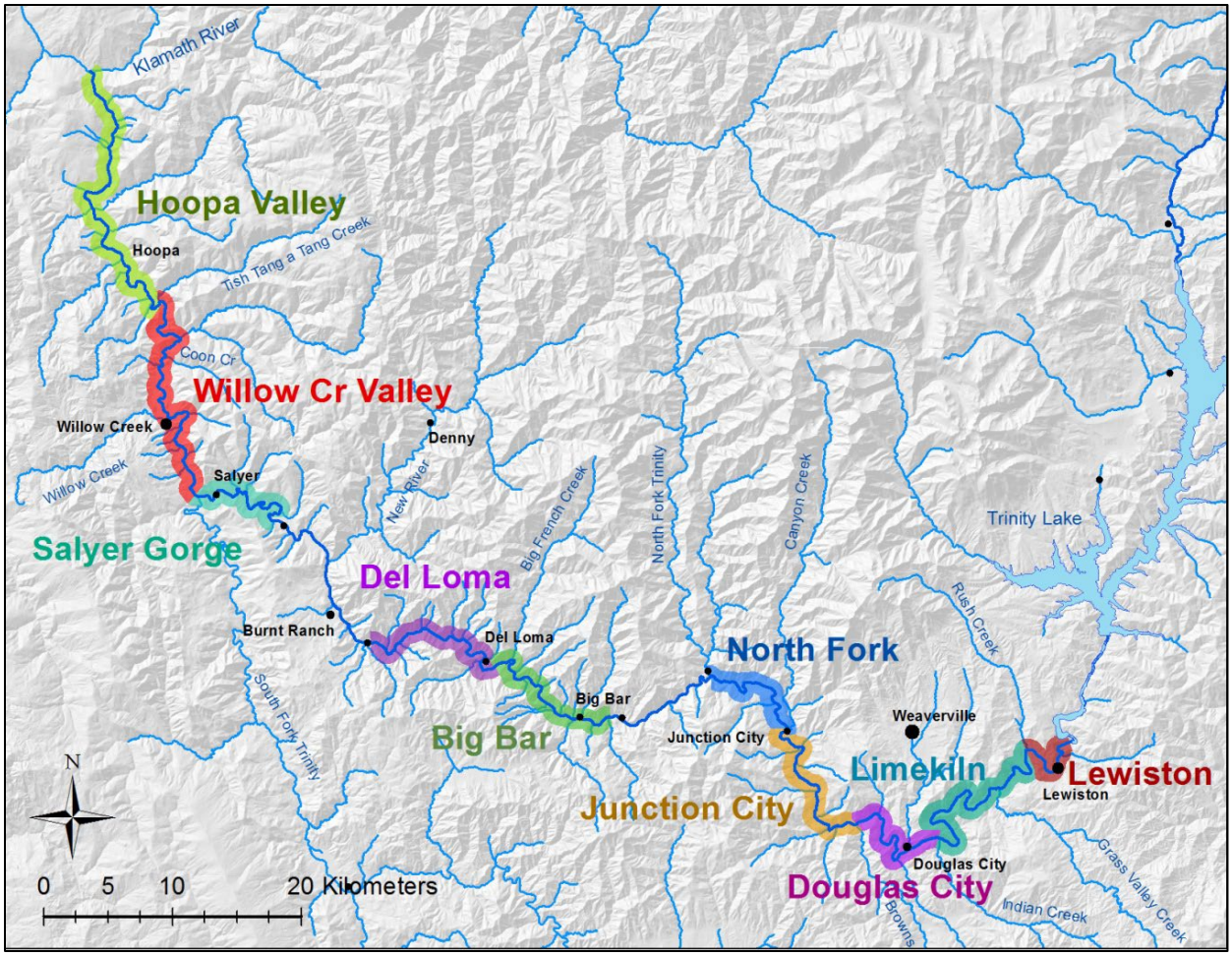


Figure 2. The ten sections of the mainstem Trinity River used for reach-scale analyses of Chinook Salmon redd distribution.

Table 2. River sections [with river kilometer (rkm)] used for the reach-scale analysis of redd abundance.

Section	Boundaries		Length (km)
	Upstream (rkm)	Downstream (rkm)	
Lewiston Rehab	Lewiston Dam (182.20)	Rush Creek (175.41)	6.79
Limekiln Rehab	Rush Creek	Indian Creek (155.42)	19.99
Douglas City Rehab	Indian Creek	Browns Creek (143.18)	12.25
Junction City Rehab	Browns Creek	Canyon Creek (129.34)	13.84
North Fork Rehab	Canyon Creek	North Fork Trinity River (117.40)	11.94
Big Bar	Big Flat access riffle unit (107.82)	Del Loma access riffle unit (94.03)	13.79
Del Loma	Del Loma access riffle unit	Cedar Flat access riffle unit (79.31)	14.72
Salyer Gorge	Hawkins Bar river access (63.76)	South Fork Trinity River (50.33)	13.41
Willow Creek Valley	South Fork Trinity River	Tish Tang a Tang Creek (26.95)	23.40
Hoopa Valley	Tish Tang a Tang Creek	Weitchpec (Trinity River mouth; 0.0)	26.95

Table 3. The reach- and site-scale sections used for redd abundance and distribution analysis within the restoration reach. Sites are listed with the approximate location of their upstream boundary, shown as distance from the Klamath River confluence (rkm).

Reach	Site (rkm)	TRRP Rehabilitation	Length (km)
Lewiston	Hatchery (182.20)	2006	0.69
	Sven Olbertson (181.51)	2008	1.28
	Old Bridge (180.22)	2008	1.75
	Sawmill (178.47)	2009	1.60
	Upper Rush Creek (176.87)		1.46
Limekiln	Lower Rush Creek (175.41)		1.33
	Dark Gulch (174.08)	2008	2.81
	Lowden Ranch (171.27)	2010	1.73
	Trinity House Gulch (169.54)	2010	0.72
	Tom Lang Gulch (168.82)		1.48
	Poker Bar (167.34)		2.30
	China Gulch (165.05)		1.47
	Limekiln Gulch (163.57)	2015	2.38
	Steel Bridge (161.20)		1.67
	McIntyre Gulch (159.53)		1.53
	Vitzthum Gulch (158.00)	2007	2.02
	Upper Indian Creek (155.98)	2007	0.56
Douglas City	Lower Indian Creek (155.42)	2007	1.52
	Upper Douglas City (153.90)	2007, 2015	0.83
	Douglas City (153.07)	2013	1.30
	Reading Creek (151.77)	2010	1.77
	Upper Steiner Flat (150.00)		1.26
	Lower Steiner Flat (148.74)	2012	1.90
	Lorenz Gulch (146.83)	2013	1.49
	The Canyon (upstream) (145.34)		2.17
Junction City	The Canyon (downstream) (143.18)		2.23
	Dutch Creek (140.95)		2.56
	Evan's Bar (138.38)		1.28
	Soldier Creek (137.11)		0.89
	Chapman Ranch (136.22)		1.10
	Deep Gulch (135.13)		1.11
	Sheridan Creek (134.02)		1.15
	Oregon Gulch (132.87)		0.76
	Sky Ranch (132.12)		1.20
	Upper Junction City (130.91)	2012	0.89
	Lower Junction City (130.01)	2014	0.67
North Fork	Hocker Flat (129.34)	2005	1.88
	Upper Conner Creek (127.46)		1.12
	Conner Creek (126.34)	2006	1.71
	Wheel Gulch (124.63)	2011	1.05
	Valdor Gulch (123.58)	2006	1.84
	Elkhorn (121.74)	2006	1.50
	Pear Tree Gulch (120.24)	2006	1.33
	Bagdad (118.92) [a]		1.52

[a] the downstream boundary of the Bagdad site was at rkm 117.4

Results

Survey Success and Conditions

Surveys were conducted from September 8 to December 10 in 2020, September 13 to December 7 in 2021, September 6 to December 19 in 2022, and September 5 to December 20 in 2023. Crews were able to complete 71% of the originally scheduled surveys in 2020, 65% in 2021, 84% in 2022, and 91% in 2023 (Appendix A). The start of surveys in 2020 and 2021 were delayed by one and two weeks, respectively, due to active nearby wildfires which caused dangerous and unhealthy smoke conditions and river access restrictions. Surveys these two years also concluded one week earlier than planned due to Covid concerns in 2020 and reduced water clarity following rain events in 2021. Few, if any, carcasses and redds were likely missed because of the delayed start and early ending. Additionally in 2021, several surveys in Reach 9 and below were cancelled throughout the survey period due to elevated turbidity. Also in 2021, Reach 1 was only surveyed for carcasses beginning in November when redds became indistinguishable over a section of recently augmented gravel.

In 2020, 2021, and 2023, September began with mainstem Trinity River mean daily discharge at Lewiston at or near 13 m^3/s, the summer base flow. Discharge at Lewiston was increased for one week beginning September 12 in 2020 and September 2 in 2021 for the Hoopa Valley Tribe's ceremonial Boat Dance during which they peaked at 30.6 m^3/s and 74.8 m^3/s, respectively (Appendix B). September in 2022 began with discharge at Lewiston around 27.0 m^3/s amid a 3-week preventative baseflow increase to ameliorate hostile conditions for fall-run Chinook Salmon in the lower Klamath River. Following these flow events each year, discharge returned to summer base flows until mid-October when discharge dropped to around 8.5 m^3/s (i.e., winter base flow) for the remainder of the survey season.

Mean daily discharge at Hoopa, California was mostly stable throughout most of the spawning period while surveys were conducted in 2020, 2022, and 2023 but more variable in 2021. In 2020, discharge ranged between 13.3 m^3/s and 18.6 m^3/s from September through early December except for rain events in mid-September and mid-November that increased flows to 33.7 m^3/s and 43.3 m^3/s, respectively. In 2021, discharge ranged between 15.5 m^3/s and 20.0 m^3/s from September through early December except for rain events in early September, late October, and early November that increased flows to 74.5 m^3/s, 244.9 m^3/s, and 143.0 m^3/s, respectively. In 2022, discharge ranged between 13.3 m^3/s and 37.9 m^3/s from September through mid-December except for a rain event in early December that increased discharge to 85.0 m^3/s. In 2023, discharge ranged between 18.7 m^3/s and 28.3 m^3/s from September through November except for a couple rain events in November that increased flows to 49.0 m^3/s and 55.2 m^3/s. Discharge in December 2023 became more variable when multiple rain events causing discharge peaks as high as 141.6 m^3/s.

Crews reported water visibility greater than 3.0 m during most of the surveys from 2020 to 2022 and between 1.5 and 3.0 m in 2023 (Appendix A). Water clarity decreased in mid-November 2020 and late October 2021 following precipitation events but were mostly consistent throughout the 2022 and 2023 surveys.

Salmon Carcasses

During the 2020 surveys, 424 fresh (Conditions 1 and 2 as described in Rupert et al. 2017a) Chinook Salmon carcasses were examined (Table 4). Of these, 44 (10.4%) were adipose fin-clipped ('ad-clipped') and 7 (1.7%) had been marked with a spaghetti tag at the Willow Creek or Junction City weir operated by the California Department of Fish and Wildlife. The sex of the fish was identified in 422 of the fresh Chinook Salmon carcasses, and of these 232 (55.0%) were females.

During the 2021 surveys, 1,084 fresh Chinook Salmon carcasses were examined (Table 4). Of these, 141 (13.0%) were ad-clipped and 91 (8.4%) had been marked with a spaghetti tag. The sex of the fish was identified in 1,080 carcasses, and of these 612 (56.7%) were females. Chinook Salmon released from TRH in 2020 were not marked due to Covid restrictions. Therefore, hatchery-origin jacks in 2021, age-3 fish in 2022, and age-4 fish in 2023 did not have hatchery marks and were thus omitted from ad-clip observations.

During the 2022 surveys, 1,121 fresh Chinook Salmon carcasses were examined (Table 4). Of these, 41 (3.7%) were ad-clipped and 67 (6.0%) had been marked with a spaghetti tag. The sex of the fish was identified in 1,105 carcasses, of which 644 (58.3%) were females.

During the 2023 surveys, 1,401 fresh Chinook Salmon carcasses were examined (Table 4). Of these, 81 (5.8%) were ad-clipped and 78 (5.6%) had been marked with a spaghetti tag. The sex of the fish was identified in 1,393 carcasses, of which 859 (61.7%) were females.

Chinook Salmon released from the TRH are batch-marked with coded-wire tags (CWT) and ad-clipped for an external mark at a target constant fractional mark rate of 25%. From the 44 ad-clipped fresh Chinook Salmon carcasses heads that were sampled in 2020, 42 CWTs were read (Table 5). One hundred fourteen CWTs were read from 141 ad-clipped carcasses in 2021, 34 CWTs were read from 41 ad-clipped carcasses in 2022, and 69 CWTs were read from 81 ad-clipped carcasses in 2023. Data from CWT recoveries yielded an average annual marking rates of 0.254 in 2020, 0.242 in 2021, 0.242 in 2022, and 0.256 in 2023.

Of the 232 fresh female Chinook Salmon carcasses recovered in 2020, 25 (10.8%) were ad-clipped, their heads were collected, and all CWTs were recovered and read. Of the 612 fresh female Chinook Salmon carcasses recovered in 2021, 89 (14.5%) were ad-clipped and of those, 79 heads were collected and 71 CWTs were recovered and read. Of the 644 fresh female Chinook Salmon carcasses recovered in 2022, 29 (4.5%) were ad-clipped and of those, 24 heads were collected and CWTs recovered and read. Of the 859 fresh female Chinook Salmon carcasses recovered in 2023, 54 (6.3%) were ad-clipped and of those, 48 heads were collected and 44 CWTs recovered and read. Of the *spawned* female hatchery-origin Chinook Salmon carcasses (spring and fall broods combined) with associated CWT data, 92.0% (23 of 25) were recovered within 7 km of Lewiston Dam in 2020, 100.0% (67 of 67) in 2021, 91.7% (22 of 24) in 2022, and 83.7% (36 of 43) in 2023 (Figure 3).

Four fresh Coho Salmon carcasses were recovered during the 2020 surveys, 18 in 2021, 21 in 2022, and 47 in 2023 (Table 6). Of the spawned female Coho Salmon carcasses recovered, 1 of the 2 had a hatchery mark (right maxillary clip) in 2020, 7 of 9 in 2021, 10 of 13 in 2022, and all 28 in 2023. These low numbers inhibited the ability to differentiate Coho Salmon redds by origin in all four years.

Table 4. Summary of fresh (conditions 1 and 2) Chinook Salmon carcass data from the mainstem Trinity River by survey reach, 2020–2023.

2020

Reach	Total [a]	Females	Males	Female proportion	Ad-clipped	Weir-tagged
1	138	94	43	68.6%	23	3
2	146	70	76	47.9%	19	3
3	39	13	26	33.3%	0	0
4	32	13	19	40.6%	1	1
5	27	14	13	51.9%	0	0
6	22	16	6	72.7%	1	0
7	7	3	3	50.0%	0	0
9	6	3	3	50.0%	0	0
10	3	3	0	100.0%	0	0
12	0	0	0	-	0	0
13	3	2	1	66.7%	0	0
14	1	1	0	100.0%	0	0
Total	424	232	190	55.0%	44	7

[a] may includes carcass(es) of unknown sex

2021

Reach	Total [a]	Females	Males	Female proportion	Ad-clipped	Weir-tagged
1	490	355	135	72.4%	94	57
2	304	141	160	46.8%	44	21
3	112	47	65	42.0%	1	6
4	61	19	41	31.7%	0	4
5	46	21	25	45.7%	1	3
6	48	15	33	31.3%	1	0
7	13	9	4	69.2%	0	0
9	0	0	0	-	0	0
10	- [b]	-	-	-	-	-
12	3	1	2	33.3%	0	0
13	4	2	2	50.0%	0	0
14	3	2	1	66.7%	0	0
Total	1,084	612	468	56.7%	141	91

[a] may includes carcass(es) of unknown sex

[d] Reach 10 not surveyed in 2021 due to restricted access during and following nearby wildfires

Table 4 (continued). Summary of fresh (conditions 1 and 2) Chinook Salmon carcass data from the mainstem Trinity River by survey reach, 2020–2023.

2022

Reach	Total [a]	Females	Males	Female proportion	Ad-clipped	Weir-tagged
1	242	174	66	72.5%	25	24
2	251	144	105	57.8%	10	21
3	152	80	70	53.3%	1	7
4	166	83	81	50.6%	5	7
5	136	74	60	55.2%	0	8
6	58	36	20	64.3%	0	0
7	30	18	10	64.3%	0	0
9	46	18	27	40.0%	0	0
10	14	4	9	30.8%	0	0
12	5	2	3	40.0%	0	0
13	20	10	10	50.0%	0	0
14	1	1	0	100.0%	0	0
Total	1,121	644	461	58.3%	41	67

[a] may includes carcass(es) of unknown sex

2023

Reach	Total	Females	Males	Female proportion	Ad-clipped	Weir-tagged
1	464	316	148	68.1%	43	32
2	277	152	124	55.1%	36	15
3	168	109	59	64.9%	1	17
4	167	96	71	57.5%	1	7
5	116	68	47	59.1%	0	6
6	49	25	24	51.0%	0	1
7	28	19	8	70.4%	0	0
9	51	20	26	43.5%	0	0
10	6	6	0	100.0%	0	0
12	31	20	11	64.5%	0	0
13	35	21	14	60.0%	0	0
14	9	7	2	77.8%	0	0
Total	1,401	859	534	61.7%	81	78

Table 5. Coded-wire tag (CWT) information retrieved from fresh adipose fin-clipped Chinook Salmon carcasses, 2020–2023 Trinity River surveys.

2020

Carcasses	CWT	Brood Year	Run type	Release type	Marking rate	Production multiplier
1	60954	2016	Spring	Fingerling	0.24	4.242
2	60955	2016	Spring	Fingerling	0.24	4.165
2	60956	2016	Spring	Fingerling	0.24	4.118
4	60961	2016	Spring	Yearling	0.24	4.165
2	60962	2016	Fall	Yearling	0.24	4.154
1	60963	2016	Spring	Fingerling	0.92	1.090
1	61490	2017	Spring	Fingerling	0.24	4.206
1	61494	2017	Fall	Fingerling	0.24	4.111
1	61496	2017	Spring	Yearling	0.23	4.316
17	61497	2017	Fall	Yearling	0.23	4.312
1	61498	2017	Fall	Fingerling	0.23	4.275
1	61547	2018	Fall	Fingerling	0.25	4.068
2	61548	2018	Fall	Fingerling	0.25	4.061
1	62018	2018	Fall	Fingerling	0.24	4.110
3	62019	2018	Fall	Fingerling	0.24	4.109
2	62022	2018	Fall	Yearling	0.24	4.114
2	-- Missing CWT/head --				NA	NA
					Mean = 4.14	Mean = 0.254

2021

Carcasses	CWT	Brood Year	Run type	Release type	Marking rate	Production multiplier
2	61489	2017	Spring	Fingerling	0.24	4.216
1	61493	2017	Fall	Fingerling	0.24	4.130
3	61496	2017	Spring	Yearling	0.23	4.316
6	61497	2017	Fall	Yearling	0.23	4.312
1	61498	2017	Fall	Fingerling	0.23	4.275
4	61543	2018	Spring	Yearling	0.24	4.178
8	61547	2018	Fall	Fingerling	0.25	4.068
12	61548	2018	Fall	Fingerling	0.25	4.061
3	61903	2018	Fall	Fingerling	0.23	4.398
1	61945	2018	Spring	Fingerling	0.24	4.172
3	61946	2018	Spring	Fingerling	0.24	4.172
4	62018	2018	Fall	Fingerling	0.24	4.110
6	62019	2018	Fall	Fingerling	0.24	4.109
7	62020	2018	Fall	Fingerling	0.24	4.093
5	62021	2018	Fall	Fingerling	0.24	4.132
48	62022	2018	Fall	Yearling	0.24	4.114
27	-- Missing CWT/head --				NA	NA
					Mean = 4.14	Mean = 0.242

Table 5 (continued). Coded-wire tag (CWT) information retrieved from fresh adipose fin-clipped Chinook Salmon carcasses, 2020–2023 Trinity River surveys.

2022

Carcasses	CWT	Brood Year	Run type	Release type	Production multiplier	Marking rate
5	061543	2018	Spring	Yearling	4.18	0.239
1	061547	2018	Fall	Fingerling	4.07	0.246
2	061548	2018	Fall	Fingerling	4.06	0.246
1	061903	2018	Fall	Experimental	4.40	0.227
1	061945	2018	Spring	Fingerling	4.18	0.239
2	062018	2018	Fall	Fingerling	4.11	0.243
2	062020	2018	Fall	Fingerling	4.09	0.244
3	062021	2018	Fall	Fingerling	4.13	0.242
14	062022	2018	Fall	Yearling	4.11	0.243
1	062097	2020	Fall	Yearling	4.24	0.236
1	062098	2020	Fall	Yearling	4.12	0.243
1	062391	2020	Fall	Yearling	4.35	0.230
3	-- Missing CWT/head --				NA	NA
					Mean = 4.14	Mean = 0.242

2023

Carcasses	CWT	Brood Year	Run type	Release type	Production multiplier	Marking rate
1	060957	2021	Fall	Fingerling	4.37	0.229
1	060958	2021	Fall	Fingerling	4.19	0.239
5	061809	2020	Fall	Fingerling	4.13	0.242
1	062077	2019	Fall	Yearling [a]	1.00	1.000
4	062095	2020	Fall	Yearling	4.43	0.226
2	062096	2020	Fall	Yearling	4.19	0.239
10	062097	2020	Fall	Yearling	4.26	0.235
8	062098	2020	Fall	Yearling	4.15	0.241
1	062389	2020	Fall	Advanced fingerling [a]	1.00	1.000
13	062390	2020	Fall	Yearling	4.26	0.235
22	062391	2020	Fall	Yearling	4.35	0.230
1	062975	2021	Fall	Yearling	4.28	0.234
12	-- Missing CWT/head --				NA	NA
					Mean = 4.18	Mean = 0.256

[a] from Iron Gate Hatchery

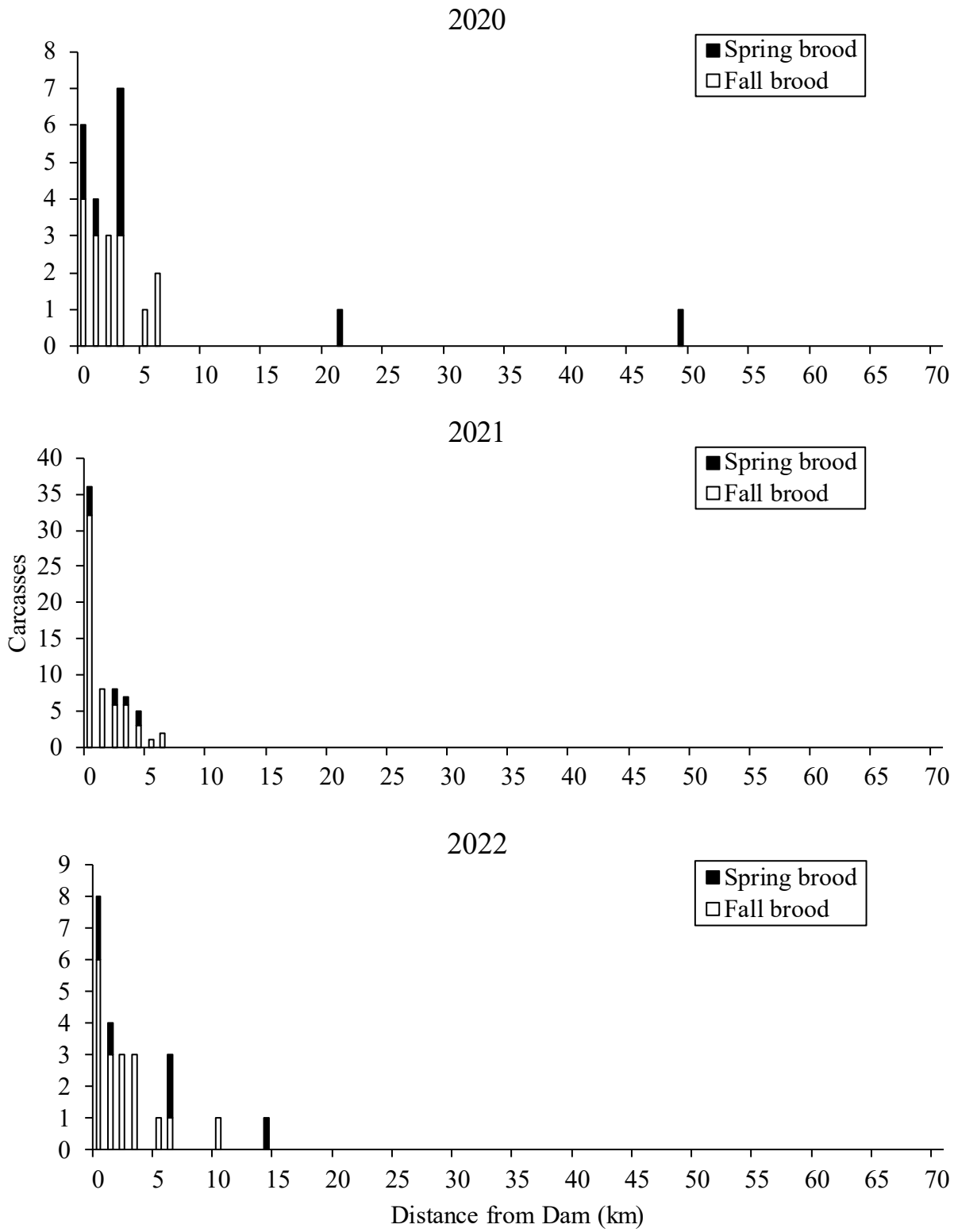


Figure 3. Distribution of coded-wire-tagged (CWT) spawned female Chinook Salmon carcasses by brood type (spring and fall) located in the mainstem Trinity River downstream of Lewiston Dam from 2020 to 2023.

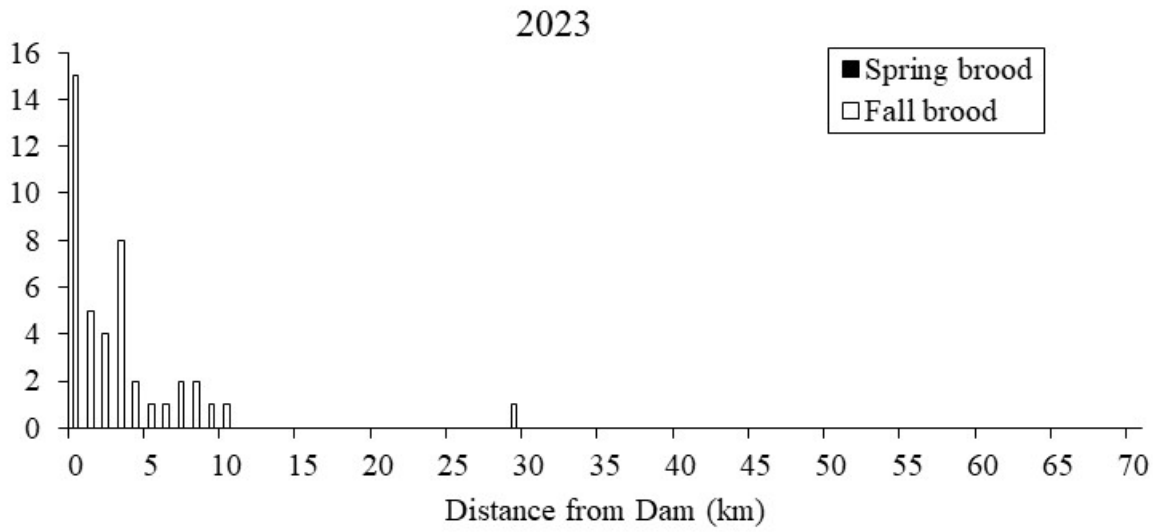


Figure 3 (continued). Distribution of coded-wire-tagged (CWT) spawned female Chinook Salmon carcasses by brood type (spring and fall) located in the mainstem Trinity River downstream of Lewiston Dam from 2020 to 2023.

Table 6. Summary of fresh (conditions 1 and 2) Coho Salmon carcass data by survey reach, 2020–2023 Trinity River surveys.

2020

Reach	Total	Females	Males	Female proportion	Maxillary-clipped	Weir-tagged
1	0	0	0	-	0	0
2	3	2	1	66.7%	2	0
3	1	0	1	0.0%	1	0
4	0	0	0	-	0	0
5	0	0	0	-	0	0
6	0	0	0	-	0	0
7	0	0	0	-	0	0
9	0	0	0	-	0	0
10	0	0	0	-	0	0
12	0	0	0	-	0	0
13	0	0	0	-	0	0
14	0	0	0	-	0	0
Total	4	2	2	50.0%	3	0

2021

Reach	Total	Females	Males	Female proportion	Maxillary-clipped	Weir-tagged
1	6	2	4	33.3%	5	3
2	6	5	1	83.3%	6	1
3	4	3	1	75.0%	2	2
4	1	0	1	0.0%	1	0
5	1	0	1	0.0%	1	0
6	0	0	0	-	0	0
7	0	0	0	-	0	0
9	0	0	0	-	0	0
10	0	0	0	-	0	0
12	0	0	0	-	0	0
13	0	0	0	-	0	0
14	0	0	0	-	0	0
Total	18	10	8	55.6%	15	6

Table 6 (continued). Summary of fresh (conditions 1 and 2) Coho Salmon carcass data by survey reach, 2020–2023 Trinity River surveys.

2022

Reach	Total	Females	Males	Female proportion	Maxillary-clipped	Weir-tagged
1	7	3	4	42.9%	7	4
2	9	7	2	77.8%	8	3
3	4	3	1	75.0%	2	1
4	0	0	0	-	0	0
5	0	0	0	-	0	0
6	0	0	0	-	0	0
7	0	0	0	-	0	0
9	0	0	0	-	0	0
10	0	0	0	-	0	0
12	1	1	0	100.0%	0	0
13	0	0	0	-	0	0
14	0	0	0	-	0	0
Total	21	14	7	66.7%	17	8

2023

Reach	Total [a]	Females	Males	Female proportion	Maxillary-clipped	Weir-tagged
1	16	10	6	62.5%	15	0
2	22	14	7	66.7%	20	2
3	2	1	1	50.0%	2	0
4	4	3	1	75.0%	4	1
5	0	0	0	-	0	0
6	0	0	0	-	0	0
7	0	0	0	-	0	0
9	2	0	0	-	1	0
10	1	0	0	-	1	0
12	0	0	0	-	0	0
13	0	0	0	-	0	0
14	0	0	0	-	0	0
Total	47	28	15	65.1%	43	3

[a] Includes carcasses of unknown sex

Carcass Estimates

The hierarchical latent variables model estimated 617 (95% CI: 509–749) Chinook Salmon carcasses in Reach 1 and 929 (95% CI: 760–1,151) in Reach 2 in 2020. Estimates of spawned female Chinook Salmon carcasses were 421 (95% CI: 340–518) in Reach 1 and 449 (95% CI: 347–580) in Reach 2.

In 2021, 1,458 (95% CI: 1,302–1,646) Chinook Salmon carcasses were estimated in Reach 1 and 1,304 (95% CI: 1,116–1,546) in Reach 2. Estimates of spawned female Chinook Salmon carcasses were 1,035 (95% CI: 917–1,180) in Reach 1 and 572 (95% CI: 469–708) in Reach 2.

In 2022, 602 (95% CI: 540–672) Chinook Salmon carcasses were estimated in Reach 1 and 893 (95% CI: 790–1,010) in Reach 2. Estimates of spawned female Chinook Salmon carcasses were 415 (95% CI: 365–471) in Reach 1 and 500 (95% CI: 429–584) in Reach 2.

In 2023, 2,323 (95% CI: 1,875–2,944) Chinook Salmon carcasses were estimated in Reach 1 and 2,310 (95% CI: 1,653–3,464) in Reach 2. Estimates of spawned female Chinook Salmon carcasses were 1,566 (95% CI:1,251–1,991) in Reach 1 and 1,262 (95% CI:885–1,910) in Reach 2.

Pre-spawn Mortality

Two fresh unspawned female Chinook Salmon carcasses were found in 2020, 19 in 2021, 18 in 2022, and 9 in 2023 (Appendix C). Only in 2021 did any of the unspawned female carcasses have hatchery marks (6 of 19). The annual pre-spawn mortality rates of female Chinook Salmon throughout the mainstem Trinity River were 0.9% in 2020, 3.1% in 2021, 2.9% in 2022, and 1.2% in 2023 (Table 7). The annual pre-spawn mortality rates of female Chinook Salmon in the Trinity River restoration reach were 0.0% in 2020, 3.0% in 2021, 2.4% in 2022, and 0.8% in 2023.

Weekly pre-spawn mortality rates ranged between 0.0% and 11.1% (the first five survey weeks and the final two were combined due to small sample sizes) in 2020, 0.0% and 7.5% (the first three survey weeks and the final two were combined due to small sample sizes) in 2021, 0.0% and 7.8% in 2022 (the first three survey weeks and the final three were combined due to small sample sizes), and 0.0% and 4.7% in 2023 (the first four survey weeks and the final two were combined due to small sample sizes; Figure 4).

Two (both spawned; one unmarked and one max-clipped) fresh female Coho Salmon carcasses were encountered in 2020 (Table 6). In 2021, 1 (max-clipped) of the 10 fresh female Coho Salmon carcasses (8 max-clipped and 2 unmarked) was a pre-spawn mortality (Table 8). In 2022, none (0.0%) of the 13 fresh female Coho Salmon carcasses (10 max-clipped and 3 unmarked) were pre-spawn mortalities. In 2023, none (0.0%) of the 28 fresh female Coho Salmon carcasses (all max-clipped) were pre-spawn mortalities. Small sample sizes precluded further pre-spawn mortality analyses for this species. Note that pre-spawn mortality rates were based on data collected through late December, while Coho Salmon are still spawning.

Table 7. Pre-spawn mortality rates of Chinook Salmon in the Trinity River below Lewiston Dam (Reaches 1–14) and in the restoration reach (Reaches 1–7), 2009–2023 surveys. Pre-spawn mortalities by week and reach for unmarked and ad-clipped Chinook Salmon are presented in Appendix C.

	Chinook Salmon pre-spawn mortality rate	
	Reaches 1-14	Reaches 1-7
Year	(Lewiston Dam to Klamath River)	(Lewiston Dam to North Fork)
2009	7.9%	6.8%
2010	10.2%	9.5%
2011	4.6%	4.6%
2012	2.4%	2.4%
2013	5.1%	6.1%
2014	11.5%	9.1%
2015	0.8%	0.0%
2016	0.7%	0.8%
2017	1.8%	2.0%
2018	2.1%	1.6%
2019	3.5%	3.6%
2020	0.9%	0.0%
2021	3.1%	3.0%
2022	2.9%	2.4%
2023	1.2%	0.9%

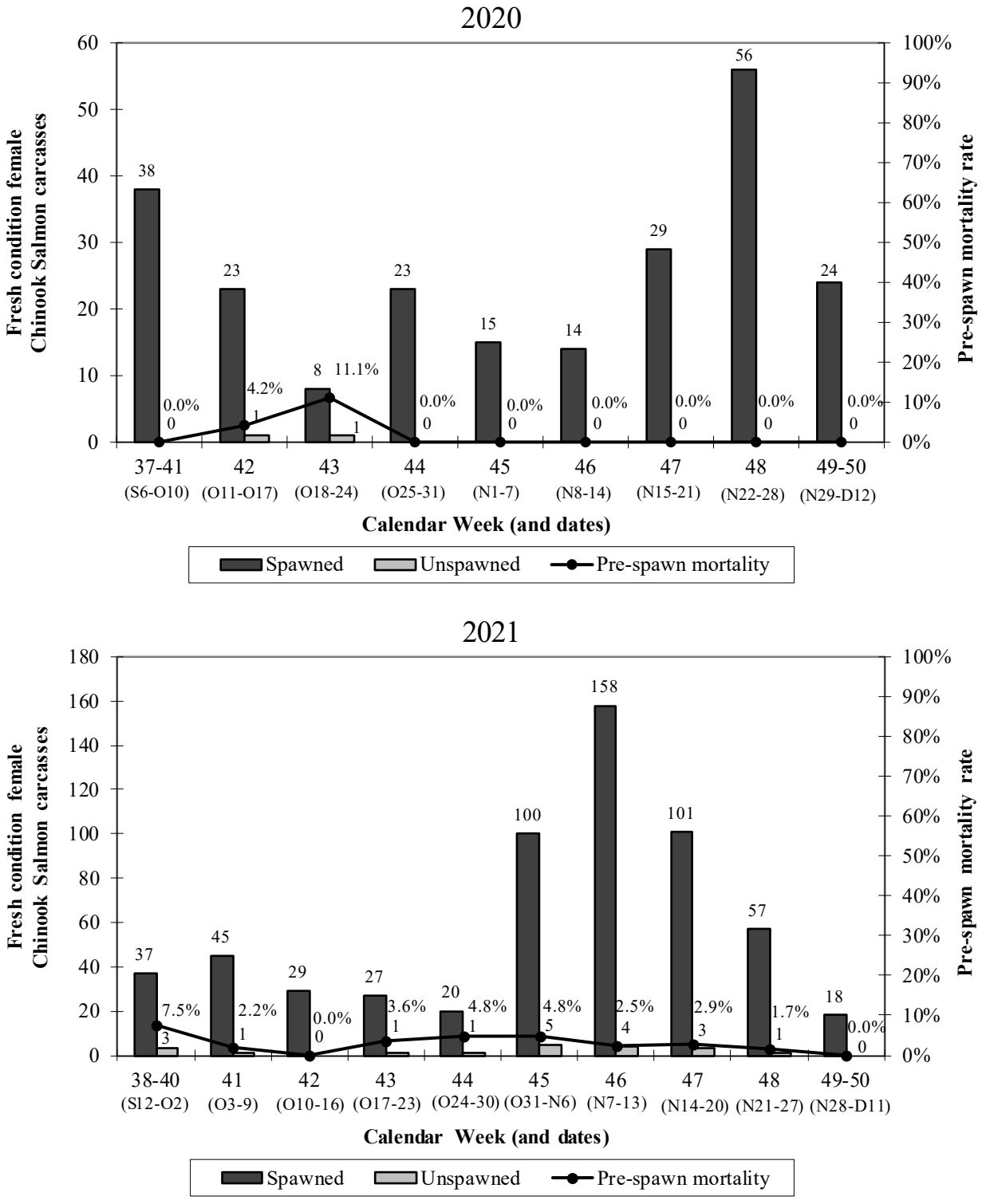


Figure 4. Weekly pre-spawn mortality from fresh (conditions 1 and 2) female Chinook Salmon carcasses, Trinity River surveys 2020-2023. Calendar weeks at the beginning and end of the survey period were combined because of low sample sizes in at least one of those weeks.

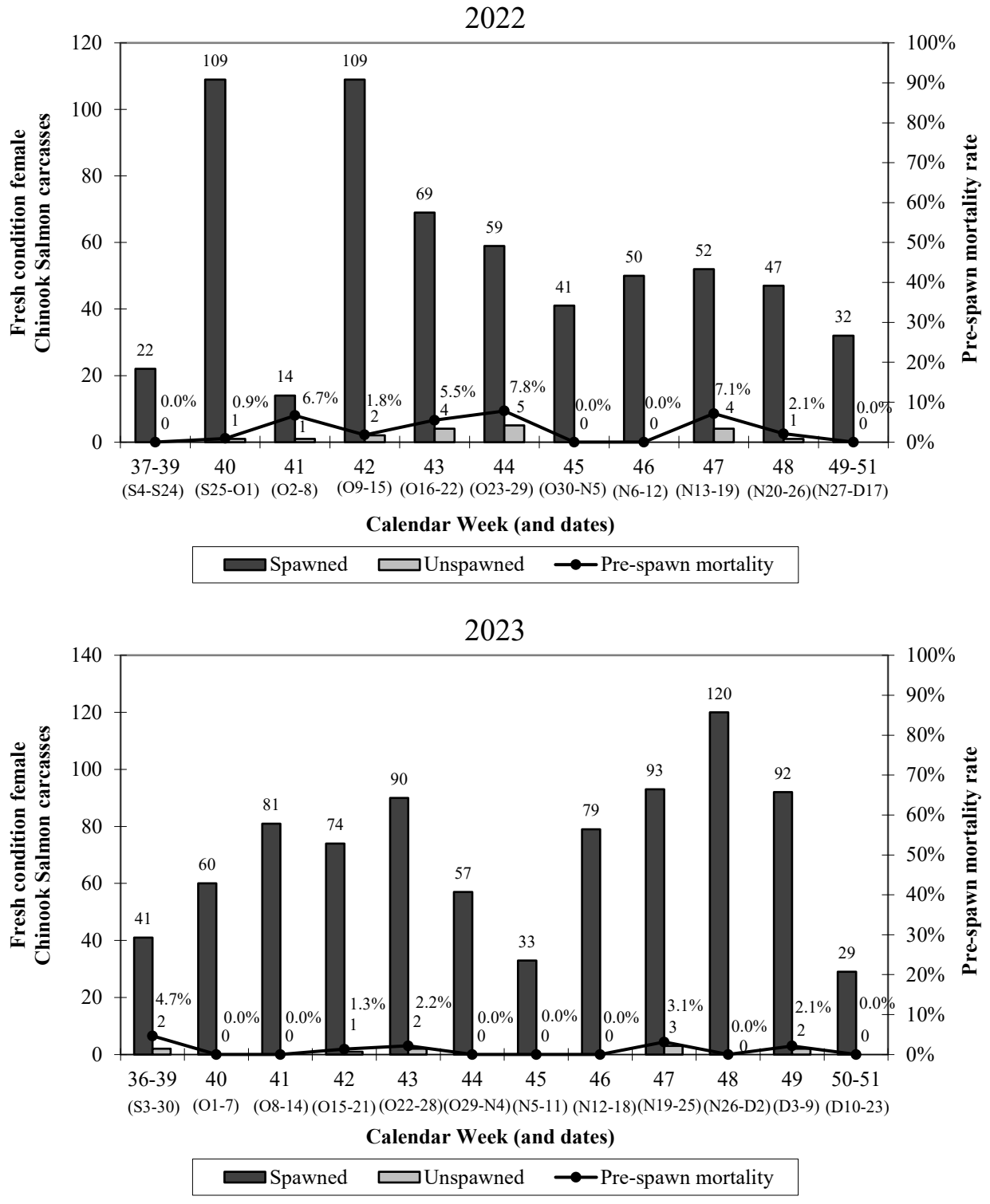


Figure 4 (continued). Weekly pre-spawn mortality from fresh (conditions 1 and 2) female Chinook Salmon carcasses, Trinity River surveys 2020-2023. Calendar weeks at the beginning and end of the survey period were combined because of low sample sizes in at least one of those weeks.

Table 8. Pre-spawn mortality rates of natural- and hatchery-origin Coho Salmon, Trinity River surveys, 2009–2023. Note that these pre-spawn mortality rates were based on data only collected through late December. Spawning success often varies, typically improving over time, and our surveys did not extend over the entire Coho Salmon spawning period.

	Coho Salmon pre-spawn mortality rate		
Year	Natural-origin	Hatchery-origin	Combined
2009	7.4%	19.0%	15.3%
2010	21.9%	15.9%	16.7%
2011	7.1%	12.7%	10.6%
2012	3.6%	9.8%	9.2%
2013	11.1%	5.2%	5.9%
2014	33.3%	26.9%	28.2%
2015	-	-	- [a]
2016	-	-	- [a]
2017	-	-	- [a]
2018	-	-	- [a]
2019	-	-	- [a]
2020	-	-	- [a]
2021	-	-	- [a]
2022	- [b]	- [b]	0.0%
2023	0.0%	- [b]	0.0%

[a] sample sizes for Coho Salmon from 2015 to 2021 were ≤10 carcasses annually

[b] sample size too low for reporting percentages by origin type

Salmon Redds

During the 2020 surveys, 1,739 salmon redds were identified (Table 9). A majority of the redds (1,296, 95% CI: 1,085–1,450; 74.5%) were estimated to have been constructed by natural-origin female Chinook Salmon, while hatchery-origin female Chinook Salmon accounted for 337 (95% CI: 183–548; 19.4%) of the total redd count (Table 10). Coho Salmon redds accounted for 106 (6.1%) of the surveyed redds.

In 2021, 1,991 salmon redds were identified (Table 9). A majority of the redds (1,340, 95% CI: 1,191–1,511; 67.3%) were estimated to have been constructed by natural-origin female Chinook Salmon, while hatchery-origin female Chinook Salmon accounted for 596 (95% CI: 426–746; 29.9%) of the total redd count (Table 10). Coho Salmon redds accounted for 55 (2.8%) of the surveyed redds.

In 2022, 4,203 salmon redds were identified (Table 9). A majority of the redds (3,725, 95% CI: 3,535–3,876; 88.6%) were estimated to have been constructed by natural-origin female Chinook Salmon, while hatchery-origin female Chinook Salmon accounted for 357 (95%

CI: 206–546; 8.5%) of the total redd count (Table 10). Coho Salmon redds accounted for 121 (2.9%) of the surveyed redds.

In 2023, 3,911 salmon redds were identified (Table 9). A majority of the redds (3,323, 95% CI: 3,320–3,640; 85.0%) were estimated to have been constructed by natural-origin female Chinook Salmon, while hatchery-origin female Chinook Salmon accounted for 463 (95% CI: 325–555; 11.8%) of the total redd count (Table 10). Coho Salmon redds accounted for 125 (3.2%) of the surveyed redds.

The low number of spawned female Coho Salmon carcasses collected from 2020 to 2023 precluded the differentiation of hatchery- and natural-origin Coho Salmon redds. Note that the Coho Salmon spawning season continued beyond the surveys.

Natural-origin Chinook Salmon redds were mostly constructed throughout the restoration reach of mainstem Trinity River with the highest numbers skewed toward Lewiston Dam (Figure 5). Hatchery-origin Chinook Salmon redds were also mainly in the upstream-most reaches with most redds constructed relatively close to Lewiston Dam, the location of the Trinity River Hatchery.

Table 9. Redd counts (before species differentiation) by week and reach, Trinity River surveys 2020–2023. NS = 'No Survey' for scheduled surveys that were missed. Dashes (-) represent days when surveys were not scheduled.

2020

Week	Reach												
start	1	2	3	4	5	6	7	9	10	12	13	14	Total
Aug 30	NS	NS	NS	NS	NS	NS	NS	-	-	-	-	-	-
Sep 6	5	1	0	0	1	0	0	-	-	-	-	-	7
Sep 13	1	2	1	1	NS	0	0	0	NS	-	-	-	5
Sep 20	15	16	15	6	10	0	1	-	-	NS	NS	NS	63
Sep 27	37	38	13	18	28	9	7	0	NS	-	-	-	150
Oct 4	28	15	16	13	14	17	33	-	-	NS	NS	NS	136
Oct 11	14	15	9	12	14	23	34	46	35	-	-	-	202
Oct 18	NS	NS	20	11	3	30	27	-	-	3	4	1	99
Oct 25	10	14	13	16	30	24	33	81	43	-	-	-	264
Nov 1	28	20	32	10	14	17	14	-	-	18	69	NS	222
Nov 8	51	35	13	1	14	6	8	34	24	-	-	-	186
Nov 15	38	41	9	8	10	3	3	-	-	1	NS	NS	113
Nov 22	27	43	NS	NS	4	6	6	NS	NS	-	49	-	135
Nov 29	9	28	11	NS	13	2	4	10	7	NS	NS	NS	84
Dec 6	NS	NS	NS	NS	NS	2	3	NS	NS	25	33	10	73
Dec 13	NS	NS	NS	NS	NS	NS	NS	-	-	NS	NS	NS	-
Total	263	268	152	96	155	139	173	171	109	47	155	11	1,739

2021

Week	Reach												
start	1	2	3	4	5	6	7	9	10	12	13	14	Total
Sep 5	NS	NS	NS	NS	NS	NS	NS	-	-	-	-	-	-
Sep 12	NS	9	2	9	2	0	1	0	NS	-	-	-	23
Sep 19	14	39	29	11	11	1	3	-	-	0	0	NS	108
Sep 26	61	73	38	35	26	4	4	12	NS	-	-	-	253
Oct 3	29	54	29	21	32	14	26	-	-	2	1	NS	208
Oct 10	18	26	49	39	42	47	55	NS	NS	-	-	-	276
Oct 17	44	33	17	0	31	39	19	-	-	38	NS	NS	221
Oct 24	52	67	47	28	13 [b]	9	26	NS	NS	-	-	-	242
Oct 31	134	132	28	0	22	4	9	-	-	NS	NS	NS	329
Nov 7	NS [a]	78	19	NS	5 [b]	9	13	NS	NS	-	-	-	124
Nov 14	NS [a]	21	9	5	13	3	9	-	-	51	22	0	133
Nov 21	NS [a]	21	NS	NS	1 [b]	3	11	NS	NS	-	-	-	36
Nov 28	NS [a]	8	4	1	7	0	0	-	-	11	6	1	38
Dec 5	NS [a]	NS	NS	NS	NS	NS	NS	NS	NS	-	-	-	-
Dec 12	NS	NS	NS	NS	NS	NS	NS	-	-	NS	NS	NS	-
Total	352	561	271	149	205	133	176	12	0	102	29	1	1,991

[a] Only carcasses were surveyed because redds became indistinguishable in high numbers on recently augmented gravel.

[b] Redds counted at the downstream end of Reach 5 by the crew that surveyed Reach 6; not a complete Reach 5 survey.

Table 9. Redd counts (before species differentiation) by week and reach, Trinity River surveys 2020–2023.NS = 'No Survey' for scheduled surveys that were missed. Dashes (-) represent days when surveys were not scheduled.

2022

Week	Reach												
start	1	2	3	4	5	6	7	9	10	12	13	14	Total
Sep 4	0	0	0	0	0	0	0	-	-	-	-	-	-
Sep 11	10	4	10	4	1	0	0	0	NS	-	-	-	29
Sep 18	7	17	63	60	31	1	0	-	-	0	0	0	179
Sep 25	109	221	151	112	139	31	43	18	3	-	-	-	827
Oct 2	64	114	41	31	115	114	70	-	-	0	0	NS	549
Oct 9	31	62	32	48	82	87	83	140	48	-	-	-	613
Oct 16	4	38	63	27	87	93	57	-	-	15	24	1	409
Oct 23	11	38	32	30	55	11	14	130	49	-	-	-	370
Oct 30	59	65	36	25	2 [a]	7	20	-	-	59	136	NS	409
Nov 6	68	75	NS	NS	NS	NS	NS	33	35	-	-	-	211
Nov 13	53	29	27	11	37	2	1	-	-	50	62	85	357
Nov 20	32	46	NS	NS	NS	NS	NS	14	0	-	-	-	92
Nov 27	17	13	6	NS	10	0	0	-	-	NS	NS	NS	46
Dec 4	9	10	3	9	5	NS	NS	0	0	3	-	-	39
Dec 11	2	20	9	5	5	NS	NS	0	0	NS	11	NS	52
Dec 18	-	-	-	-	-	-	-	-	-	-	-	21	21
Total	476	752	473	362	569	346	288	335	135	127	233	107	4,203

[a] Redds counted at the downstream end of Reach 5 by the crew that surveyed Reach 6; not a complete Reach 5 survey.

2023

Week	Reach												
start	1	2	3	4	5	6	7	9	10	12	13	14	Total
Sep 3	1	3	0	0	0	0	0	-	-	-	-	-	4
Sep 10	15	19	7	3	1	0	0	0	0	-	-	-	45
Sep 17	26	63	49	37	12	0	0	-	-	0	0	0	187
Sep 24	56	76	71	52	60	9	8	3	0	-	-	-	335
Oct 1	25	42	40	43	54	56	34	-	-	3	1	NS	298
Oct 8	10	36	40	54	44	39	49	117	46	-	-	-	435
Oct 15	5	16	24	62	72	57	38	-	-	39	37	7	357
Oct 22	4	30	26	14	74	105	66	198	77	-	-	-	594
Oct 29	11	20	21	22	39	32	30	-	-	85	183	NS	443
Nov 5	30	33	15	20	18	44	7	53	51	-	-	-	271
Nov 12	79	36	19	13	27	4	3	-	-	73	77	91	422
Nov 19	119	50	NS	NS	3	4	1	4	NS	-	-	-	181
Nov 26	68	42	18	7	6	0	0	-	-	18	8	NS	167
Dec 3	74	36	4	0	2	0	0	NS	0	-	-	-	116
Dec 10	17	10	6	1	3	NS	NS	-	-	14	NS	3	54
Dec 17	2	-	-	-	-	-	-	-	-	-	-	-	2
Total	542	512	340	328	415	350	236	375	174	232	306	101	3,911

Table 10. Estimated numbers of salmon redds by species and origin observed in the mainstem Trinity River, 2020–2023. Hatchery- and natural-origin estimates are for the maternal first generation only. Bootstrap-generated 95% confidence intervals are in parentheses.

		Chinook Salmon			Coho Salmon [a]		
		Redd	95% confidence limits		Redd	95% confidence limits	
Year	Origin	estimate	Lower	Upper	estimate [b]	Lower	Upper
2020	All	1,633	- [c]	- [c]	106	- [c]	- [c]
	Natural	1,296	1,085	1,450	-	-	-
	Hatchery	337	183	548	-	-	-
2021	All	1,936	- [c]	- [c]	55	- [c]	- [c]
	Natural	1,340	1,191	1,511	-	-	-
	Hatchery	596	426	746	-	-	-
2022	All	4,082	- [c]	- [c]	121	- [c]	- [c]
	Natural	3,725	3,535	3,876	-	-	-
	Hatchery	357	206	546	-	-	-
2023	All	3,786	- [c]	- [c]	125	- [c]	- [c]
	Natural	3,323	3,230	3,640	-	-	-
	Hatchery	463	325	555	-	-	-

[a] The survey season only partially covers the Coho Salmon spawning period.

[b] Not enough fresh female Coho Salmon carcasses were found to calculate separate estimates for natural- and hatchery-origin Coho Salmon redds.

[c] Confidence intervals are generated with both Chinook and Coho salmon data. Not enough fresh female Coho Salmon carcasses were found to calculate a confidence interval.

2020

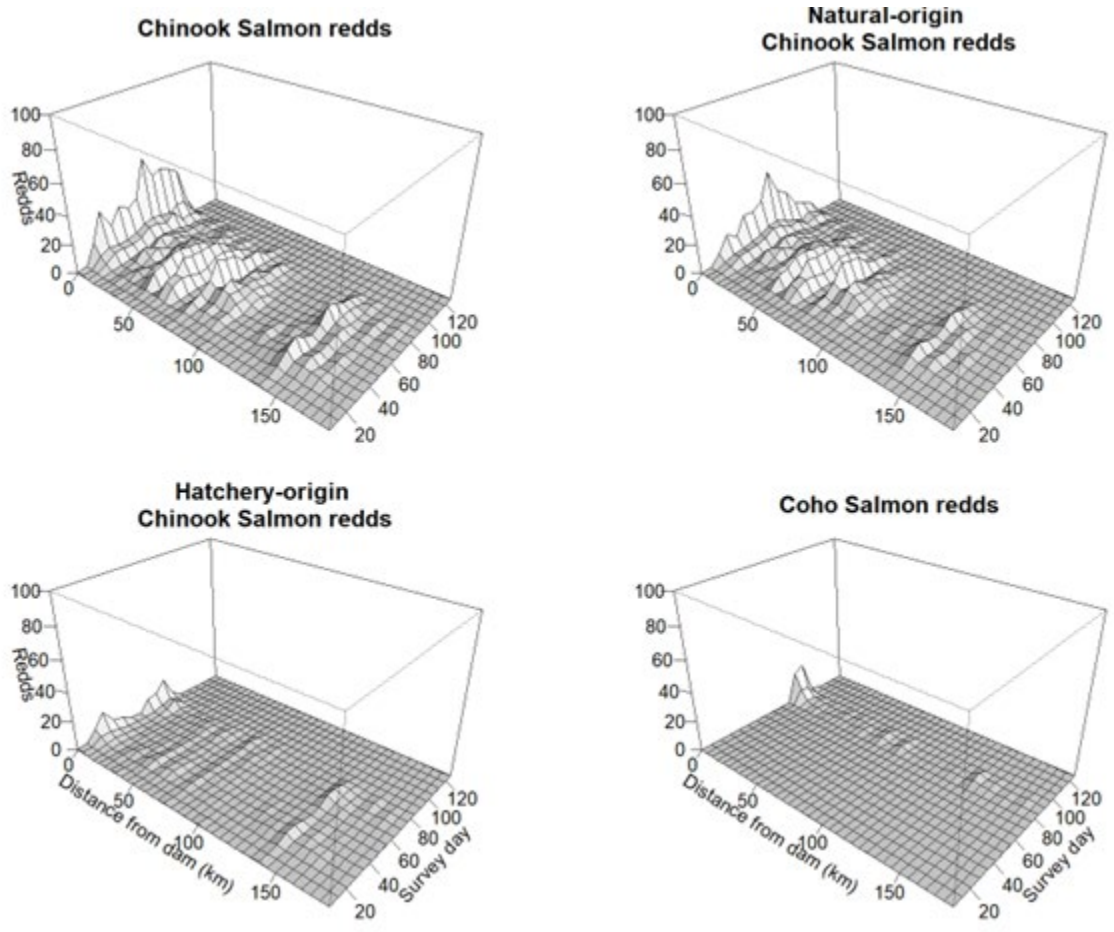


Figure 5. Spatiotemporal distribution of mainstem Trinity River salmon redds from Lewiston Dam to Weitchpec, 2020–2023. Surveys were not conducted in Reaches 8 (rkm 107.6–117.4) and 11 (rkm 63.4–79.1). Survey day 1 = September 1.

2021

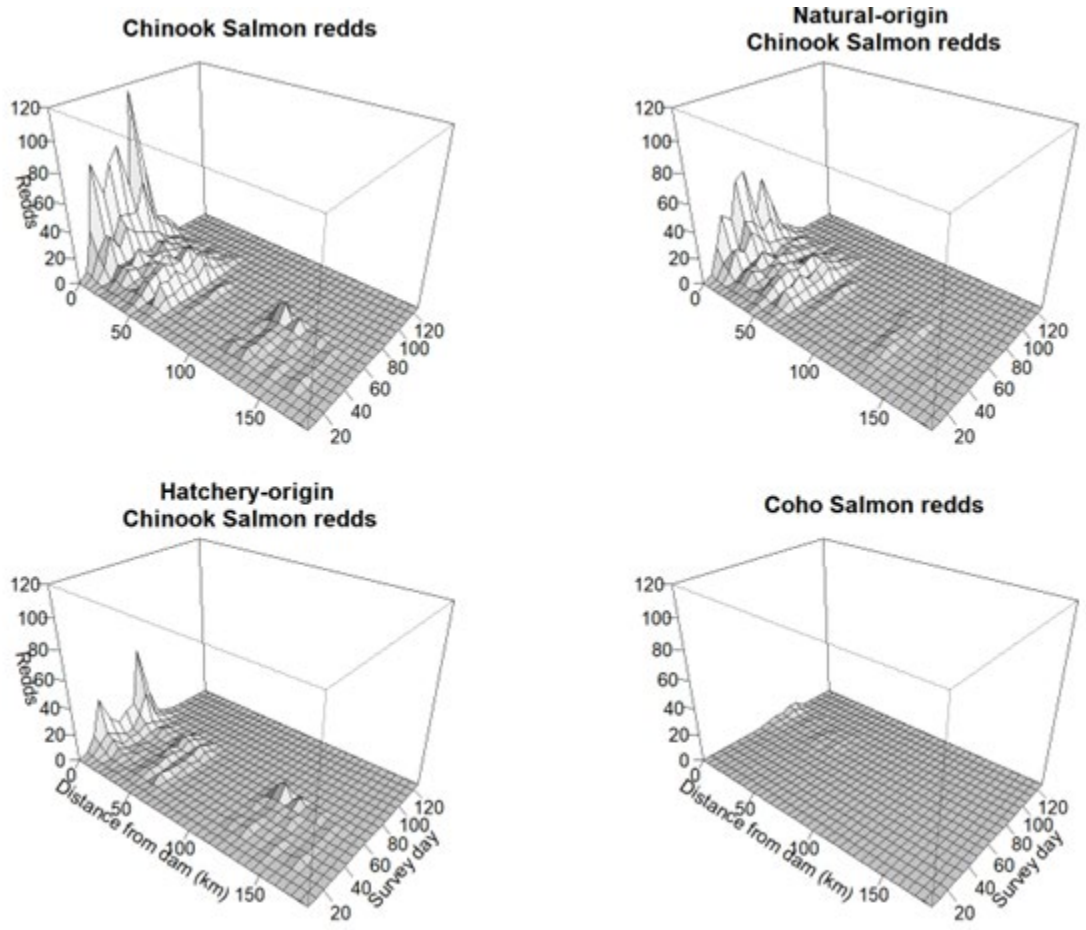


Figure 5 (continued). Spatiotemporal distribution of mainstem Trinity River salmon redds from Lewiston Dam to Weitchpec, 2020–2023. Surveys were not conducted in Reaches 8 (rkm 107.6–117.4) and 11 (rkm 63.4–79.1). Survey day 1 = September 1.

2022

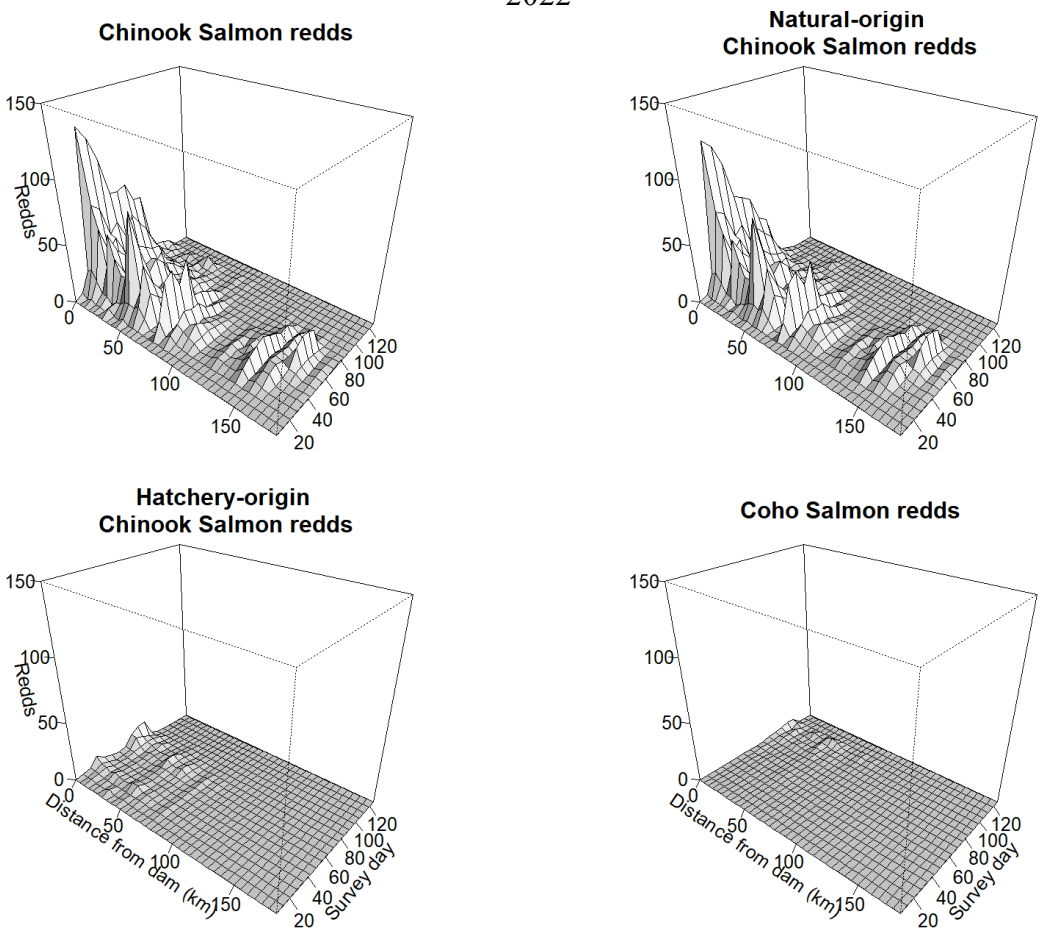


Figure 5 (continued). Spatiotemporal distribution of mainstem Trinity River salmon redds from Lewiston Dam to Weitchpec, 2020–2023. Surveys were not conducted in Reaches 8 (rkm 107.6–117.4) and 11 (rkm 63.4–79.1). Survey day 1 = September 1.

2023

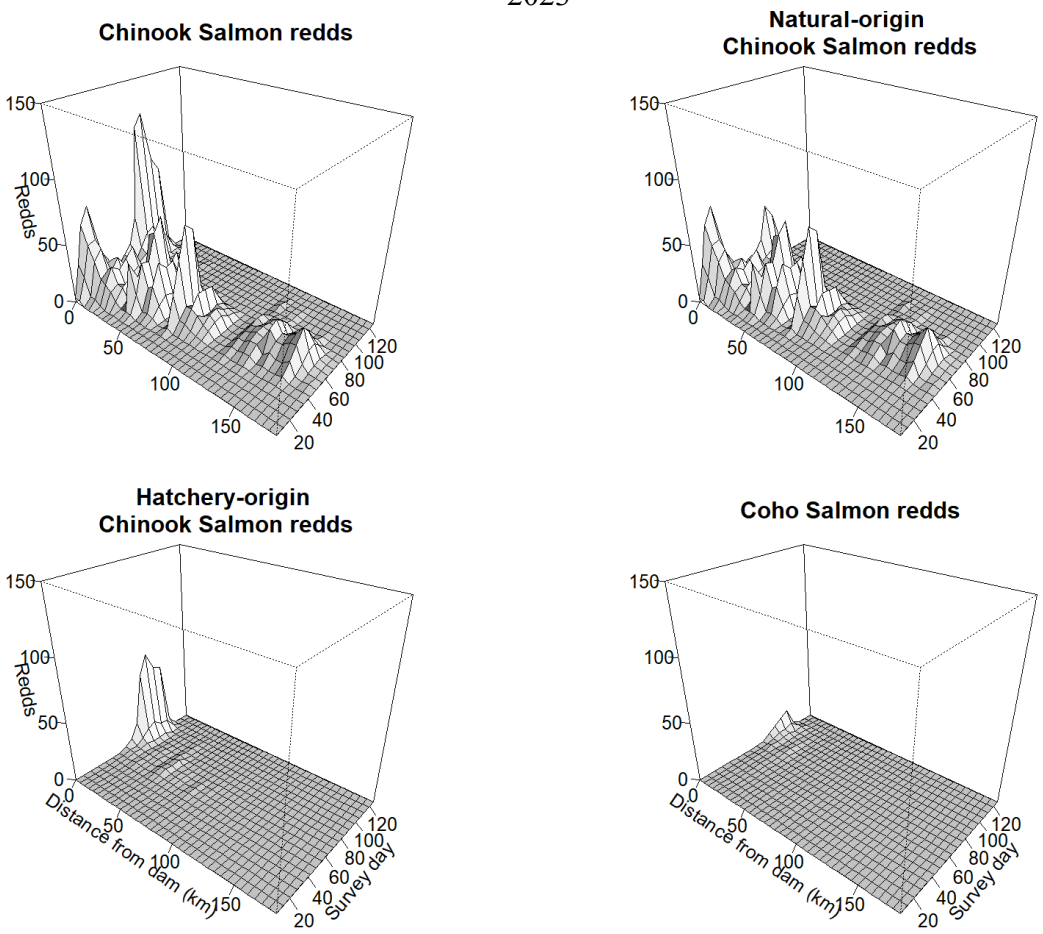


Figure 5 (continued). Spatiotemporal distribution of mainstem Trinity River salmon redds from Lewiston Dam to Weitchpec, 2020–2023. Surveys were not conducted in Reaches 8 (rkm 107.6–117.4) and 11 (rkm 63.4–79.1). Survey day 1 = September 1.

Redd–Carcass Relationship

Chinook Salmon redds [natural log-(*ln*-) transformed] and spawned female Chinook Salmon (*ln*-transformed) in Reaches 1 and 2 from 2012 to 2023 had a positive linear correlation ($R^2 = 0.69$, $p < 0.001$; Figure 6). A significant difference was detected between a slope of '1' and the slope of the linear regression between log-transformed Chinook Salmon redd estimates and Chinook Salmon carcass estimates (slope = 0.590, 95% CI: 0.425–0.755).

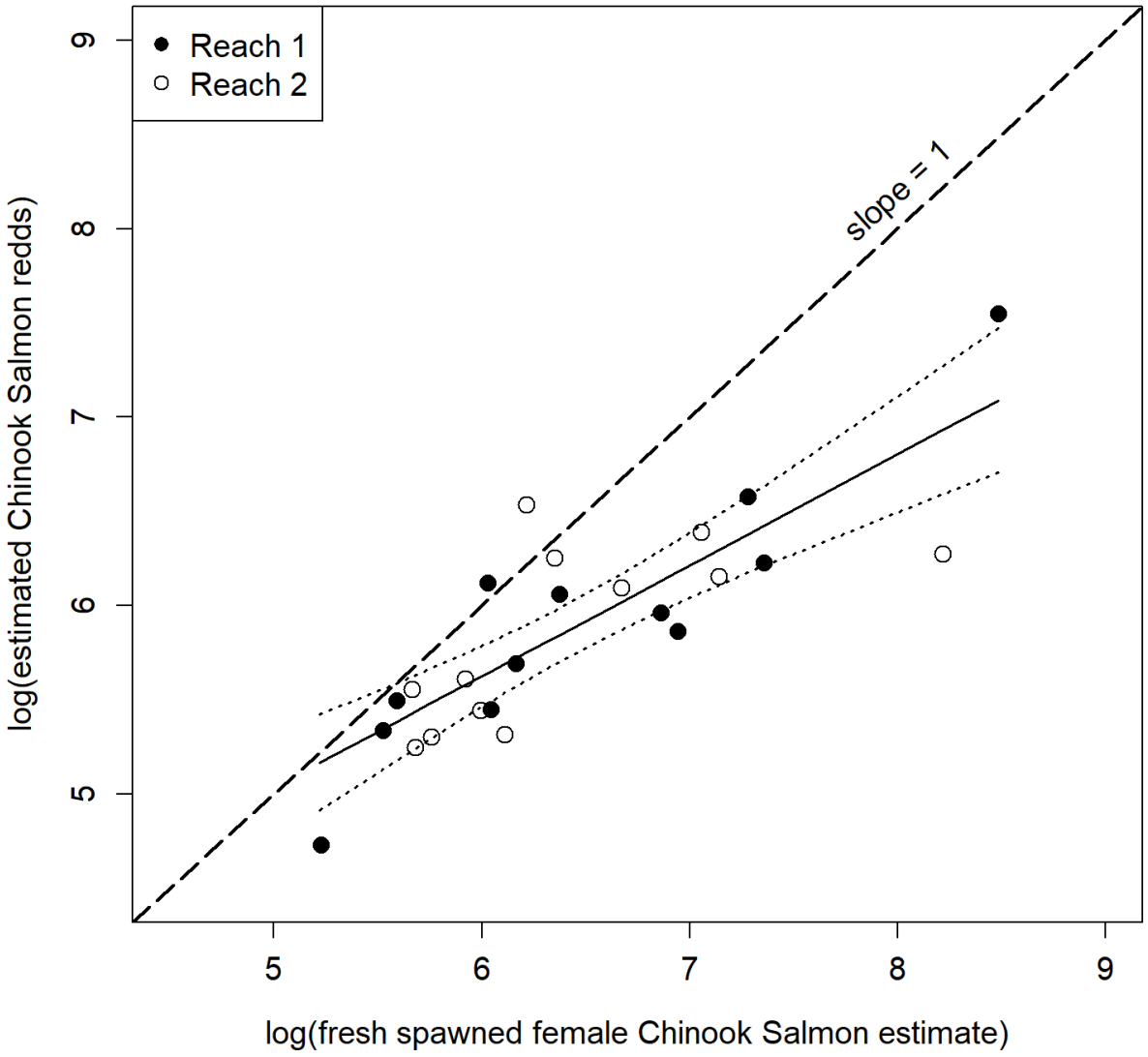


Figure 6. Relationship between counts of *ln*-transformed Chinook Salmon redds and *ln*-transformed estimates of spawned female Chinook Salmon carcasses in Reaches 1 and 2 (solid line), 2012–2023. The dashed line is included to represent a slope of '1', which would be the slope of two perfectly proportional variables. Dotted lines represent 95% confidence limits of the linear model.

Redd Abundance and Distribution: System Scale

From 2002 to 2023, the number of mainstem salmon redds ranged between 1,549 and 7,588 and decreased over time ($R^2 = 0.3764$, $p = 0.002$; Figure 7). The number of redds constructed by natural-origin Chinook Salmon in the mainstem Trinity River also generally decreased over time, but with no significant trend ($R^2 = 0.1156$, $p = 0.12$), while the number of redds constructed by hatchery-origin Chinook Salmon trended downward ($R^2 = 0.5153$, $p < 0.001$) over this time frame.

The trends in redd abundance within the restoration reach were similar to the mainstem-wide data (Figure 7). From 2002 to 2023, the number of redds constructed annually by natural- and hatchery-origin Chinook Salmon in the restoration reach were variable but trended downward ($R^2 = 0.2758$, $p = 0.01$ and $R^2 = 0.5035$, $p < 0.001$, respectively).

Downstream of the restoration reach the number of natural-origin Chinook Salmon redds constructed from 2002 to 2023 increased slightly but with no significant trend ($R^2 = 0.0507$, $p = 0.31$; Figure 7). A significant decrease in hatchery-origin Chinook Salmon redds was detected downstream of the restoration reach ($R^2 = 0.3240$, $p = 0.006$), but relatively few to no redds were constructed by hatchery-origin Chinook Salmon in this section of river. From 2002 to 2006 between 33 and 72 redds per year were constructed by hatchery-origin Chinook Salmon downstream of the restoration reach except for 2004 when there were none. From 2007 to 2023 between 0 and 14 redds per year were constructed by hatchery-origin Chinook Salmon downstream of the restoration reach and only two or less in 12 of those 17 years.

In the section of river from Lewiston Dam to Cedar Flat (Reaches 1–10), the mean distance from the dam of redds constructed by natural- and hatchery-origin Chinook Salmon in 2020 were 45.4 and 12.1 km, respectively. Mean distances from the dam for natural- and hatchery-origin Chinook Salmon were 28.3 and 5.6 km in 2021, 35.1 and 9.7 km in 2022, and 39.7 and 9.9 km in 2023, respectively. From 2002 to 2019, the mean distance of redds from the dam ranged between 15.3 and 49.2 km annually for natural-origin and between 2.1 and 14.2 km for hatchery-origin Chinook Salmon. Note that the values from 2021 may have been negatively affected by the lack of surveys in Reach 10. In this section of river, the mean distance from Lewiston Dam of natural-origin Chinook Salmon redds shifted downstream from 2002 to 2023 ($R^2 = 0.6264$, $p < 0.001$; Figure 8). This trend, to a lesser degree (i.e., with a much more gradual slope), was also evident for redds constructed by hatchery-origin Chinook Salmon ($R^2 = 0.3808$, $p = 0.002$), which still consistently spawned near Lewiston Dam.

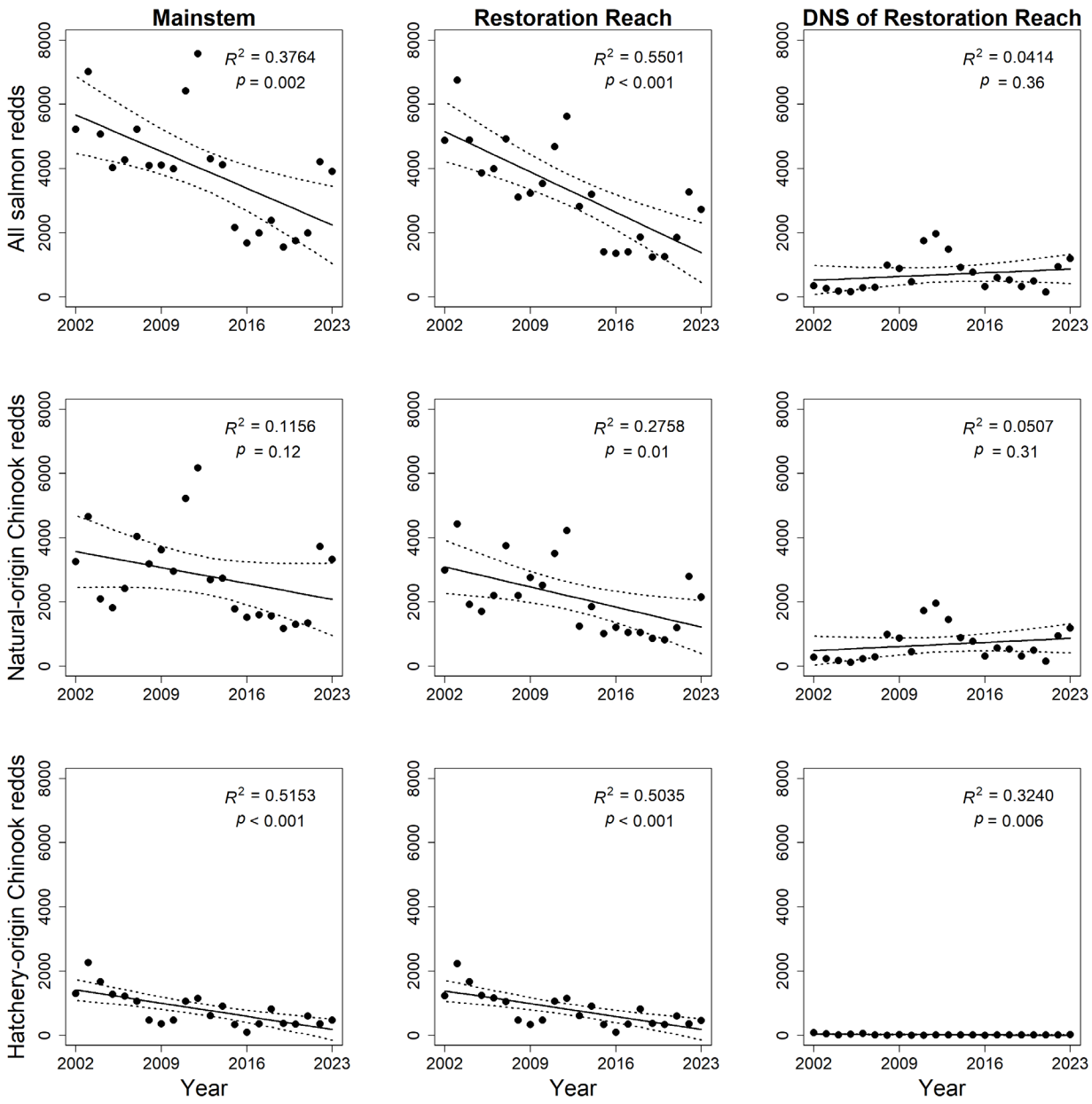


Figure 7. Estimated number of redds constructed in the entire mainstem Trinity River (left), within the restoration reach (center), and downstream (DNS) of the restoration reach (right) by all Chinook Salmon (top), natural-origin Chinook Salmon (middle), and hatchery-origin Chinook Salmon (bottom) from 2002 to 2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines).

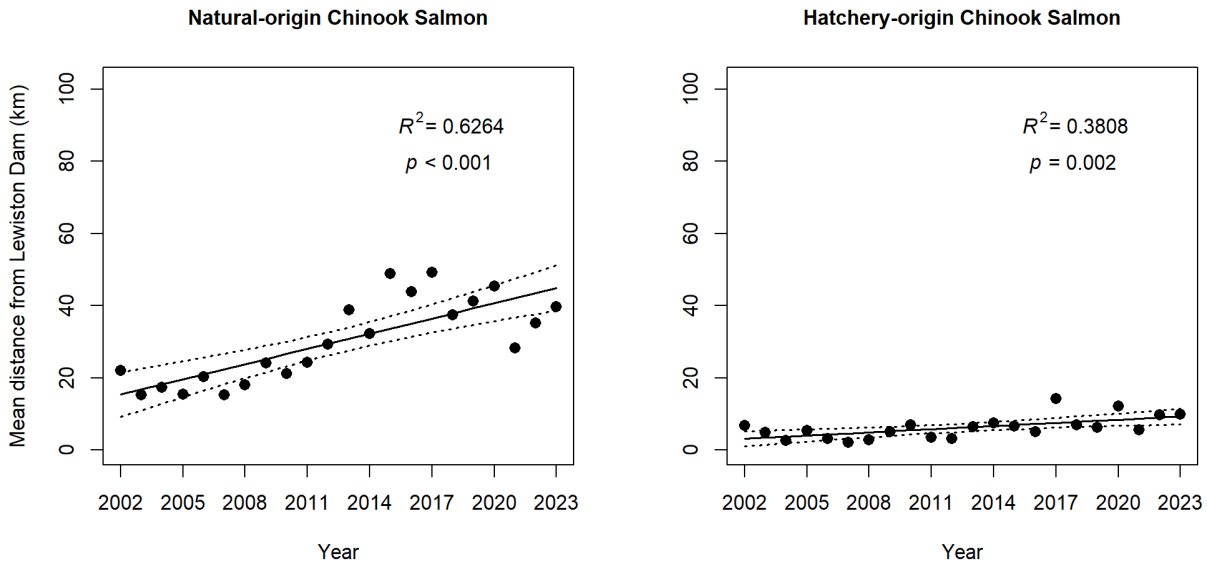


Figure 8. Mean distance from Lewiston Dam of redds constructed by natural- (left) and hatchery-origin (right) Chinook Salmon females between Lewiston Dam and Cedar Flat (0–102.8 km from Lewiston Dam; Reaches 1–10) on the mainstem Trinity River, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines).

Redd Abundance and Distribution: Reach Scale

Long-term changes in natural-origin Chinook Salmon redd distribution were detected at the reach scale (~10–20 km). Redds by natural-origin Chinook Salmon most drastically trended downward in the Lewiston (R^2 = 0.5103, p < 0.001) and Limekiln (R^2 = 0.1949, p = 0.04) reaches and decreased to a lesser degree in the Douglas City reach from 2002 to 2023 (Figure 9). The number of redds between the Junction City and Del Loma reaches did not significantly change over this time period, nor between the Salyer Gorge and Hoopa Valley reaches over the shorter available time period from 2007 to 2023.

To account for annual variation in run size we compared the proportions of natural-origin Chinook Salmon redds within each of the ten reach-scale segments relative to the annual total in the entire mainstem river (Figure 10). This analysis revealed a shift in spawning distribution from 2002 to 2023 where natural-origin Chinook Salmon redds decreased in the upstream-most reach (Lewiston; R^2 = 0.6390, p < 0.001), did not significantly change in the Limekiln and Douglas City reaches, and increased in the mid-river reaches [Junction City (R^2 = 0.2749, p = 0.01), North Fork (R^2 = 0.3289, p = 0.005), Big Bar (R^2 = 0.2850, p = 0.01), and Del Loma (R^2 = 0.2405, p =0.02) reaches]. The proportion of redds in the downstream-most reaches (Salyer Gorge, Willow Creek Valley, and Hoopa Valley) did not change significantly from 2007 to 2023.

Most hatchery-origin Chinook Salmon redds were constructed in the Lewiston reach (range = 72–1,888 redds/year, mean = 651 redds/year) and, to a lesser degree, in the Limekiln reach (range = 19–236 redds/year, mean = 94 redds/year) from 2002 to 2023. Over

this time frame, the abundance of hatchery-origin Chinook Salmon redds significantly decreased in the Lewiston reach ($R^2 = 0.5554$, $p < 0.001$; Figure 11). Fewer hatchery-origin Chinook Salmon redds were found downstream of the Limekiln reach to the Del Loma reach where their redd numbers averaged between 5 and 17 per year in each reach. No redds were predicted to be associated with hatchery-origin Chinook Salmon downstream of the Del Loma reach from 2007 to 2022, but in 2023, one was predicted to be in the Hoopa Valley reach, one in Salyer Gorge, and two in Willow Creek Valley.

To account for annual variation in run size, the proportions of hatchery-origin Chinook Salmon redds within each of the reaches were compared to the annual total in the entire mainstem river (Figure 12). The majority of hatchery-origin Chinook Salmon redds were consistently observed in the Lewiston reach (range = 51.7%–95.4%, mean = 78.3%) and, to a smaller degree, the Limekiln reach (range = 3.5%–30.9%, mean = 15.0%) from 2002 to 2023. The proportion of hatchery-origin Chinook Salmon redds in the Lewiston reach decreased ($R^2 = 0.5928$, $p < 0.001$) while the proportion increased in the Limekiln reach ($R^2 = 0.5720$, $p < 0.001$) and slightly increased in the Douglas City reach ($R^2 = 0.2412$, $p = 0.02$) over this time period. The mean annual proportion of hatchery-origin Chinook Salmon redds in each reach downstream of the Limekiln reach ranged between 0.0% and 2.4% (Figure 12).

Redd Abundance and Distribution: Site Scale

The proportional abundance of natural-origin Chinook Salmon within the 44 site-scale river sections in the restoration reach showed a range of long-term (2002–2023) trends. Most sites (25) did not show a significant change, 14 sites showed an increasing trend, and 5 sites showed a decreasing trend (Appendix D). The three upstream-most sites (Lewiston Hatchery, Sven Olbertson, and Old Bridge sites) underwent significant decreases in the proportion of natural-origin Chinook Salmon redds. The sections from the Sawmill site to the Lower Indian Creek site did not significantly change except for an upward trend at the Tom Lang Gulch site and downward trend at the Poker Bar site. At each site from the Upper Douglas City site and downstream, the proportion of natural-origin Chinook Salmon redds either increased or showed no trend.

Of the 24 mechanical channel rehabilitation sites, the proportional abundance of natural-origin Chinook Salmon redds post-construction trended upward at 5 sites, trended downward at 2 sites, and displayed no significant change at 17 sites (Appendix E). Similar to the long-term trends, the proportional abundance of natural-origin Chinook Salmon redds decreased in the upstream-most sites (Lewiston Hatchery and Sven Olbertson sites) and either increased or showed no trend in the middle and downstream-most sites (Old Bridge to Pear Tree Bar sites).

Hatchery-origin Chinook Salmon redds were not distributed throughout the restoration sites and were too few or absent to merit statistical analysis at the site scale. Like at the reach scale, the percentage of hatchery-origin fish was at or close to 0.0% at most sites below the Limekiln reach from 2002 to 2023.

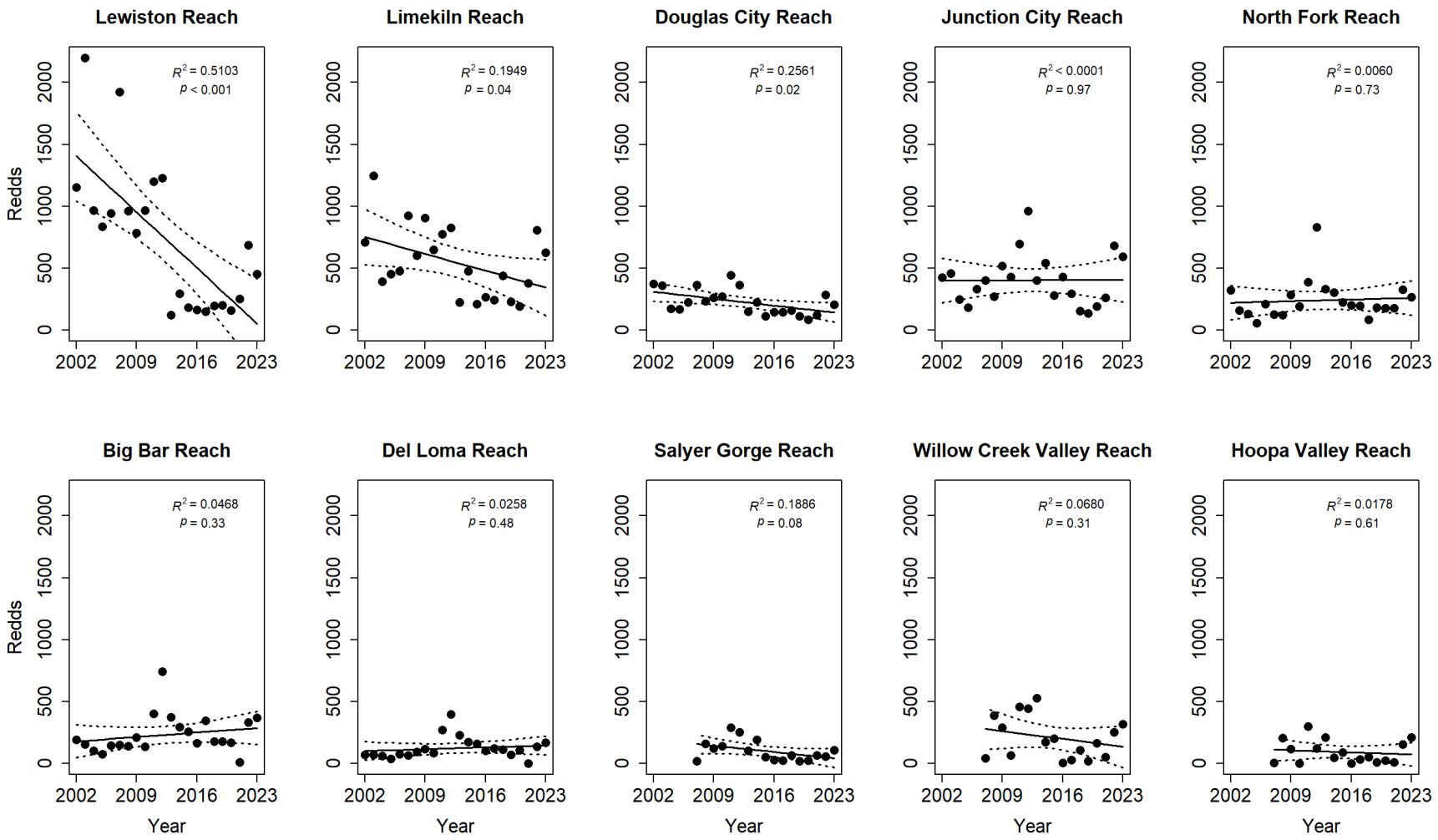


Figure 9. Estimated number of mainstem Trinity River natural-origin Chinook Salmon redds within ten reach-scale sections, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines).

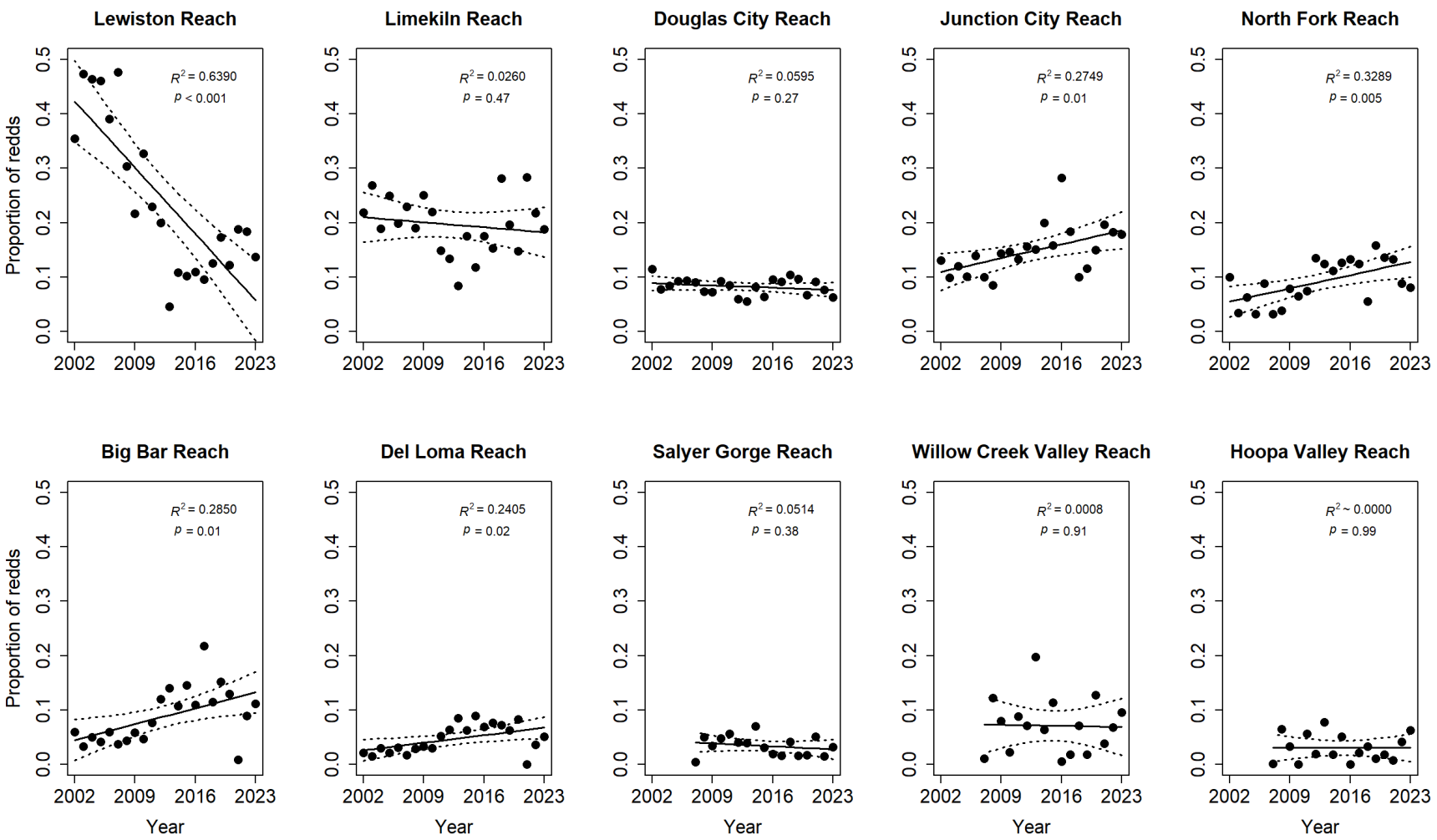


Figure 10. Proportions of mainstem Trinity River natural-origin Chinook Salmon redds relative to the total mainstem count of natural-origin Chinook Salmon redds within ten reach-scale sections, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines).

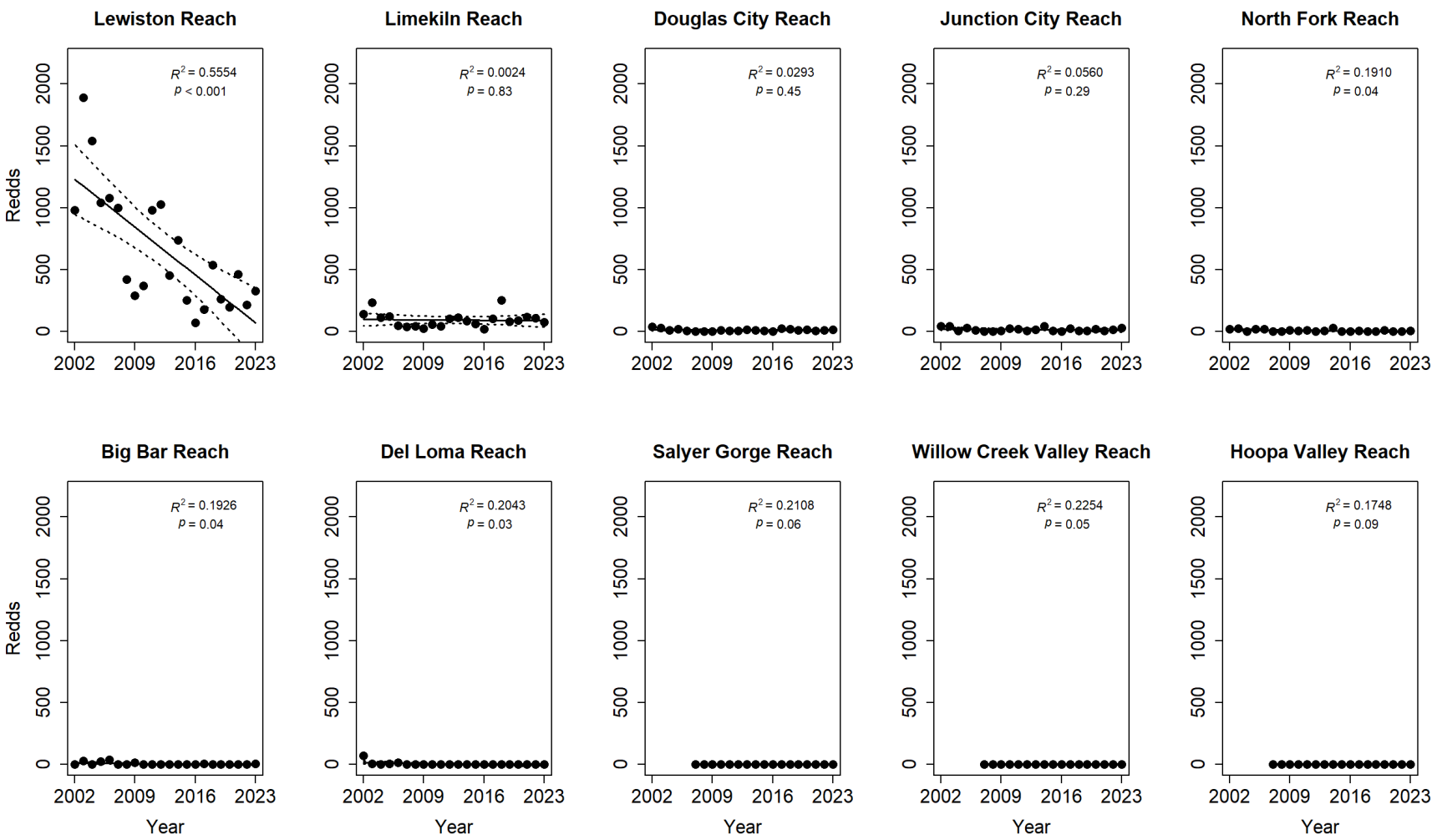


Figure 11. Estimated number of mainstem Trinity River hatchery-origin Chinook Salmon redds within ten reach-scale sections, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines).

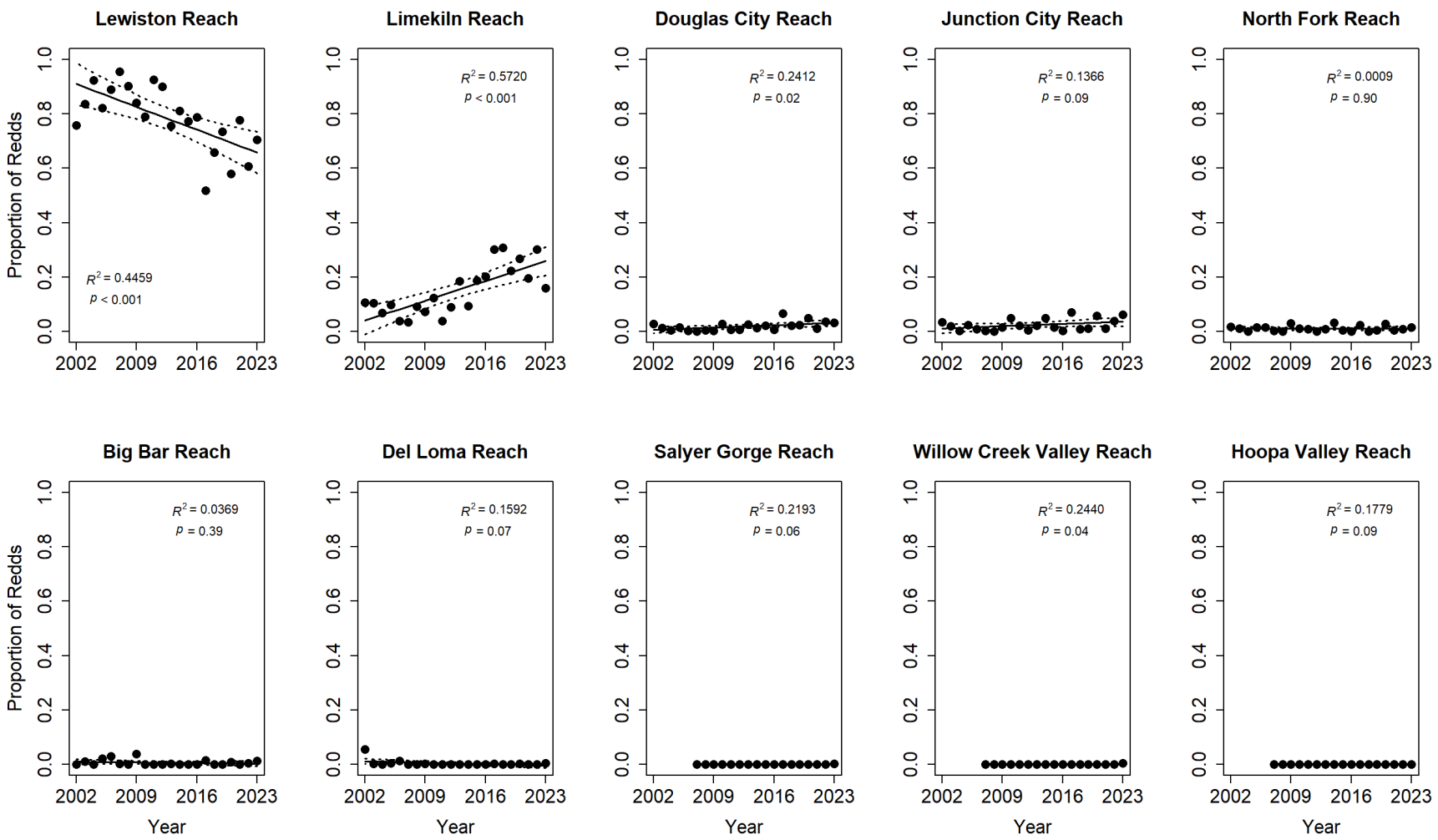


Figure 12. Proportions of mainstem Trinity River hatchery-origin Chinook Salmon redds relative to the total mainstem count of hatchery-origin Chinook Salmon redds within ten reach-scale sections, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines).

Discussion

Redd counts from the 2020, 2021, and 2023 spawning seasons were below the mean (3,955 redds) for the 2002–2023 period of record, and just above the mean in 2022. Compared to available estimates since 2012, Chinook Salmon carcass estimates in Reaches 1 and 2 were below average in 2020 and 2022, above average in 2021, and second highest in 2023. Results from 2020 to 2023 are mostly consistent with the California Department of Fish and Wildlife Chinook Salmon natural spawner escapement estimates for the Trinity River Basin, which estimated below-average numbers of spring-run Chinook Salmon in 2020, 2021, and 2023 and above average in 2022, and below-average numbers of fall-run Chinook Salmon from 2020 to 2022 and above average in 2023 (CDFW 2024a, 2024b). The 2020–2023 Trinity River fall-run natural-spawner adult Chinook Salmon escapement estimates continued to be notably below the TRRP annual river escapement goal of 62,000 naturally produced fall-run adults (CDFW 2024a). The escapement goal of 6,000 spring-run adults was met in 2022 for the third time since 2013 (CDFW 2024b).

The analyses of long-term data from our spawning surveys provide insight into the dynamics of Chinook Salmon spawning activity in the mainstem Trinity River. The main themes that emerge are 1) the annual abundance of natural-origin Chinook Salmon redds did not change significantly from 2002 to 2023, 2) straying and spawning of hatchery-origin salmon is generally confined to areas near the hatchery below Lewiston Dam, 3) the spatial distribution of natural-origin Chinook Salmon spawning continues to change, trending downriver, and 4) pre-spawn mortality has been relatively low in recent years.

The annual natural-origin Chinook Salmon redd count from 2002 to 2023 ranged between 1,117 (in 2019) and 6,170 (in 2012). Spawner abundance was hypothesized to increase following restoration actions (TRRP and ESSA 2009), but the abundance of natural-origin Chinook Salmon redds in the mainstem Trinity River from 2002 to 2023 did not significantly change (Figure 7). Other factors (e.g., harvest, ocean conditions, in-river conditions, etc.) may influence in-river escapement and thus mask responses of spawning activity to river restoration. Shifts in abundance are common to Chinook Salmon populations (Mantua et al. 1997; Brown 2002) and are evident in the Klamath Basin (CDFW 2024a, 2024b).

Although the abundance of natural-origin Chinook Salmon redds did not show a significant trend from 2002 to 2023, the spatial distribution of redds shifted downstream (Figure 8, Figure 10). The increase in mean distance from Lewiston Dam of natural-origin Chinook Salmon redds was previously documented (Chamberlain et al. 2012; Rupert et al. 2017a, 2017b; Gough et al. 2019, 2021a, 2021b) and data collected from 2020 to 2023 continued to follow this trend. This shift is consistent with the IAP's suggestion that changes in longitudinal redd distribution would happen within three to four brood cycles following restoration activities (TRRP and ESSA 2009).

The abundance of hatchery-origin Chinook Salmon redds (redds constructed by hatchery-produced females regardless of male origin) decreased significantly from 2002 to 2023, as evident in the Lewiston Reach where the majority of hatchery-origin Chinook Salmon spawn (Figure 11). Also, even though the distribution of hatchery-origin Chinook Salmon redds has remained skewed towards the TRH (Figure 5), the proportion of hatchery-origin

Chinook Salmon redds has generally decreased in the Lewiston Reach and increased in the Limekiln Reach (Figure 12). The number and release timing of marked hatchery-reared juvenile Chinook Salmon has remained relatively constant over these years, so the reason for the decrease in abundance of hatchery-origin Chinook Salmon redds is unclear. While IAP objectives advocate limiting the genetic interaction of hatchery- and natural-origin Chinook Salmon, having fewer hatchery-origin Chinook Salmon redds on the spawning grounds does support these objectives. Further investigations are suggested to examine the causes for this decrease in hatchery-origin Chinook redds.

Reach-scale analyses revealed the clearest resolution for analyzing spawning distribution shifts of natural-origin Chinook Salmon in the mainstem Trinity River. The proportion of natural-origin Chinook Salmon that spawned near TRH and Lewiston Dam (i.e., Lewiston Reach) decreased from 2002 to 2023 while the proportion in some mid-river sections (Junction City–Del Loma reaches) increased (Figure 10). Annual abundance of natural-origin Chinook Salmon redds decreased in the three upstream-most reaches (Lewiston, Limekiln, and Douglas City reaches) from 2002 to 2023, but no trend was detected in any reach downstream of the Douglas City Reach (Figure 9). The IAP hypothesized that redd abundance in the reaches below the North Fork Trinity River would not increase until escapement began to approach restoration goals (TRRP and ESSA 2009). TRRP restoration actions may therefore be influencing spawning distribution in the Trinity River but the goal to increase annual abundance has not yet been met. Presumably, flow management is the primary factor for the spawning distribution shift of natural-origin Chinook Salmon since the effects of flow extend downstream much further than the generally localized effects of mechanical channel rehabilitation, course sediment augmentation, and watershed (i.e., tributaries) restoration.

Changes in redd abundance at the site scale, the smallest scale used in our analyses, were specifically used to evaluate the effect of TRRP channel rehabilitation activities. Post-construction responses at rehabilitation sites have become clearer at some sites with the addition of data from 2020 to 2023, but more years of post-construction data should improve detection of responses to restoration. A positive response in the abundance of Chinook Salmon redds to channel rehabilitation may take many generations that encompass several years of geomorphic change and restoration site maturation. TRRP channel rehabilitation sites only secondarily affect spawning habitat since many constructed features are intended to increase and diversify juvenile rearing habitats and/or change the geomorphology of the site. The long-term effects of flow management, however, are intended to increase spawning habitat, though this would presumably affect all sites regardless of channel rehabilitation treatments (TRRP and ESSA 2009).

The relationship between redd counts and the estimated number of spawned female Chinook Salmon in Reaches 1 and 2 using the 2012–2023 data set indicate a density-dependent redd observation bias (Figure 6). This is contrary to the result that Rupert et al. (2017a) reported with just the 2012–2014 data set. The Reach 2 data point from 2012, the largest run year, appears to have a negative influence on the slope of the regression line. More large spawning runs in the future are needed validate or refute the density-dependent observation bias within this section of the river.

The importance of describing pre-spawn mortality has increased in recent years with ongoing drought conditions and associated higher risks of epizootic events. Aguilar et al.

(1996) reported that pre-spawn mortality for Chinook Salmon ranged between 1.1% and 44.9% in the mainstem Trinity River above the North Fork confluence from 1978 to 1982 and 1987 to 1995. In comparison, pre-spawn mortality rates that we measured were relatively low (between 0.0% and 9.5% from 2009 to 2019, 0.0% in 2020, 3.0% in 2021, 2.4% in 2022, and 0.9% in 2023) in this section of the river. Aguilar et al. (1996) also reported a positive correlation between pre-spawn mortality and run size for Trinity River Chinook Salmon from 1978 to 1995. After adding the 2020–2023 data to the data from 2009 to 2019, no correlation was detected between these two parameters in the restoration reach (Appendix F). The lack of correlation suggests that other factors beyond run size (i.e., river conditions, run timing, etc.) may be influencing pre-spawn mortality rates. The 2020–2023 Coho Salmon carcass numbers during the survey period continued to be notably small, as since 2015, and sample sizes (between 2 and 28 fresh females each year) were insufficient to evaluate pre-spawn mortality for this species. Interpretation of results pertaining to spawning success should consider that pre-spawn mortality goes beyond what we observe on the spawning ground surveys. The spatiotemporal locations of pre-spawn mortality carcass recoveries are unlikely to be an accurate depiction of when and where they were destined to spawn had they survived. For instance, pre-spawn mortality occurring in the Lower Klamath River for Trinity River-bound fish were not detectable during our Trinity River spawn surveys. Likewise, spring-run Chinook Salmon that expired well before the first surveys in September may also not have been detected.

Acknowledgements

We are grateful to work in partnership with the Yurok and Hoopa Valley tribes and recognize the importance of the salmon of the Trinity River to native history, culture, and subsistence. We extend special gratitude to Charlie Chamberlain (USFWS) and Derek Rupert [U.S. Bureau of Reclamation (BOR)] for producing the initial study designs and modeling scripts that provided the foundation for this project's analyses. Thanks to the field personnel that collected the data for this survey, including: Chad Abel (BOR), Tuffy Anzora (YTFP), Samantha Adams (USFWS), Lauren Alvarez (BOR), Jotham Barragar (USFS), Olivia Black (USFWS), Mike Bradford (CDFW), Jacqueline Bridegum (USFWS), Blaze Carpenter (YTFP), Sierra Castro (USFWS), Emmanuel Cyr (YTFP), Emily Cooper-Hertel (YTFP), Amelia Fleitz (USFS), Nick Glaser (USFWS), Jon Guczek (YTFP), Aliah Guerrero (USFWS), Braydon Hayes (HVT), Gabe Hayden (YTFP), Yadao Inong (YTFP), David Kissling (USFWS), Mikayla Logan (YTFP), Chris Laskodi (YTFP), Matthew Marshall (YTFP), Aaron Masse-Bachelier (USFWS), Quincy Masten (HVT), Thomas Masten (HVT), Albert Perry (YTFP), Max Ramos (YTFP), James Rickaby (HVT), Sophia Ritachka (YTFP), Arnold Sanchez (YTFP), Scott Searle (HVT), Clara Smith (USFWS), Ron Smith (CDFW), Hali Swasnick (CDFW), Adam Wojtczak (USFWS), and Keiki Yamasaki (YTFP).

Literature Cited

Aguilar, B., L. D. Davis, B. W. Collins, L. Hanson, W. Sinnen, M. Zuspan, and M. Dean. 1996. Annual Report: Trinity River Basin salmon and steelhead monitoring project, 1994–1995 season. R. M. Kano, editor. California Department of Fish and Game, Inland Fisheries Division, Sacramento, California. 223 p.

Bradford, M., and D. Hankin. 2012. Trinity River Restoration Program adult salmonid monitoring evaluation. Prepared for TRRP. Weaverville, California. 47 p.

Brown, E. M. 2002. 2000 salmon spawning ground surveys. Pacific Salmon Treaty Program, 538 Award Number NA77FP0445. Idaho Fish Game Report 02-33, Boise, Idaho.

Buffington, J., C. Jordan, M. Merigliano, J. Peterson, and C. Stalnaker. 2014. Review of the Trinity River Restoration Program following Phase 1, with emphasis on the Program's channel rehabilitation strategy. Prepared by the Trinity River Restoration Program's Science Advisory Board for the Trinity River Restoration Program with assistance from Anchor QEA, LLC, Stillwater Sciences, BioAnalysts, Inc., and Hinrichsen Environmental Services.

CDFW (California Department of Fish and Wildlife). 2024a. Klamath River Basin fall Chinook Salmon spawner escapement, in-river harvest and run-size estimates, 1978–2023. California Department of Fish and Wildlife, Arcata, California.

CDFW (California Department of Fish and Wildlife). 2024b. Klamath River Basin spring Chinook Salmon spawner escapement, river harvest and run-size estimates, 1980–2023. California Department of Fish and Wildlife, Arcata, California.

Chamberlain, C. D., S. Quinn, and W. Matilton. 2012. Distribution and abundance of Chinook Salmon redds in the mainstem Trinity River 2002 to 2011. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report TR 2012-16, Arcata, California.

Gaeuman, D., R. Stewart, and T. Buxton. 2016. First steps towards a river corridor management strategy. Technical report: TR-TRRP-2016-1. Trinity River Restoration Project, Weaverville, California.

Gough, S. A., N. A. Som, N. S. Quinn, W. C. Matilton, A. M. Hill, and W. Brock. 2019. Mainstem Trinity River Chinook Salmon spawning survey, 2017. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2019–62, Arcata, California.

Gough, S. A., N. A. Som, C. Laskodi, W. C. Matilton, A. M. Hill, and A. Fleitz. 2021a. Mainstem Trinity River Chinook Salmon spawning survey, 2018. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2021–65, Arcata, California.

Gough, S. A., N. A. Som, T. T. Daley, C. Laskodi, B. Lester, A. M. Hill, and E. Wiseman. 2021b. Mainstem Trinity River Chinook Salmon Spawning Survey, 2019. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2021–66, Arcata, California.

HVT (Hoopa Valley Tribe), McBain and Trush, and Northern Hydrology and Engineering. 2011. Channel rehabilitation design guidelines for the mainstem Trinity River. Prepared for the Trinity River Restoration Program, Hoopa, California.

Kery, M., and M. Schaub. 2012. Bayesian population analysis using WinBUGS. Academic Press, Oxford, United Kingdom.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78(6):1069–1080.

Moffett, J. W., and S. H. Smith. 1950. Biological investigations of the fishery resources of the Trinity River, California. Special Scientific Report No. 12, U.S. Fish and Wildlife Service. 71 p.

Quihillalt, R. R. 1999. Mainstem Trinity River fall Chinook Salmon spawning redd survey, 1996 through 1998. U.S. Fish and Wildlife Service, Arcata, California.

Rogers, D. W. 1972. King Salmon (*Oncorhynchus tshawytscha*) and Silver Salmon (*Oncorhynchus kisutch*) spawning escapement and spawning habitat in the upper Trinity River, 1970. California Fish and Game, Region 1, Anadromous Fisheries Branch Administrative Report Number 73-10.

Rupert, D. L., C. D. Chamberlain, S. A. Gough, N. A. Som, N. J. Davids, W. C. Matilton, A. M. Hill, and E. R. Wiseman. 2017a. Mainstem Trinity River Chinook Salmon Spawning Survey 2012-2014. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2017–52, Arcata, California.

Rupert, D. L., S. A. Gough, N. A. Som, N. J. Davids, W. C. Matilton, A. M. Hill, and J. L. Pabich. 2017b. Mainstem Trinity River Chinook Salmon Spawning Distribution, 2015 and 2016. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2017–56, Arcata, California.

TRRP and ESSA (Trinity River Restoration Program and ESSA Technologies Ltd.). 2009. Integrated Assessment Plan, Version 1.0 – September 2009. Draft report prepared for the Trinity River Restoration Project, Weaverville, California. 285 p.

USDOI (U.S. Department of Interior). 2000. Record of Decision: Trinity River mainstem fishery restoration final Environmental Impact Statement / Environmental Report.

USFWS (U.S. Fish and Wildlife Service). 1986, 1987. Trinity River flow evaluation study, 2 reports. Annual Report, U.S. Fish and Wildlife Service, Sacramento, California.

USFWS (U.S. Fish and Wildlife Service) and HVT (Hoopa Valley Tribe). 1999. Trinity River flow evaluation, Final Report. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California and Hoopa Valley Tribe, Hoopa, California.

Appendices

Appendix A. Trinity River water visibility by week and reach throughout the 2020–2023 survey periods. Grey boxes represent surveys with sub-optimal visibility. NS = No Survey for scheduled surveys that were missed. NA = This data was not recorded. Dashes (-) represent days when surveys were not scheduled or performed.

2020

Week start	Reach											
	1	2	3	4	5	6	7	9	10	12	13	14
Aug 30	NS	NS	NS	NS	NS	NS	NS	-	-	-	-	-
Sep 6	>3.0	>3.0	0.9-1.5	0.9-1.5	0.9-1.5 [a]	1.5-3.0	1.5-3.0	-	-	-	-	-
Sep 13	>3.0	>3.0	>3.0 [b]	>3.0	NS	1.5-3.0	1.5-3.0	1.5-3.0	NS	-	-	-
Sep 20	>3.0 [b]	>3.0 [b]	>3.0	>3.0	>3.0	1.5-3.0	1.5-3.0	1.5-3.0	-	NS	NS	NS
Sep 27	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0 [b]	NS	-	-	-
Oct 4	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	-	-	NS	NS	NS
Oct 11	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	-	-	-
Oct 18	NS	NS	>3.0	>3.0	NS	>3.0	>3.0	-	-	>3.0	>3.0	>3.0
Oct 25	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	1.5-3.0	>3.0	>3.0	-	-	-
Nov 1	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0 [b]	>3.0 [b]	-	-	>3.0	>3.0	NS
Nov 8	>3.0	>3.0	>3.0	0.9-1.5	>3.0	>3.0	>3.0	1.5-3.0 [b]	>3.0	-	-	-
Nov 15	1.5-3.0	1.5-3.0	0.9-1.5 [a]	0.9-1.5	1.5-3.0	1.5-3.0 [a]	1.5-3.0 [a]	-	-	<0.9	NS	NS
Nov 22	1.5-3.0	1.5-3.0	NS	NS	NS	0.9-1.5 [a]	0.9-1.5 [a]	NS [c]	NS [c]	-	1.5-3.0 [a]	-
Nov 29	1.5-3.0	1.5-3.0	1.5-3.0	NS	1.5-3.0	>3.0	>3.0	>3.0 [b]	>3.0 [b]	NS [c]	NS [c]	NS [c]
Dec 6	NS	NS	NS	NS	NS	>3.0	>3.0	NS	NS	NA	>3.0	NA
Dec 13	NS	NS	NS	NS	NS	NS	NS	-	-	NS	NS	NS

[a] This is the lower visibilty reported by the two crews. Chosen as reported visibility because more similar to other nearest reaches at the time.

[b] This is the higher visibilty reported by the two crews. Chosen as reported visibility because more similar to other nearest reaches at the time.

[c] Missed survey rescheduled for the following week.

Appendix A (continued). Trinity River water visibility by week and reach throughout the 2020–2023 survey periods. Grey boxes represent surveys with sub-optimal visibility. NS = No Survey for scheduled surveys that were missed. NA = This data was not recorded. Dashes (-) represent days when surveys were not scheduled or performed.

2021

Week start	Reach											
	1	2	3	4	5	6	7	9	10	12	13	14
Sep 5	NS	NS	NS	NS	NS	NS	NS	-	-	-	-	-
Sep 12	NS	>3.0	>3.0	>3.0	>3.0	>3.0 [a]	>3.0 [a]	>3.0 [a]	NS	-	-	-
Sep 19	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	-	-	>3.0	>3.0	NS
Sep 26	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	0.9-1.5	NS	-	-	-
Oct 3	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	-	-	>3.0	>3.0	NS
Oct 10	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	NS	NS	-	-	-
Oct 17	>3.0	>3.0	>3.0	<0.9	>3.0	1.5-3.0 [b]	1.5-3.0	-	-	1.5-3.0 [b]	NS	NS
Oct 24	>3.0	>3.0	>3.0	1.5-3.0	NS	1.5-3.0 [a]	1.5-3.0 [a]	NS	NS	-	-	-
Oct 31	>3.0	>3.0	1.5-3.0	NA	1.5-3.0 [b]	1.5-3.0 [a]	1.5-3.0 [a]	-	-	NS	NS	NS
Nov 7	1.5-3.0 [b,c]	1.5-3.0	1.5-3.0 [b]	NS	NS	0.9-1.5 [b]	0.9-1.5 [b]	NS	NS	-	-	-
Nov 14	1.5-3.0 [a,c]	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	0.9-1.5	0.9-1.5	-	-	1.5-3.0 [d]	1.5-3.0 [d]	1.5-3.0 [a]
Nov 21	0.9-1.5 [c]	1.5-3.0	NS	NS	NS	1.5-3.0 [a]	1.5-3.0 [a]	NS	NS	-	-	-
Nov 28	0.9-1.5 [c]	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0 [a]	1.5-3.0 [a]	-	-	1.5-3.0 [d]	1.5-3.0 [d]	1.5-3.0 [d]
Dec 5	1.5-3.0 [c]	NS	NS	NS	NS	NS	NS	NS	NS	-	-	-
Dec 12	NS	NS	NS	NS	NS	NS	NS	-	-	NS	NS	NS

[a] This is the higher visibilty reported by the two crews. Chosen as reported visibility because more similar to other nearest reaches at the time.

[b] This is the lower visibilty reported by the two crews. Chosen as reported visibility because more similar to other nearest reaches at the time.

[c] Not surveyed for redds, just carcasses, due to redds becoming indistinguishable on recently augmented gravel.

[d] Mean visibility reported between the two crews.

Appendix A (continued). Trinity River water visibility by week and reach throughout the 2020–2023 survey periods. Grey boxes represent surveys with sub-optimal visibility. NS = No Survey for scheduled surveys that were missed. NA = This data was not recorded. Dashes (-) represent days when surveys were not scheduled or performed.

2022

Week start	Reach											
	1	2	3	4	5	6	7	9	10	12	13	14
Sep 4	NA	NA	NA	NA	NA	NA	NA	-	-	-	-	-
Sep 11	NA	NA	NA	NA	NA	NA	NA	NA	NS	-	-	-
Sep 18	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0 [a]	1.5-3.0 [a]	1.5-3.0	1.5-3.0	-	-	0.9-1.5	0.9-1.5	0.9-1.5 [a]
Sep 25	>3.0	>3.0 [a]	>3.0	>3.0	1.5-3.0	>3.0	1.5-3.0	NA	1.5-3.0	-	-	-
Oct 2	NA	NA	NA	NA	NA	NA	NA	-	-	NA	NA	NS
Oct 9	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0 [a]	>3.0 [a]	-	-	-
Oct 16	>3.0	>3.0	NA	>3.0	>3.0	>3.0 [a]	>3.0 [a]	-	-	>3.0	>3.0 [a]	>3.0
Oct 23	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0 [a]	>3.0	-	-	-
Oct 30	>3.0	1.5-3.0	1.5-3.0	>3.0	NS	1.5-3.0	1.5-3.0	-	-	>3.0	>3.0 [a]	NS
Nov 6	>3.0	>3.0	NS	NS	NS	NS	NS	>3.0 [a]	>3.0 [a]	-	-	-
Nov 13	>3.0	>3.0	>3.0	>3.0	>3.0	>3.0 [a]	>3.0 [a]	-	-	>3.0	>3.0 [a]	>3.0
Nov 20	>3.0	>3.0	NS	NS	NS	NS	NS	>3.0 [a]	>3.0	-	-	-
Nov 27	>3.0	>3.0	>3.0	NS	>3.0	1.5-3.0	>3.0	-	-	NS	NS	NS
Dec 4	1.5-3.0	>3.0	>3.0	>3.0	>3.0	NS	NS	>3.0 [a]	>3.0 [a]	<0.9	-	-
Dec 11	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	NS	NS	-	-	NS	>3.0	NS
Dec 18	-	-	-	-	-	-	-	-	-	-	-	>3.0 [a]

[a] This is the higher visibilty reported by the two crews. Chosen as reported visibility because more similar to other nearest reaches at the time.

Appendix A (continued). Trinity River water visibility by week and reach throughout the 2020–2023 survey periods. Grey boxes represent surveys with sub-optimal visibility. NS = No Survey for scheduled surveys that were missed. NA = This data was not recorded. Dashes (-) represent days when surveys were not scheduled or performed.

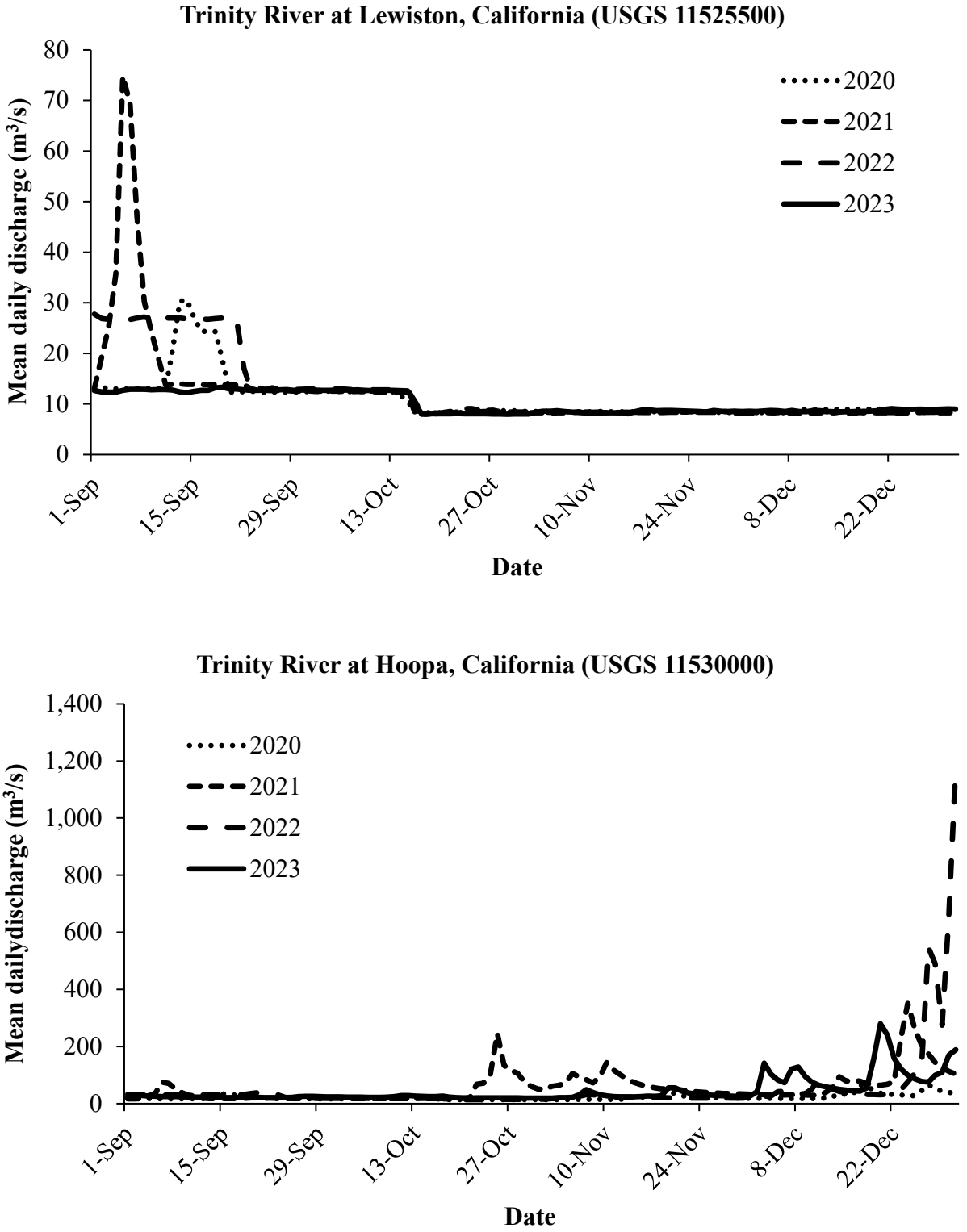
2023

Week start	Reach											
	1	2	3	4	5	6	7	9	10	12	13	14
Sep 3	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	>3.0	>3.0	-	-	-	-	-
Sep 10	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0 [a]	1.5-3.0 [a]	1.5-3.0	1.5-3.0	-	-	-
Sep 17	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	-	-	1.5-3.0 [a]	1.5-3.0 [a]	1.5-3.0 [a]
Sep 24	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0 [a]	1.5-3.0	1.5-3.0	NA	-	-	-
Oct 1	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	-	-	1.5-3.0 [a]	1.5-3.0 [a]	NS
Oct 8	0.9-1.5	0.9-1.5	1.5-3.0	1.5-3.0	1.5-3.0	0.9-1.5	0.9-1.5	0.9-1.5	0.9-1.5	-	-	-
Oct 15	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	0.9-1.5	0.9-1.5	-	-	1.5-3.0	1.5-3.0	1.5-3.0
Oct 22	1.5-3.0 [a]	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0 [a]	1.5-3.0 [b]	1.5-3.0 [a]	1.5-3.0 [a]	-	-	-
Oct 29	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0 [a]	1.5-3.0 [a]	-	-	1.5-3.0	1.5-3.0	NS
Nov 5	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	NS	1.5-3.0	1.5-3.0	0.9-1.5	0.9-1.5	-	-	-
Nov 12	1.5-3.0	0.9-1.5	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	-	-	0.9-1.5	1.5-3.0	1.5-3.0
Nov 19	1.5-3.0	1.5-3.0	NS	NS	NS	0.9-1.5	0.9-1.5	1.5-3.0 [b]	NS	-	-	-
Nov 26	>3.0	1.5-3.0	>3.0	1.5-3.0	>3.0	>3.0	>3.0	-	-	1.5-3.0 [b]	1.5-3.0 [b]	NS
Dec 3	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	NS	0.9-1.5 [c]	-	-	-
Dec 10	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	1.5-3.0	NS	NS	-	-	1.5-3.0	NS	1.5-3.0
Dec 17	0.9-1.5	-	-	-	-	-	-	-	-	-	-	-

[a] This is the lower visibilty reported by the two crews. Chosen as reported visibility because more similar to other nearest reaches at the time.

[b] This is the mean visibilty reported by the two crews.

[c] This is the higher visibilty reported by the two crews. Chosen as reported visibility because more similar to other nearest reaches at the time.



Appendix B. Trinity River mean daily discharge at Lewiston (USGS Gage 11525500) and Hoopa, California (USGS Gage 11530000) during the 2020-2023 salmon spawning survey seasons.

Appendix C. Pre-spawn mortality numbers by week and reach of unmarked and ad-clipped fresh (Conditions 1 and 2) female Chinook Salmon carcasses, mainstem Trinity River surveys 2020–2023. Also included are weekly pre-spawn mortality percentage among like mark-type carcasses. Ad-clipped carcass numbers were not expanded by CWT-specific production multipliers and are therefore about 25% of hatchery-origin carcass numbers. Likewise, unmarked carcass numbers include hatchery-origin carcasses that were not ad-clipped. 'NS' = no survey and dashes (-) represent a sample size of zero.

2020 unmarked

Calendar		Reach												All reaches	
week	Dates	1	2	3	4	5	6	7	9	10	12	13	14	n	Pct.
37	Sep 6-12	-	-	-	-	-	-	-	NS	NS	NS	NS	NS	-	-
38	Sep 13-19	-	-	-	-	NS	-	-	-	NS	NS	NS	NS	-	-
39	Sep 20-26	0	-	-	-	-	-	-	-	NS	NS	NS	NS	**0**	**0.0%**
40	Sep 27-Oct 3	0	0	0	0	0	-	-	-	NS	NS	NS	NS	**0**	**0.0%**
41	Oct 4-10	0	0	-	0	0	0	-	NS	NS	NS	NS	NS	**0**	**0.0%**
42	Oct 11-17	0	0	0	0	0	0	-	1	-	NS	NS	NS	**1**	**4.8%**
43	Oct 18-24	NS	NS	-	0	0	0	0	NS	NS	-	-	1	**1**	**11.1%**
44	Oct 25-31	0	0	0	0	0	0	0	-	0	NS	NS	NS	**0**	**0.0%**
45	Nov 1-7	0	0	0	0	-	0	-	NS	NS	-	-	NS	**0**	**0.0%**
46	Nov 8-14	0	0	0	-	0	-	0	0	-	NS	NS	NS	**0**	**0.0%**
47	Nov 15-21	0	0	-	-	0	0	-	NS	NS	-	NS	NS	**0**	**0.0%**
48	Nov 22-28	0	0	NS	NS	NS	-	-	NS	NS	NS	0	NS	**0**	**0.0%**
49	Nov 29-Dec 5	0	0	0	NS	-	0	-	0	0	NS	NS	NS	**0**	**0.0%**
50	Dec 6-12	NS	NS	NS	NS	NS	-	-	NS	NS	NS	-	NS	-	-
	All weeks	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**-**	**0**	**1**	***2***	***1.0%***

2020 ad-clipped

Calendar		Reach												All reaches	
week	Dates	1	2	3	4	5	6	7	9	10	12	13	14	n	Pct.
37	Sep 6-12	-	-	-	-	-	-	-	NS	NS	NS	NS	NS	-	-
38	Sep 13-19	-	-	-	-	NS	-	-	-	NS	NS	NS	NS	-	-
39	Sep 20-26	-	-	-	-	-	-	-	-	NS	NS	NS	NS	-	-
40	Sep 27-Oct 3	0	-	-	-	-	-	-	-	NS	NS	NS	NS	**0**	**0.0%**
41	Oct 4-10	0	0	-	-	-	-	-	NS	NS	NS	NS	NS	**0**	**0.0%**
42	Oct 11-17	-	0	-	0	-	0	-	-	-	NS	NS	NS	**0**	**0.0%**
43	Oct 18-24	NS	NS	-	-	-	-	-	NS	NS	-	-	-	-	-
44	Oct 25-31	-	-	-	-	-	-	-	-	-	NS	NS	NS	-	-
45	Nov 1-7	-	-	-	-	-	-	-	NS	NS	-	-	NS	-	-
46	Nov 8-14	0	-	-	-	-	-	-	-	-	NS	NS	NS	**0**	**0.0%**
47	Nov 15-21	0	-	-	-	-	-	-	NS	NS	-	NS	NS	**0**	**0.0%**
48	Nov 22-28	0	0	NS	NS	NS	-	-	NS	NS	NS	-	NS	**0**	**0.0%**
49	Nov 29-Dec 5	0	0	-	NS	-	-	-	-	-	NS	NS	NS	**0**	**0.0%**
50	Dec 6-12	NS	NS	NS	NS	NS	-	-	NS	NS	NS	-	NS	-	-
	All weeks	**0**	**0**	**-**	**0**	**-**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	***0***	***0.0%***

Appendix C (continued). Pre-spawn mortality numbers by week and reach of unmarked and ad-clipped fresh (Conditions 1 and 2) female Chinook Salmon carcasses, mainstem Trinity River surveys 2020–2023. Also included are weekly pre-spawn mortality percentage among like mark-type carcasses. Ad-clipped carcass numbers were not expanded by CWT-specific production multipliers and are therefore about 25% of hatchery-origin carcass numbers. Likewise, unmarked carcass numbers include hatchery-origin carcasses that were not ad-clipped. 'NS' = no survey and dashes (-) represent a sample size of zero.

2021 unmarked

Calendar		Reach												All reaches	
week	Dates	1	2	3	4	5	6	7	9	10	12	13	14	n	Pct.
38	Sep 12-18	NS	-	-	0	-	-	-	-	NS	NS	NS	NS	**0**	**0.0%**
39	Sep 19-25	1	0	0	0	-	-	-	NS	NS	1	-	NS	**2**	**33.3%**
40	Sep 26-Oct 2	0	0	0	0	0	1	-	-	NS	NS	NS	NS	**1**	**3.4%**
41	Oct 3-9	0	1	0	0	-	-	-	NS	NS	-	-	NS	**1**	**2.7%**
42	Oct 10-16	0	0	0	0	0	0	0	NS	NS	NS	NS	NS	**0**	**0.0%**
43	Oct 17-23	1	0	0	-	0	0	0	NS	NS	-	NS	NS	**1**	**3.7%**
44	Oct 24-30	1	-	0	0	0	0	0	NS	NS	NS	NS	NS	**1**	**5.3%**
45	Oct 31-Nov 6	0	3	1	0	0	0	0	NS	NS	NS	NS	NS	**4**	**4.4%**
46	Nov 7-13	1	0	0	NS	0	0	-	NS	NS	NS	NS	NS	**1**	**0.7%**
47	Nov 14-20	1	0	1	0	-	-	0	NS	NS	-	0	0	**2**	**2.2%**
48	Nov 21-27	0	0	-	NS	NS	0	-	NS	NS	NS	NS	NS	**0**	**0.0%**
49	Nov 28-Dec 4	0	0	0	-	-	0	-	NS	NS	-	-	-	**0**	**0.0%**
50	Dec 5-11	-	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-
	All weeks	**5**	**4**	**2**	**0**	**0**	**1**	**0**	**-**	**-**	**1**	**0**	**0**	***13***	***2.5%***

2021 ad-clipped

Calendar		Reach												All reaches	
week	Dates	1	2	3	4	5	6	7	9	10	12	13	14	n	Pct.
38	Sep 12-18	NS	-	-	-	-	-	-	-	NS	NS	NS	NS	-	-
39	Sep 19-25	-	-	-	-	-	-	-	NS	NS	-	-	NS	-	-
40	Sep 26-Oct 2	0	0	-	-	0	-	-	-	NS	NS	NS	NS	**0**	**0.0%**
41	Oct 3-9	0	0	-	-	-	-	-	NS	NS	-	-	NS	**0**	**0.0%**
42	Oct 10-16	-	-	-	-	-	-	-	NS	NS	NS	NS	NS	-	-
43	Oct 17-23	-	0	-	-	-	-	-	NS	NS	-	NS	NS	**0**	**0.0%**
44	Oct 24-30	0	0	-	-	-	-	-	NS	NS	NS	NS	NS	**0**	**0.0%**
45	Oct 31-Nov 6	0	1	-	-	-	-	-	NS	NS	NS	NS	NS	**1**	**6.7%**
46	Nov 7-13	1	2	-	NS	-	-	-	NS	NS	NS	NS	NS	**3**	**11.1%**
47	Nov 14-20	1	0	-	-	-	-	-	NS	NS	-	-	-	**1**	**6.7%**
48	Nov 21-27	1	0	-	NS	NS	-	-	NS	NS	NS	NS	NS	**1**	**7.1%**
49	Nov 28-Dec 4	0	0	-	-	-	-	-	NS	NS	-	-	-	**0**	**0.0%**
50	Dec 5-11	-	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-
	All weeks	**3**	**3**	**-**	**-**	**0**	**-**	**-**	**-**	**-**	**0**	**0**	**0**	***6***	***6.7%***

Appendix C (continued). Pre-spawn mortality numbers by week and reach of unmarked and ad-clipped fresh (Conditions 1 and 2) female Chinook Salmon carcasses, mainstem Trinity River surveys 2020–2023. Also included are weekly pre-spawn mortality percentage among like mark-type carcasses. Ad-clipped carcass numbers were not expanded by CWT-specific production multipliers and are therefore about 25% of hatchery-origin carcass numbers. Likewise, unmarked carcass numbers include hatchery-origin carcasses that were not ad-clipped. 'NS' = no survey and dashes (-) represent a sample size of zero.

2022 unmarked

Calendar		Reach												All reaches	
week	Dates	1	2	3	4	5	6	7	9	10	12	13	14	n	Pct.
37	Sep 4-10	-	-	-	-	-	-	-	NS	NS	NS	NS	NS	-	-
38	Sep 11-17	0	-	-	-	-	-	-	-	NS	NS	NS	NS	**0**	**0.0%**
39	Sep 18-24	-	0	0	0	0	-	-	NS	NS	-	-	-	**0**	**0.0%**
40	Sep 25-Oct 1	0	0	0	0	0	-	-	-	1	NS	NS	NS	**1**	**1.0%**
41	Oct 2-8	NS	NS	NS	NS	0	0	1	NS	NS	0	0	NS	**1**	**6.7%**
42	Oct 9-15	1	0	0	0	0	0	1	0	0	NS	NS	NS	**2**	**1.8%**
43	Oct 16-22	0	0	0	0	0	2	2	NS	NS	-	-	-	**4**	**5.5%**
44	Oct 23-29	0	0	0	0	0	2	0	2	1	NS	NS	NS	**5**	**7.8%**
45	Oct 30-Nov 5	0	0	0	0	NS	0	-	NS	NS	0	0	NS	**0**	**0.0%**
46	Nov 6-12	0	0	NS	NS	NS	NS	NS	0	-	NS	NS	NS	**0**	**0.0%**
47	Nov 13-19	4	0	0	0	0	-	-	NS	NS	0	0	0	**4**	**7.7%**
48	Nov 20-26	0	1	NS	NS	NS	NS	NS	0	-	NS	NS	NS	**1**	**2.3%**
49	Nov 27-Dec 3	0	0	0	NS	-	-	-	NS	NS	NS	NS	NS	**0**	**0.0%**
50	Dec 4-10	0	0	-	0	-	NS	NS	-	-	-	NS	NS	**0**	**0.0%**
51	Dec 11-17	-	0	-	-	-	NS	NS	-	-	NS	0	NS	**0**	**0.0%**
	All weeks	**5**	**1**	**0**	**0**	**0**	**4**	**4**	**2**	**2**	**0**	**0**	**0**	***18***	***3.0%***

2022 ad-clipped

Calendar		Reach												All reaches	
week	Dates	1	2	3	4	5	6	7	9	10	12	13	14	n	Pct.
37	Sep 4-10	-	-	-	-	-	-	-	NS	NS	NS	NS	NS	-	-
38	Sep 11-17	0	-	0	-	-	-	-	-	NS	NS	NS	NS	**0**	**0.0%**
39	Sep 18-24	-	-	-	-	-	-	-	NS	NS	-	-	-	-	-
40	Sep 25-Oct 1	0	0	-	0	-	-	-	-	-	NS	NS	NS	**0**	**0.0%**
41	Oct 2-8	NS	NS	NS	NS	-	-	-	NS	NS	-	-	NS	-	-
42	Oct 9-15	-	-	-	0	-	-	-	-	-	NS	NS	NS	**0**	**0.0%**
43	Oct 16-22	-	-	-	-	-	-	-	NS	NS	-	-	-	-	-
44	Oct 23-29	-	-	-	-	-	-	-	-	-	NS	NS	NS	-	-
45	Oct 30-Nov 5	0	0	-	-	NS	-	-	NS	NS	-	-	NS	**0**	**0.0%**
46	Nov 6-12	0	0	NS	NS	NS	NS	NS	-	-	NS	NS	NS	**0**	**0.0%**
47	Nov 13-19	0	0	-	-	-	-	-	NS	NS	-	-	-	**0**	**0.0%**
48	Nov 20-26	0	0	NS	NS	NS	NS	NS	-	-	NS	NS	NS	**0**	**0.0%**
49	Nov 27-Dec 3	0	-	-	NS	-	-	-	NS	NS	NS	NS	NS	**0**	**0.0%**
50	Dec 4-10	-	-	-	-	-	NS	NS	-	-	-	NS	NS	-	-
51	Dec 11-17	-	-	-	-	-	NS	NS	-	-	NS	-	NS	-	-
	All weeks	**0**	**0**	**0**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	***0***	***0.0%***

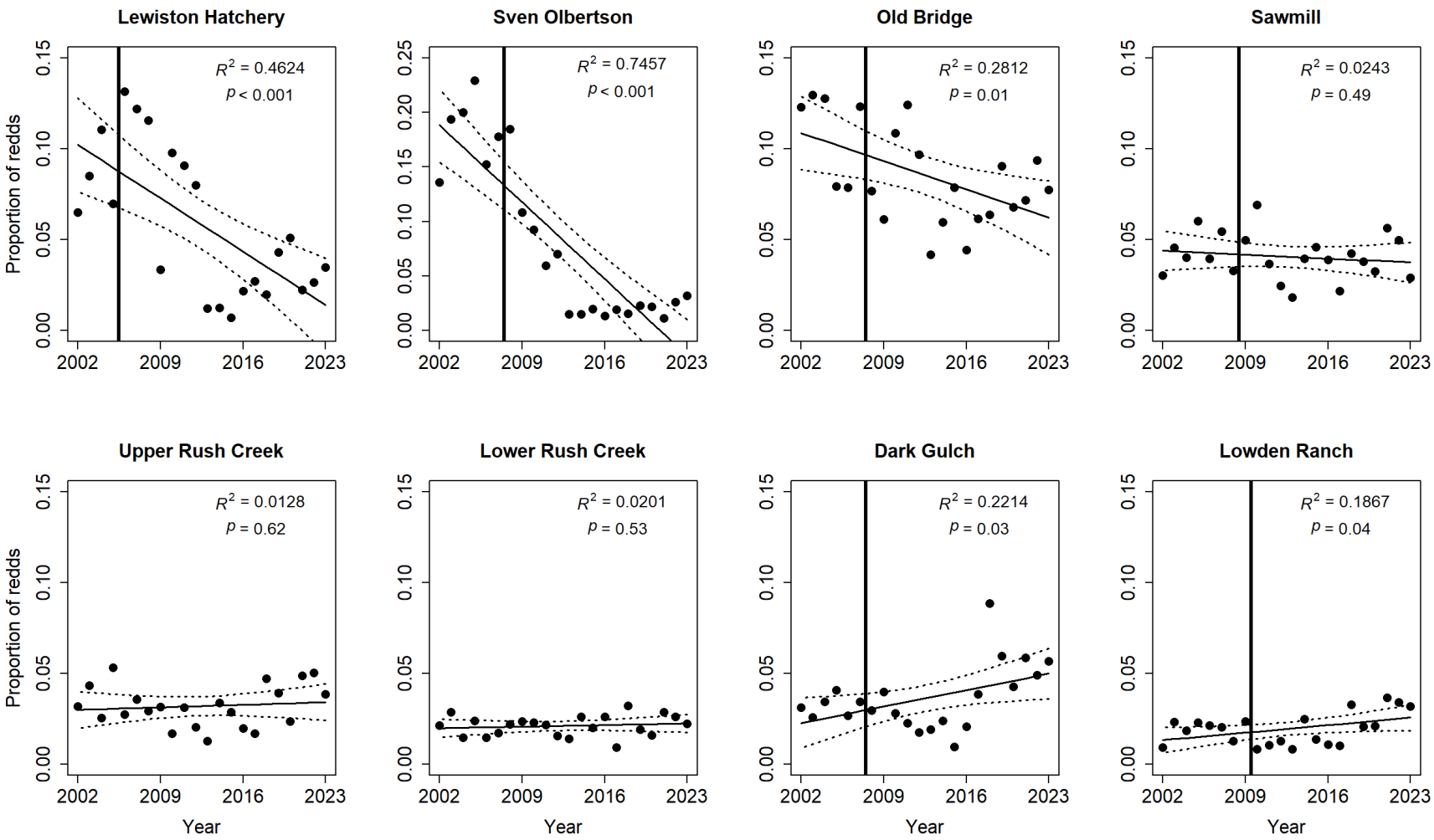
Appendix C (continued). Pre-spawn mortality numbers by week and reach of unmarked and ad-clipped fresh (Conditions 1 and 2) female Chinook Salmon carcasses, mainstem Trinity River surveys 2020–2023. Also included are weekly pre-spawn mortality percentage among like mark-type carcasses. Ad-clipped carcass numbers were not expanded by CWT-specific production multipliers and are therefore about 25% of hatchery-origin carcass numbers. Likewise, unmarked carcass numbers include hatchery-origin carcasses that were not ad-clipped. 'NS' = no survey and dashes (-) represent a sample size of zero.

2023 unmarked

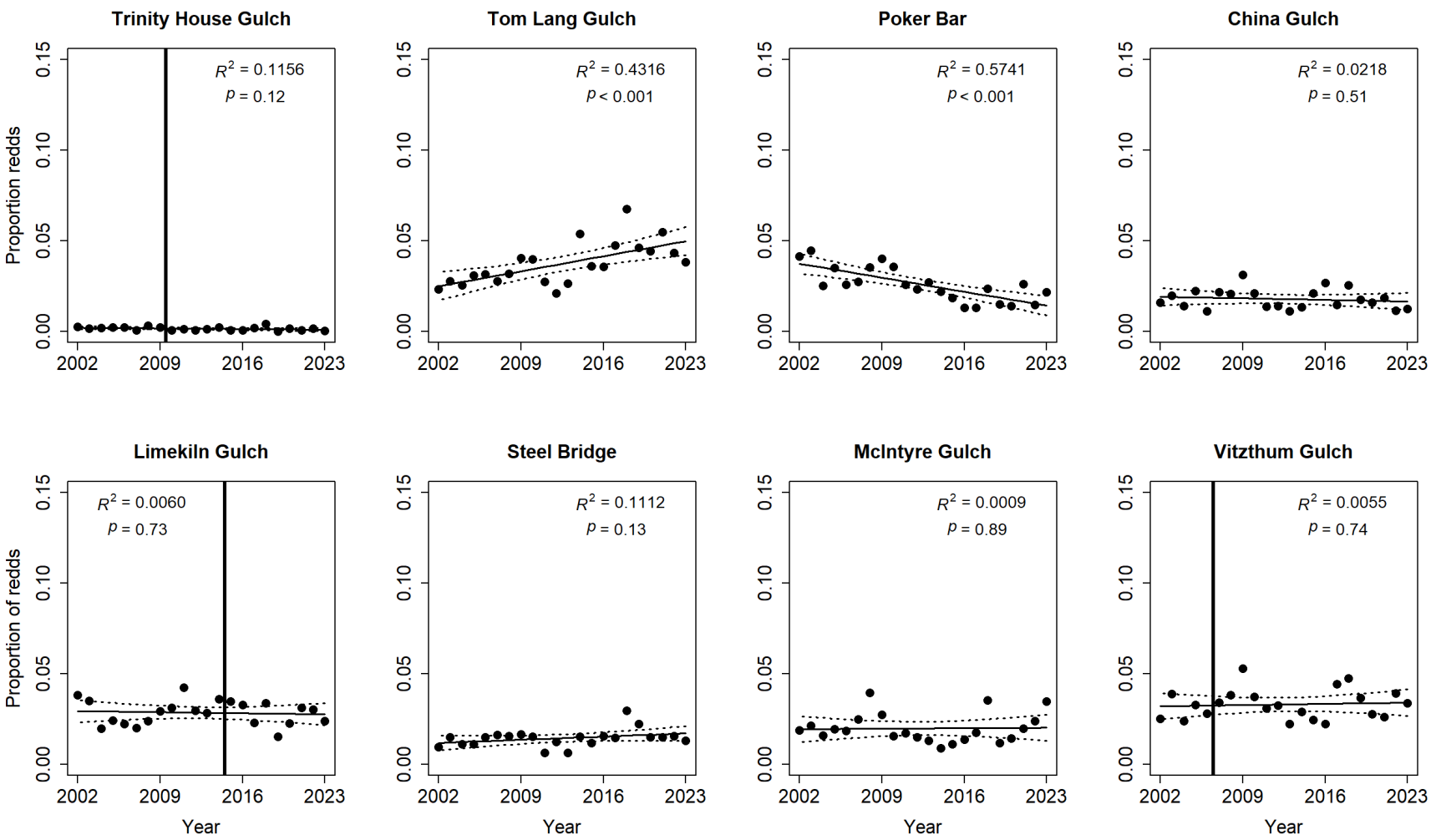
Calendar		Reach												All reaches	
week	Dates	1	2	3	4	5	6	7	9	10	12	13	14	n	Pct.
36	Sep 3-9	-	-	-	-	-	-	-	NS	NS	NS	NS	NS	-	-
37	Sep 10-16	-	-	-	-	-	-	-	-	-	NS	NS	NS	-	-
38	Sep 17-23	0	0	-	0	-	-	-	NS	NS	-	1	-	**1**	**10.0%**
39	Sep 24-30	0	0	1	0	0	-	-	-	-	NS	NS	NS	**1**	**3.0%**
40	Oct 1-7	0	0	0	0	0	0	-	NS	NS	-	-	NS	**0**	**0.0%**
41	Oct 8-14	0	0	0	0	0	0	0	-	-	NS	NS	NS	**0**	**0.0%**
42	Oct 15-21	1	0	0	0	0	0	0	NS	NS	-	-	-	**1**	**1.3%**
43	Oct 22-28	0	0	0	0	0	0	0	2	0	NS	NS	NS	**2**	**2.2%**
44	Oct 29-Nov 4	0	0	0	0	0	0	0	NS	NS	0	0	NS	**0**	**0.0%**
45	Nov 5-11	0	-	0	0	0	0	0	0	0	NS	NS	NS	**0**	**0.0%**
46	Nov 12-18	0	0	0	0	0	0	-	NS	NS	0	0	0	**0**	**0.0%**
47	Nov 19-25	1	2	NS	NS	NS	0	-	0	NS	NS	NS	NS	**3**	**3.6%**
48	Nov 26-Dec 2	0	0	0	-	0	-	-	NS	NS	0	0	NS	**0**	**0.0%**
49	Dec 3-9	1	0	-	-	-	-	-	NS	-	NS	NS	NS	**1**	**1.2%**
50	Dec 10-16	0	0	0	-	-	NS	NS	NS	NS	-	NS	-	**0**	**0.0%**
51	Dec 17-23	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**0**	**0.0%**
	All weeks	**3**	**2**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**1**	**0**	***9***	***1.1%***

2023 ad-clipped

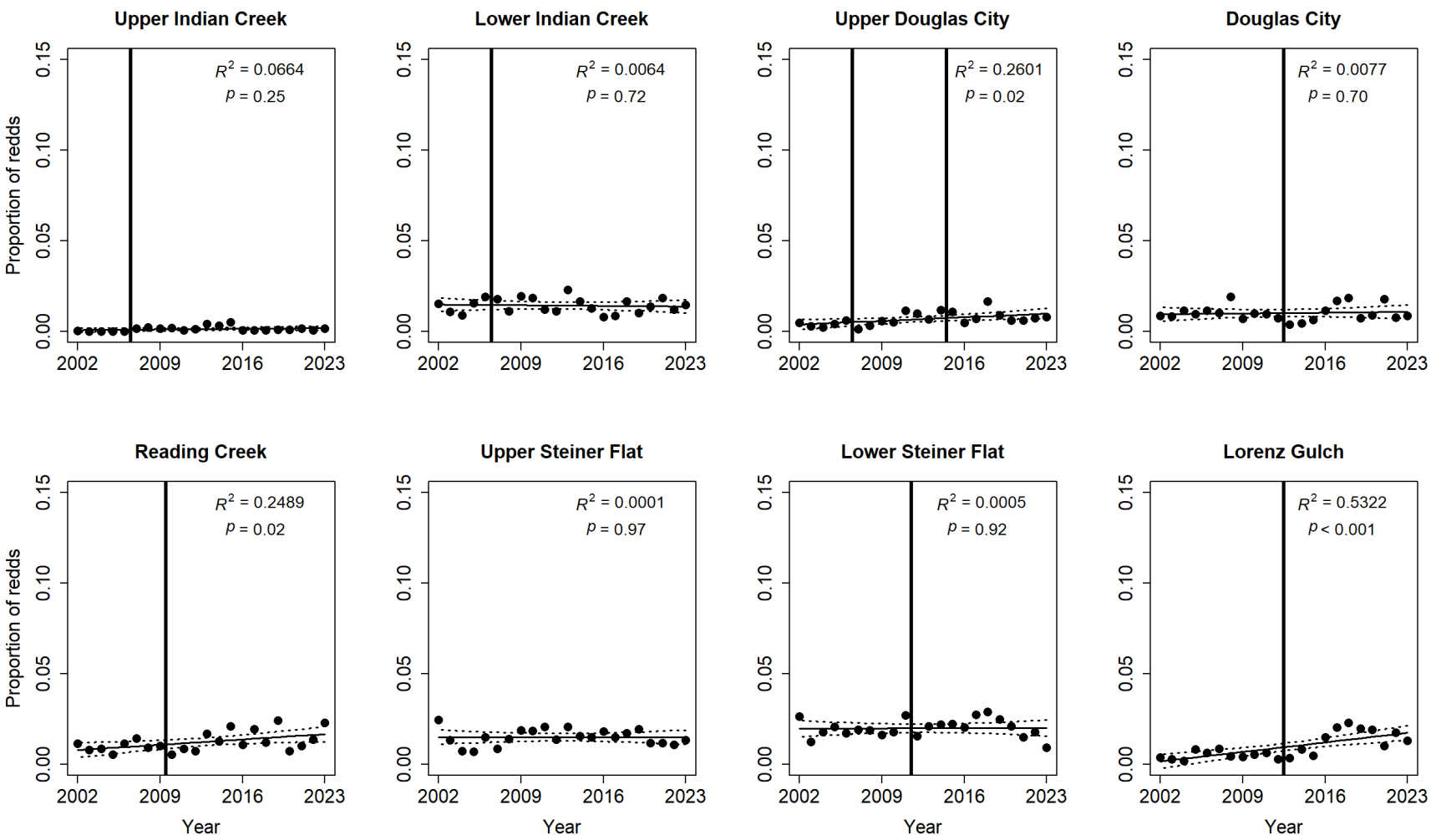
Calendar		Reach												All reaches	
week	Dates	1	2	3	4	5	6	7	9	10	12	13	14	n	Pct.
36	Sep 3-9	-	-	-	-	-	-	-	NS	NS	NS	NS	NS	-	-
37	Sep 10-16	-	-	-	-	-	-	-	-	-	NS	NS	NS	-	-
38	Sep 17-23	-	-	-	-	-	-	-	NS	NS	-	-	-	-	-
39	Sep 24-30	-	-	-	-	-	-	-	-	-	NS	NS	NS	-	-
40	Oct 1-7	-	-	-	-	-	-	-	NS	NS	-	-	NS	-	-
41	Oct 8-14	-	-	-	-	-	-	-	-	-	NS	NS	NS	-	-
42	Oct 15-21	-	-	-	-	-	-	-	NS	NS	-	-	-	-	-
43	Oct 22-28	-	-	-	0	-	-	-	-	-	NS	NS	NS	**0**	**0.0%**
44	Oct 29-Nov 4	-	-	-	-	-	-	-	NS	NS	-	-	NS	-	-
45	Nov 5-11	-	-	-	-	-	-	-	-	-	NS	NS	NS	-	-
46	Nov 12-18	0	0	-	-	-	-	-	NS	NS	-	-	-	**0**	**0.0%**
47	Nov 19-25	0	0	NS	NS	NS	-	-	-	NS	NS	NS	NS	**0**	**0.0%**
48	Nov 26-Dec 2	0	0	-	-	-	-	-	NS	NS	-	-	NS	**0**	**0.0%**
49	Dec 3-9	0	1	-	-	-	-	-	NS	-	NS	NS	NS	**1**	**7.7%**
50	Dec 10-16	0	0	-	-	-	NS	NS	NS	NS	-	NS	-	**0**	**0.0%**
51	Dec 17-23	0	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**0**	**0.0%**
	All weeks	**0**	**1**	**-**	**0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	***1***	***1.9%***



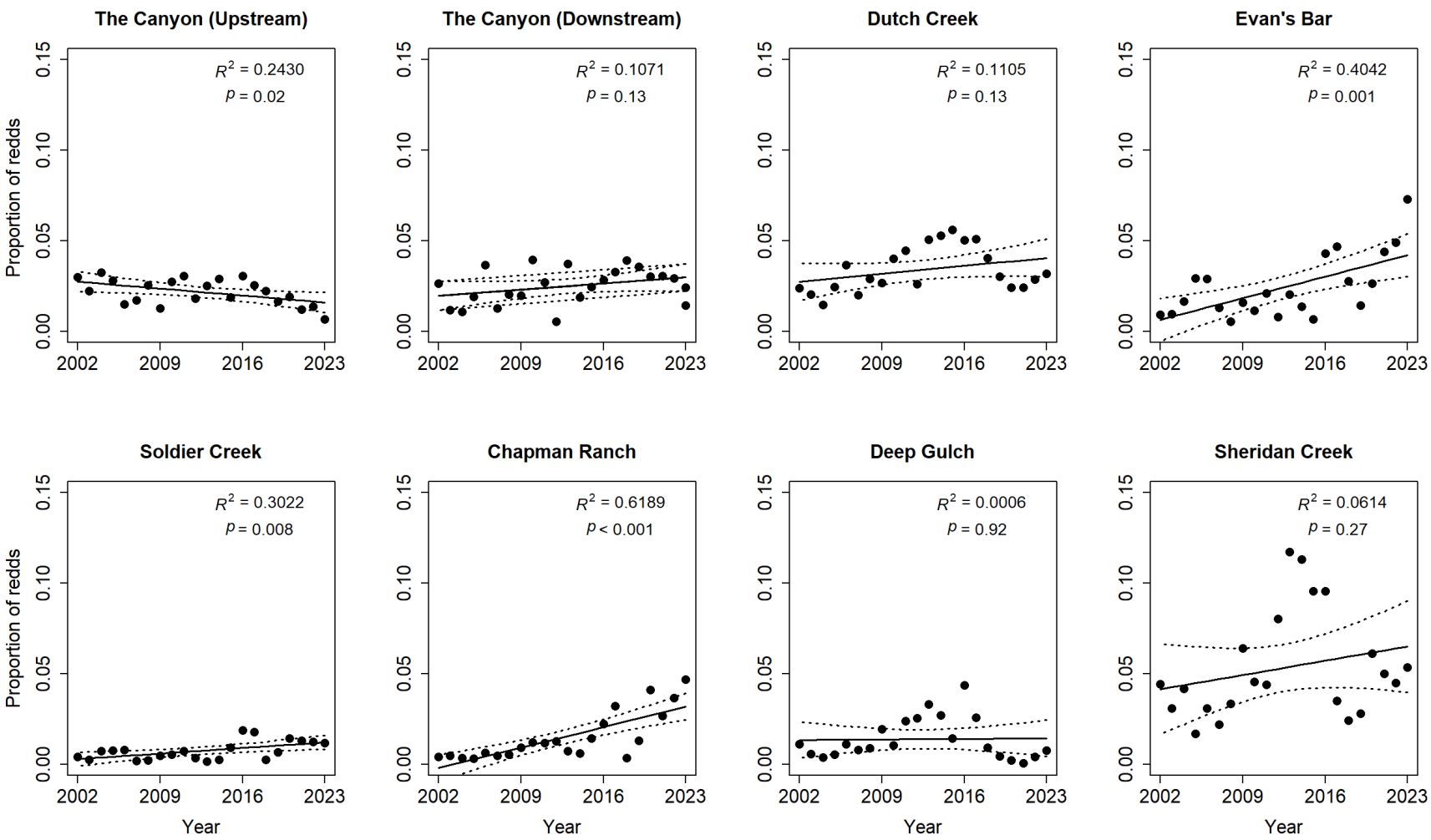
Appendix D. Proportion of TRRP restoration reach natural-origin Chinook Salmon redds within site-scale sections, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines). The time mechanical channel rehabilitation was initiated is shown as black vertical bars. Note the change in y-axis scale in the Sven Olbertson site.



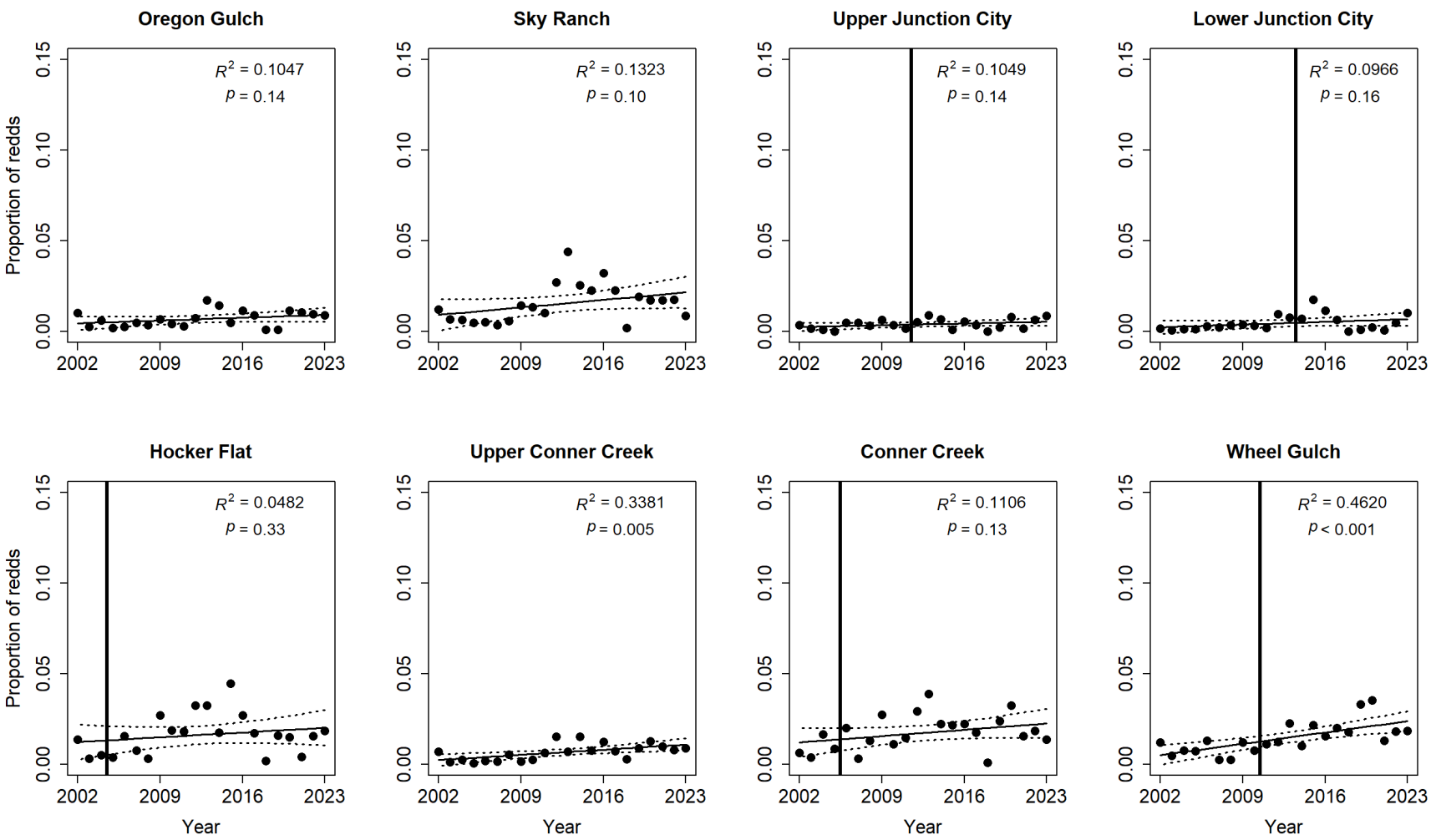
Appendix D (continued). Proportion of restoration reach natural-origin Chinook Salmon redds within site-scale sections, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines). The time mechanical channel rehabilitation was initiated is shown as black vertical bars.



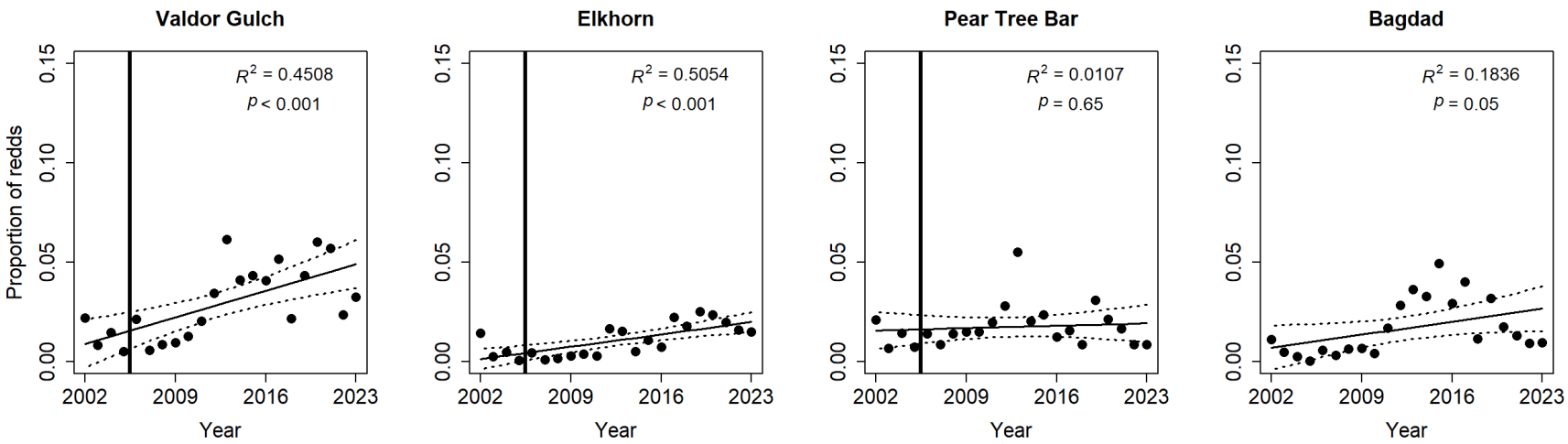
Appendix D (continued). Proportion of restoration reach natural-origin Chinook Salmon redds within site-scale sections, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines). The time mechanical channel rehabilitation was initiated is shown as black vertical bars.



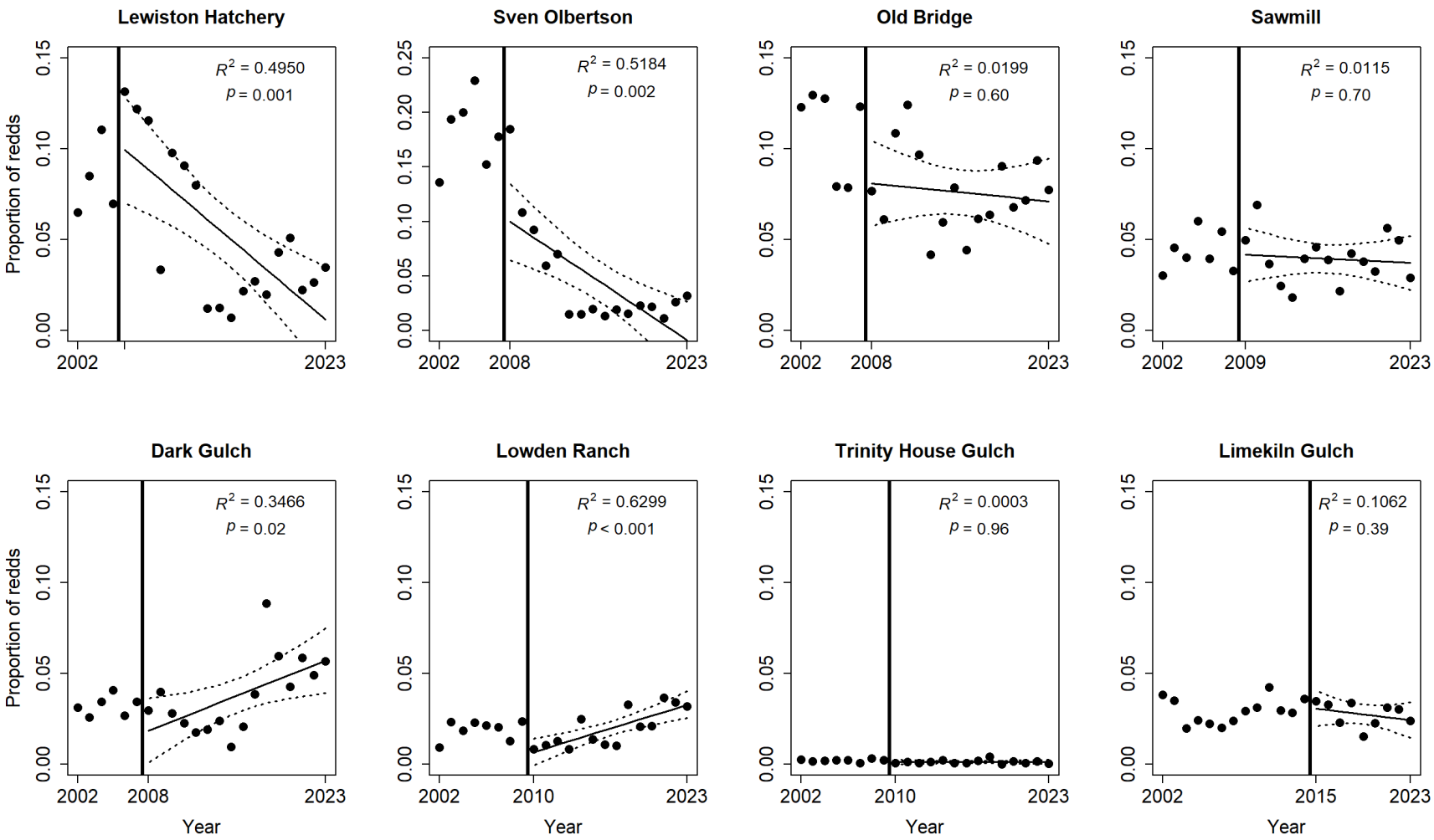
Appendix D (continued). Proportion of restoration reach natural-origin Chinook Salmon redds within site-scale sections, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines).



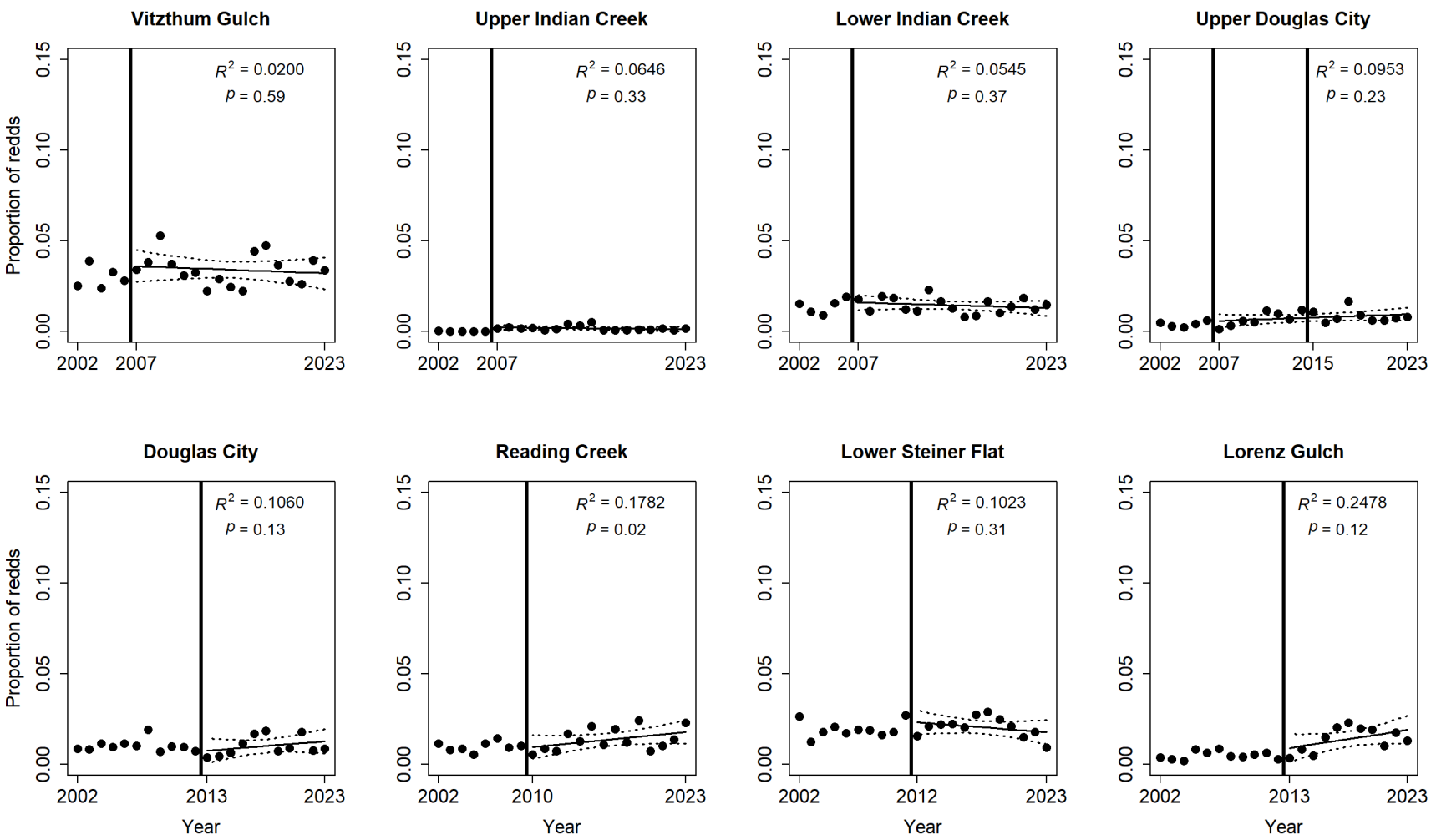
Appendix D (continued). Proportion of restoration reach natural-origin Chinook Salmon redds within site-scale sections, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines). The time mechanical channel rehabilitation was initiated is shown as black vertical bars.



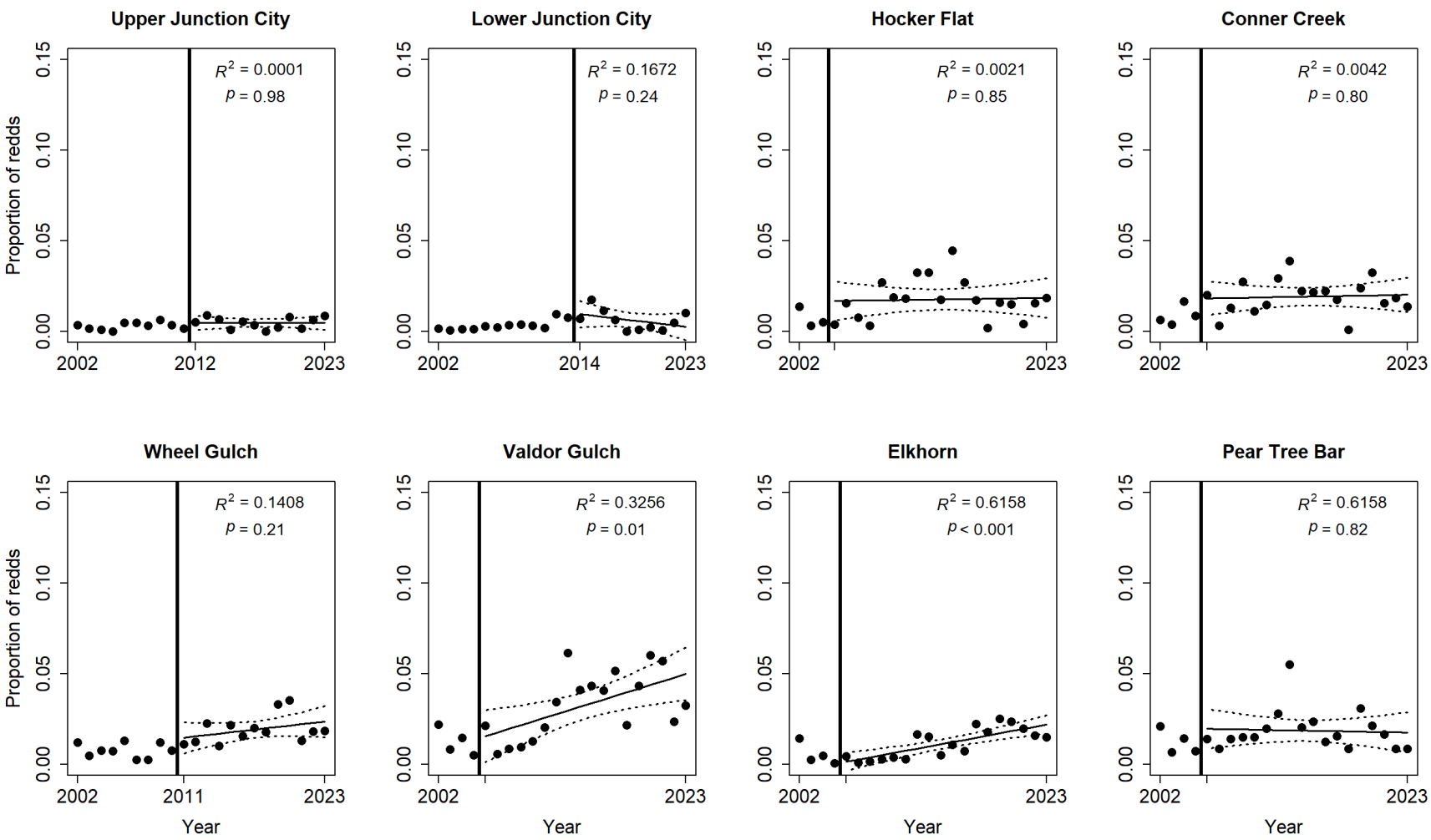
Appendix D (continued). Proportion of restoration reach natural-origin Chinook Salmon redds within site-scale sections, 2002–2023. Each plot includes a linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines). The time mechanical channel rehabilitation was initiated is shown as black vertical bars.



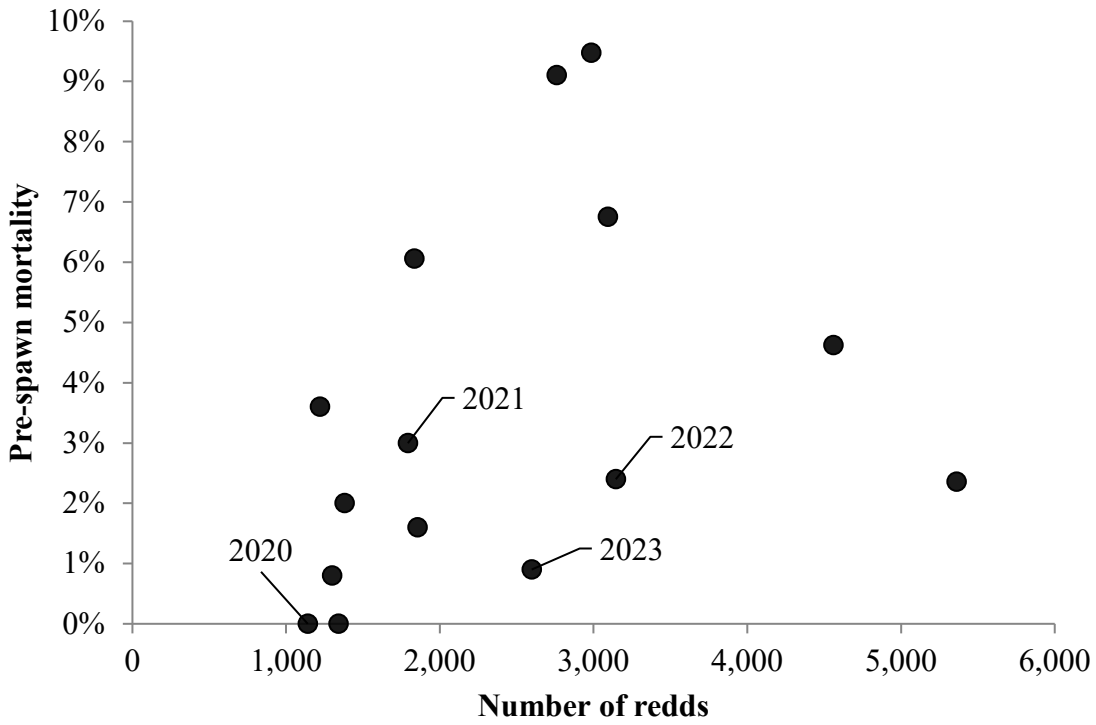
Appendix E. Proportion of natural-origin Chinook Salmon redds within site-scale sections in the TRRP restoration reach that encompass mechanical channel rehabilitation locations, 2002–2023. Each plot includes a post-construction linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines). The time mechanical channel rehabilitation was initiated is shown as black vertical bars.



Appendix E (continued). Proportion of natural-origin Chinook Salmon redds within site-scale sections in the TRRP restoration reach that encompass mechanical channel rehabilitation locations, 2002–2023. Each plot includes a post-construction linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines). The time mechanical channel rehabilitation was initiated is shown as black vertical bars.



Appendix E (continued). Proportion of natural-origin Chinook Salmon redds within site-scale sections in the TRRP restoration reach that encompass mechanical channel rehabilitation locations, 2002–2023. Each plot includes a post-construction linear model with the R^2 value, p-value, and 95% confidence limits (dotted lines). The time mechanical channel rehabilitation was initiated is shown as black vertical bars.



Appendix F. Natural-origin Chinook Salmon redd counts versus estimates of pre-spawn mortality from Lewiston Dam to the North Fork confluence, Trinity River surveys, 2009–2023.