4 North-Central California Coast Recovery Domain

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The North-Central California Coast Recovery Domain encompasses the geographic region from Redwood Creek (Humboldt County) south to Aptos Creek (Santa Cruz County) inclusive. Two salmon Evolutionarily Significant Units (ESUs) and two steelhead Distinct Population Segments (DPSs) lie wholly within this region: California Coastal Chinook Salmon, Central California Coast Coho Salmon, Northern California Steelhead, and Central California Coast Steelhead.

The Technical Recovery Team (TRT) for the North-Central California Coast Recovery Domain prepared two documents intended to guide recovery planning efforts for the ESA-listed salmonids within the domain. The first of these reports described the historical population structure of the four listed ESU/DPSs within the recovery domain (Bjorkstedt et al. 2005). Within this document, the TRT categorized each population into one of three distinct types based on its posited historical functional role:

> *Functionally independent populations*: populations with a high likelihood of persisting over 100-year time scales and that conform to the definition of independent "viable salmonid populations" offered by McElhany et al. (2000).
>
> *Potentially independent populations*: populations with a high likelihood of persisting over 100-year time scales, but that were too strongly influenced by immigration from other populations to exhibit independent dynamics.
>
> *Dependent populations*: populations that had a substantial likelihood of going extinct within 100-year time period in isolation, yet received sufficient immigration to alter their dynamics and reduce their risk of extinction.

In addition to categorizing individual populations, the population structure report also places populations into *diversity strata*, which are groups of populations that likely exhibit genotypic and phenotypic similarity due to exposure to similar environmental conditions or common evolutionary history (Bjorkstedt et al. 2005; revised in Spence et al. 2008). Here, the TRT set the stage for development of viability criteria that consider processes and risks operating at spatial scales larger than those of individual populations.

The second TRT report proposes a framework for assessing viability of populations and ESU/DPSs within the recovery domain (Spence et al. 2008). This report establishes both population-level and ESU/DPS-level biological viability criteria. The population viability criteria developed by the TRTs represent an extension of an approach developed by Allendorf et al. (1997) and include criteria related to population abundance (effective population size), population decline, catastrophic decline, spawner density, and hatchery influence (Table 4.1). In general, the spawner density low-risk criterion, which seeks to ensure a population's ability to fulfill its historical functional role within the ESU, is the most conservative, and preliminary viability targets for each population were determined primarily by this criterion. The ESU-level criteria are intended to ensure representation of the diversity within an ESU/DPS across much of its historical range, to buffer the

Table 4.1. Criteria for assessing the level of risk of extinction for populations of Pacific salmonids. Overall risk is determined by the highest risk score for any category. N_g = generational sum of abundance*;* N_e = effective population size*;* and N_a = annual spawner abundance. From Spence et al. (2008).

Population Characteristic	Extinction Risk: High	Extinction Risk: Moderate	Extinction Risk: Low
Extinction risk from population viability analysis (PVA)	≥ 20% within 20 yrs - or any ONE of the following -	≥ 5% within 100 yrs but < 20% within 20 yrs - or any ONE of the following -	< 5% within 100 yrs - or ALL of the following -
Effective population size per generation *-or-* Total population size per generation	$N_e \leq 50$ *-or-* $N_g \leq 250$	$50 < N_e < 500$ *-or-* $250 < N_g < 2500$	$N_e \geq 500$ *-or-* $N_g \geq 2500$
Population decline	Precipitous decline[a]	Chronic decline or depression[b]	No decline apparent or probable
Catastrophic decline	Order of magnitude decline within one generation	Smaller but significant decline[c]	Not apparent
Spawner density	$N_a/IPkm$[d] ≤ 1	$1 < N_a/IPkm <$ MRD[e]	$N_a/IPkm \geq$ MRD[e]
Hatchery influence[f]	Evidence of adverse genetic, demographic, or ecological effects of hatcheries on wild population		No evidence of adverse genetic, demographic, or ecological effects of hatchery fish on wild population

a – Population has declined within the last two generations or is projected to decline within the next two generations (if current trends continue) to annual run size $N_a \leq 500$ spawners (historically small but stable populations not included) *or* $N_a > 500$ but declining at a rate of ≥10% per year over the last two-to-four generations.
b – Annual run size N_a has declined to ≤ 500 spawners, but is now stable *or* run size $N_a > 500$ but continued downward trend is evident.
c – Annual run size decline in one generation < 90% but biologically significant (e.g., loss of year class).
d – *IPkm* = the estimated aggregate intrinsic habitat potential for a population inhabiting a particular watershed (i.e., total accessible km weighted by reach-level estimates of intrinsic potential; see Bjorkstedt et al. [2005] for greater elaboration).

ESU/DPS against potential catastrophic risks, and to provide sufficient connectivity among populations to maintain long-term demographic and genetic processes. These criteria are summarized in Table 4.2.

Since the TRT developed viability criteria for the NCCC Recovery Domain, NMFS recovery planning teams have completed the federal recovery plan for CCC-Coho Salmon (NMFS 2012a). This plan includes establishment of population-level and ESU-level recovery criteria for independent populations of the CCC-Coho Salmon ESU. These

Table 4.2. ESU-level criteria for assessing the level of risk of extinction for Pacific salmonid ESUs. From Spence et al. (2008).

Criterion	Description
Representation	All identified diversity strata that include historical functionally or potentially independent populations within an ESU/DPS should be represented by viable populations for the ESU/DPS to be considered viable -AND- Within each diversity stratum, all extant phenotypic diversity (i.e., major life-history types) should be represented by viable populations
Redundancy and Connectivity	At least 50% of historically independent populations in each diversity stratum must be demonstrated to be at low risk of extinction according to the population viability criteria outlined in Table 1 of Spence et al. (2008) -AND- Within each diversity stratum, the total aggregate abundance of independent populations selected to satisfy this criterion must meet or exceed 50% of the aggregate viable population abundance (i.e., meeting density-based criteria for low risk) for all independent populations Remaining populations, including historical dependent populations and any historical independent populations that are not expected to attain a viable status must exhibit occupancy patterns consistent with those expected under sufficient immigration subsidy arising from the "core" independent populations selected to satisfy the preceding criterion The distribution of extant populations, regardless of historical status, must maintain connectivity within the diversity stratum, as well as connectivity to neighboring diversity strata

recovery criteria generally follow the viability criteria developed by the TRT, but may deviate slightly for certain populations based on additional analysis. Additionally, the plan develops numeric criteria for selected dependent populations. For the purpose of this viability assessment, we use the recovery criteria for CCC-Coho Salmon outlined in the recovery plan as the benchmark for assessing viability.

A draft multispecies recovery plan covering the CC-Chinook Salmon ESU , NC-Steelhead DPS, and CCC-Steelhead DPS is currently undergoing public review. Because the recovery criteria specified in this draft plan are subject to change, we have used the TRT's viability criteria as the basis for evaluating viability in this review.

Application of recovery and viability criteria requires population-level estimates of adult spawner abundance spanning a minimum of four generations for independent populations (Spence et al. 2008). In reality, for most of the salmon and steelhead populations in this recovery domain, estimates meeting these criteria are lacking. However, since the mid-2000s, implementation of the Coastal Monitoring Plan (CMP) has greatly expanded, and shorter time series of adult spawner abundance are now available for many watersheds. In other areas, indices of spawner abundance or local population estimates representing only a portion of the population constitute the best available data. If data collection has occurred in a consistent manner, these shorter time series, indices, or partial population estimates are presented herein despite the shortcomings, as they provide the only basis for evaluating current viability. However, the reader is cautioned that short-term trends in abundance or abundance indices can be highly misleading given natural variation in environmental conditions in both the freshwater and marine environments. A complete list of data sources for the analysis of ESU/DPSs in the North-Central California Coast Recovery Domain can be found in Appendix A.

4.1 Central California Coast Coho Salmon ESU

ESU Boundary Delineation

The initial status review for the Central California Coast (CCC) Coho Salmon ESU (Weitkamp et al. 1995) defined the ESU as populations from Punta Gorda southward to and including the San Lorenzo River. Since that time, the boundary has been extended southward to include Soquel and Aptos creeks (77 FR 19552) based on analysis of historical and recent evidence of occurrence as well as environmental conditions in these two watersheds (Spence et al. 2011). Successful reproduction of coho salmon in Soquel Creek was again documented in summer of 2015 (B. Spence and J. Kiernan, NMFS SWFSC, personal communication), which supports the boundary extension.

In 2003, NMFS Southwest Fisheries Science Center conducted an extensive genetic survey of coho salmon populations in coastal California. Genetic samples were taken from juvenile coho salmon collected at 30 sites in 23 different watersheds spanning the SONCC and CCC ESUs. Multiple analyses of microsatellite data provided consistent and strong support for the current ESU boundary at Punta Gorda (Gilbert-Horvath et al. in press).

Summary of Previous Assessments

Status reviews by Weitkamp et al. (1995) and Good et al. (2005) both concluded that the CCC-Coho Salmon ESU was in danger of extinction. These reviews cited concerns over low abundance and long-term downward trends in abundance throughout the ESU, as well as extirpation or near extirpation of populations across most of the southern two-thirds of the ESU’s historical range, including several major river basins. They further cited as risk factors the potential loss of genetic diversity associated with range reductions or loss of one or more brood lineages, coupled with historical influence of hatchery fish (Good et al. 2005). NMFS initially listed CCC-Coho Salmon ESU as threatened in 1996 (61 FR 56138), but changed the status to endangered in 2005 (70 FR 37160). In the most recent assessment, Spence and Williams (2011) concluded that conditions of populations in the CCC-Coho Salmon ESU had worsened since 2005, noting negative trends for most independent and dependent populations for which longer term monitoring data were available, and the near complete collapse and loss of genetic diversity for populations in the Santa Cruz Mountains Diversity Stratum. NMFS subsequently concluded that the CCC-Coho Salmon ESU remained endangered (77 FR 19552).

New Data and Updated Analyses

Abundance and Trends

Information on population status and trends for CCC-Coho Salmon has improved considerably since the 2010 viability assessment due to recent implementation of the Coastal Monitoring Plan across significant portions of the ESU. Population estimates are based on redd counts from surveys of stream reaches selected according to a Generalized Randomized Tessellation Survey (GRTS) design. Redd counts are then expanded to adult estimates based on spawner:redd ratios determined at a network of life-cycle monitoring stations. Although many of the time series of abundance do not currently meet the requisite four generations called for by the TRT for application of viability criteria, they still provide a substantially better basis for assessing viability compared with previous reviews and will increase greatly in value as these time series become longer. Below, we review available information for each of the four diversity strata for which recovery criteria have been proposed.

Lost Coast – Navarro Point Stratum. Population-level estimates of adult abundance are now available for all four independent populations and as well as seven dependent populations of coho salmon within this stratum. For the Noyo River, Pudding Creek, Caspar Creek, and Little River, these time series span from 12–15 years, whereas for the remainder of populations, the time series are shorter (3–6 years). Recent population estimates indicate that population sizes are currently from 4% (Big River) to 13% (Noyo River) of the proposed recovery targets (Table 4.3). One population (Big River) is below the high-risk depensation threshold ($D_{dep} = 0.6$) and a second (Albion River) is right at the threshold ($D_{dep} = 1.0$). Recent trends are variable, with the Ten Mile River, Big River, and Albion River showing positive but non-significant trends ($p > 0.10$) and the Noyo River showing essentially no trend (Table 4.3; Figures 4.1a-d; Figures 4.2a-d). Importantly, the Noyo River time series is six years longer than the other populations, and the trend for the past 5–6 years has been positive.

For dependent populations, Pudding Creek and Caspar Creek appear to be the strongest populations, with average returns of 417 and 115 adults, respectively over the last 14–15 years (Table 4.4). These numbers are approximately 42% and 26% of recovery targets, respectively. However, trends for these two populations, as well as for the Little River population, for the period of record are negative and significant ($p < 0.05$) (Table 4.4; Figure 4.3b-d; Figure 4.4b-d). Very low numbers of coho salmon have been observed in Usal Creek and Big Salmon Creek, and no coho salmon have been observed in four years of record for Wages Creek and Cottaneva Creek (Table 4.4).

Table 4.3. Viability metrics for independent populations of coho salmon in the CCC-Coho Salmon ESU. NA indicates not available or applicable. Trends are shown only for populations where time series is at least six years; bold indicates significant trend. IPkm includes only habitats that are currently accessible. $N_{a(arith)}$ target refers to target identified in recovery plan (NMFS 2012a).

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{C}$	$\hat{T}$ (95% CI)	IPkm	$\hat{D}_{dep}$	$\hat{D}_{ssd}$	$\hat{D}_{ssd}$ target	$\overline{N}_{a(arith)}$ target
Lost Coast - Navarro Pt											
Ten Mile River[a]	6	359	69	1163	NA	0.300 (-1.794, 2.393)	105.1	1.9	3.4	34.9	3700
Noyo River[a]	12	539	455	1182	0.50	-0.020 (-0.114, 0.073)	118.0	2.4	4.4	34.0	4000
Big River[a]	6	220	183	609	NA	0.224 (-0.134, 0.582)	191.8	0.6	1.1	28.9	5500
Albion River[a]	6	188	21	328	NA	0.243 (-1.798, 2.285)	59.2	1.0	3.2	38.1	2300
Navarro Pt - Gualala Pt											
Navarro River[a]	6	257	102	867	NA	-0.645 (-2.158, 0.868)	201.0	1.0	1.3	28.3	5700
Garcia River[a]	6	64	18	166	NA	-0.276 (-1.766, 1.214)	76.0	0.4	0.8	36.9	3700
Gualala River	-	-	-	-	-	-	251.6	-	-	24.8	6200
Coastal											
Russian River[b]	5	364	-	-	-	-	757.4	-	-	20.0	10100
Walker Creek	-	-	-	-	-	-	76.2	-	-	36.9	2600
Lagunitas Creek[c]	17	512	408	1109	0.85	-0.063 (-0.140, 0.014)	70.4	1.8	6.9	37.3	2600
Santa Cruz Mtn											
Pescadero Creek[d]	4	0	1	0	NA	NA	60.6	0	0	38.0	2300
San Lorenzo River[d]	3	1	1	3	NA	NA	126.4	0	0	33.4	3800

a – Numbers indicate the estimated number of adults based on fish/redd expansions from life-cycle monitoring stations.
b – Numbers indicate expanded estimates derived from multiple methods (spawner surveys, adult traps, video counts, PIT tag detections, hatchery returns, and independent observations, as well as inference from juvenile observations and downstream migrant trapping). As methods and spatial extent have varied over time, only arithmetic mean is presented as a minimum estimate. give a .
c – Numbers indicate 2x total redd counts. Methods have not yet been developed to derive fish/redd estimates for expansion.
d – Numbers indicate numbers of observed fish (live adults + carcasses). Methods have not yet been developed to derive fish/redd estimates for expansion.

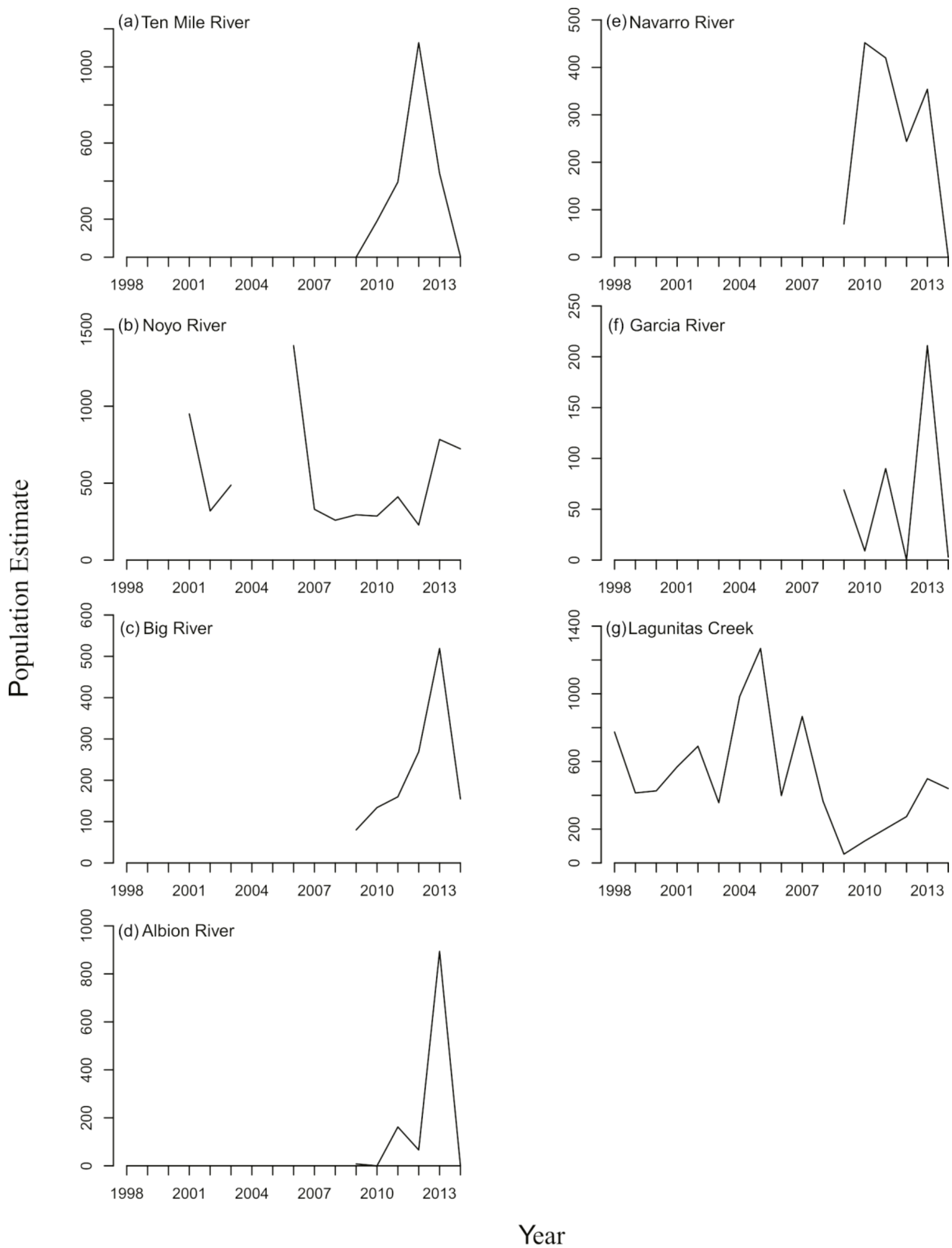

Figure 4.1. Time series of population abundance estimates for independent populations of CCC-Coho Salmon. Values for Lagunitas Creek are two times the total redd count for the watershed. All other estimates are based on fish/redd expansions from life-cycle monitoring stations.

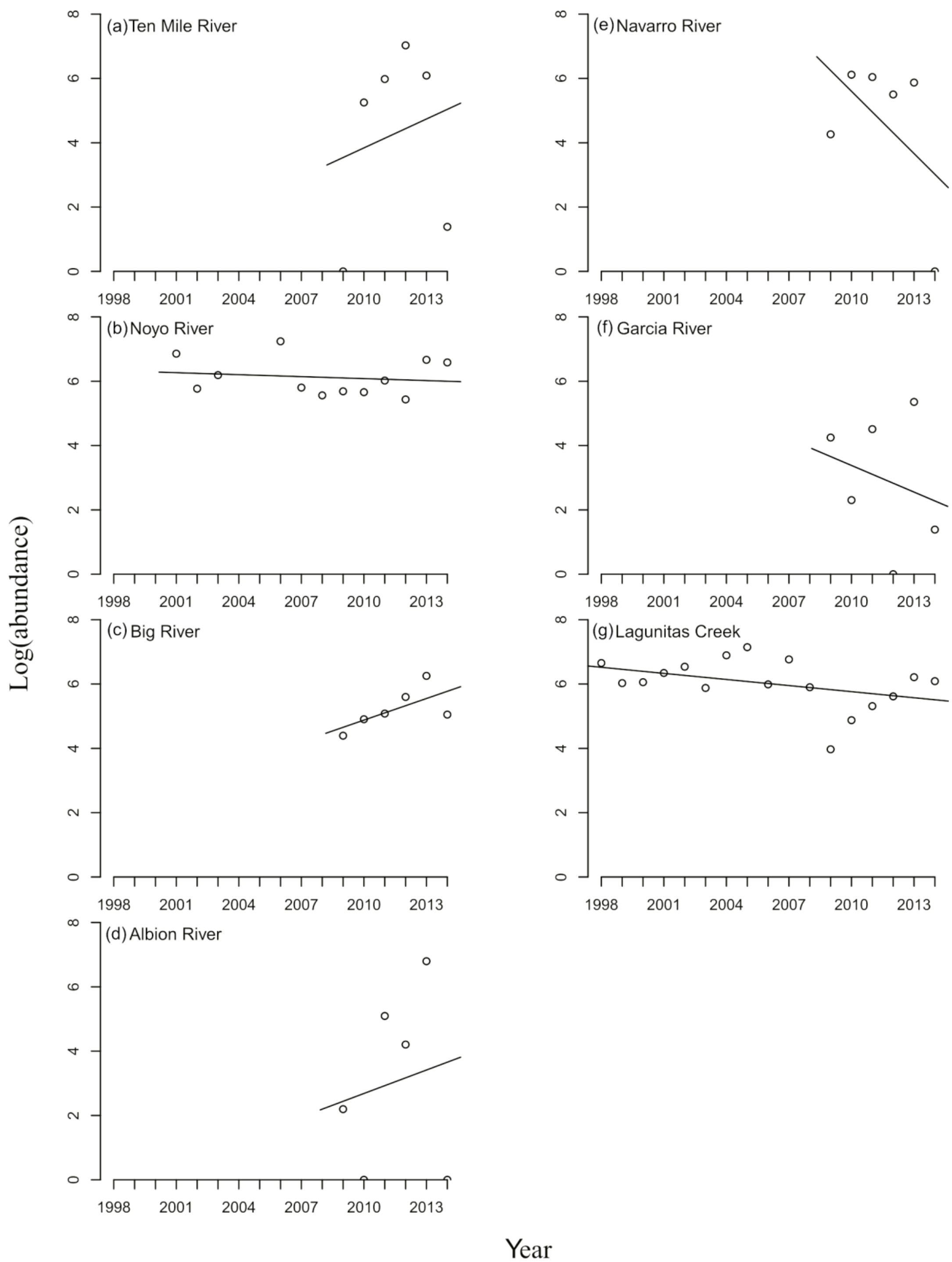

Figure 4.2. Population trends (log abundance) for independent populations of CCC-Coho Salmon. Values for Lagunitas Creek are based on two times the total redd count for the watershed. All other estimates are based on fish/redd expansions from life-cycle monitoring stations.

Table 4.4. Viability metrics for dependent populations of coho salmon in the CCC-Coho Salmon ESU. NA indicates not available or applicable. Trends are shown only for populations where time series is at least six years, **bold** indicates significant trend. $N_{a(arith)}$ target refers to target identified in CCC-coho salmon recovery plan (NMFS 2012a).

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{T}$ *(95% CI)*	$\overline{N}_{a(arith)}$ target
Lost Coast - Navarro Pt						
Usal Creek	6	6	4	16	-0.142 (-1.031, 0.747)	360
Cottaneva Creek	4	0	NA	NA	NA	469
Wages Creek	4	0	NA	NA	NA	340
Pudding Creek	14	417	184	741	**-0.272 (-0.510, -0.034)**	983
Caspar Creek	15	115	40	86	**-0.304 (-0.447, -0.161)**	435
Little River	15	30	10	19	**-0.236 (-0.361, -0.110)**	NA
Big Salmon Creek	3	6	3	NA	NA	578
Navarro Pt – Gualala Pt						
Greenwood Creek	2	4	3	NA	NA	NA
Elk Creek	2	0	NA	NA	NA	NA
Brush Creek	6	0	NA	NA	NA	NA
Coastal						
Salmon Creek	-	-	-	-	-	1367
Pine Gulch	14	1	2	0	-0.064 (-0.171, 0.043)	394
Redwood Creek	17	47	23	90	-0.105 (-0.229, 0.020)	272
Santa Cruz Mtn						
San Gregorio Creek	-	-	-	-	-	1363
Gazos Creek	3	0	NA	NA	NA	279
Waddell Creek	4	1*	1*	0*	NA	313
Scott Creek	13	71	18	31	-0.095 (-0.380, 0.189)	510
San Vicente Creek	3	2*	2*	6*	NA	105
Soquel Creek	-	-	-	-	-	1122
Aptos Creek	1	0	NA	NA	NA	932

* Low abundances of coho salmon have precluded development of relationships between redd counts and estimated numbers of spawners. Mean values presented reflect numbers of observed fish (live adults plus recovered carcasses).

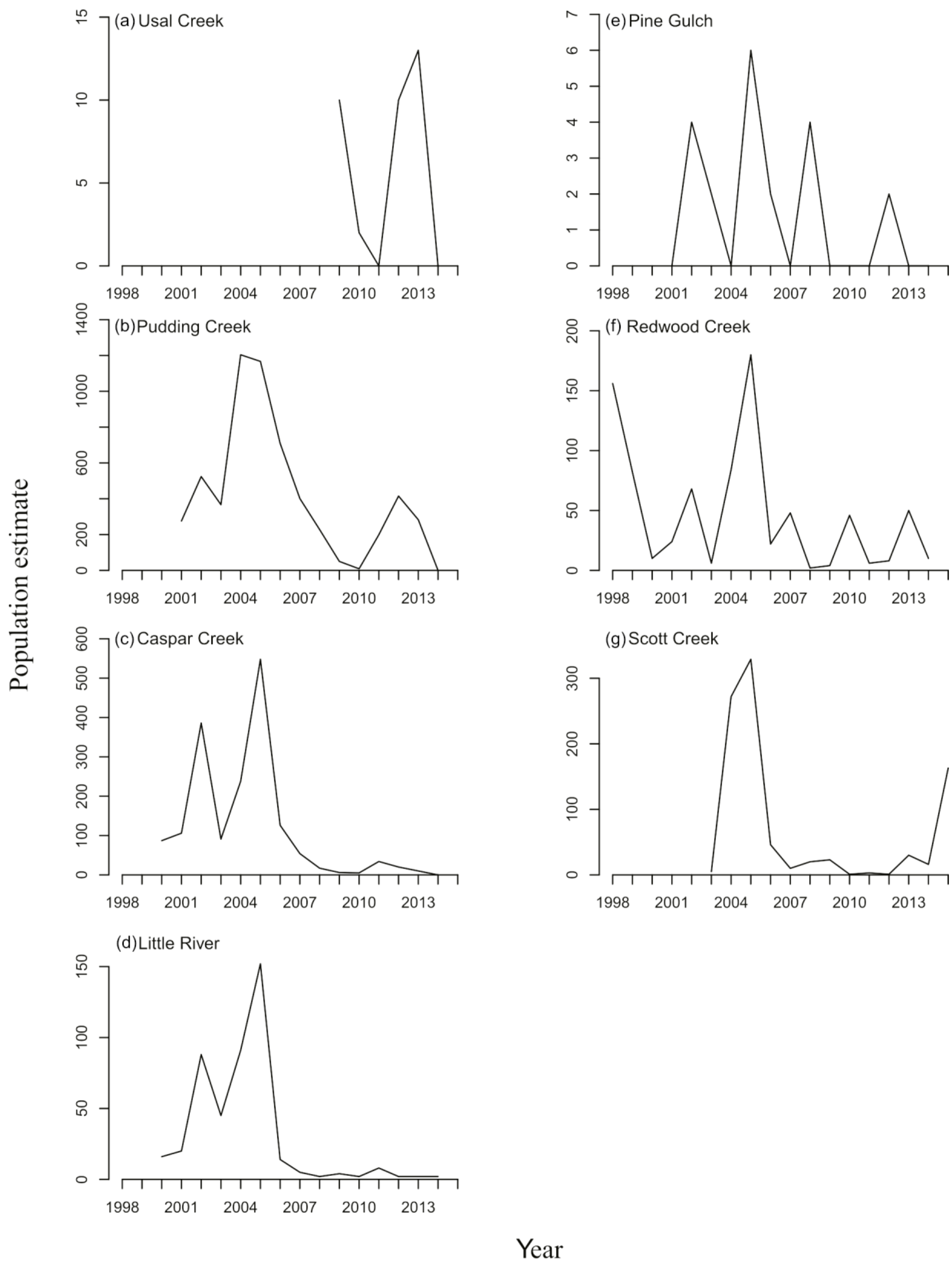

Figure 4.3. Time series of population abundance estimates for dependent populations of CCC-Coho Salmon. Values for Redwood Creek and Pine Gulch are two times the total redd count for the watershed. All other estimates are based on fish/redd expansions from life-cycle monitoring stations.

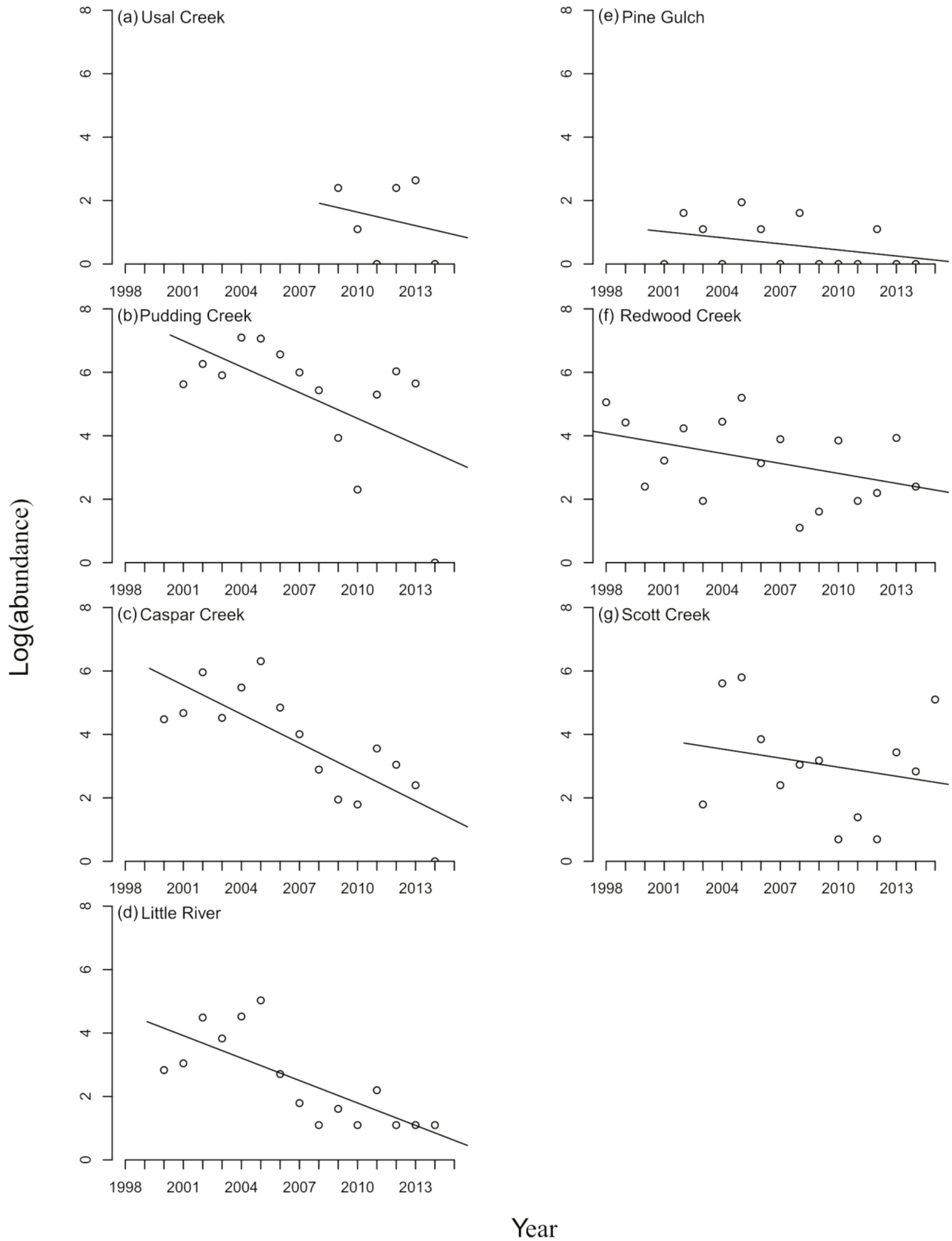

Figure 4.4. Population trends (log abundance) for dependent populations of CCC-Coho Salmon. Values for Redwood Creek and Pine Gulch are based on two times the total redd count for the watershed. All other estimates are based on fish/redd expansions from life-cycle monitoring stations.

Navarro Point – Gualala Point Stratum. Two of three independent populations in this stratum now have time series of adult abundance spanning six years: Navarro River and Garcia River. These data sets indicate that adult population sizes have averaged 257 and 64 fish, respectively (Table 4.3). Both populations are at less than 5% of the recovery targets and are at or below the depensation high-risk threshold. The six-year trend for both populations is negative but non-significant ($p > 0.10$) (Table 4.3; Figure 4.2e-f). No population data are available for the Gualala River, but numbers are believed to be extremely low.

Monitoring of three dependent populations in this stratum has been initiated (Table 4.4). Brush Creek has been surveyed for adult spawners for the past six seasons, but no coho salmon have been observed. Greenwood and Elk creeks have been surveyed as part of the CMP; however, these creeks are not sampled every year due to the relatively small spatial extent of potential coho salmon habitat. A small number of coho salmon redds were found in Greenwood Creek in the 2008–2009 spawning season, but they were not observed in 2012–2013. No coho salmon have been observed in Elk Creek in the two years it has been surveyed.

Coastal Stratum. Population monitoring is ongoing for two of three independent populations in the Coastal Stratum. Redd surveys have been conducted in Lagunitas Creek and its tributaries annually since the 1997–1998 spawning season by Marin Municipal Water District, the National Park Service, and the Salmon Protection and Watershed Network. Methods for expanding redd counts to adult estimates have not been developed as there is no life-cycle monitoring station in this stratum to develop spawner:redd relationships. For this assessment, we have assumed a ratio of two adults per redd (assuming one redd and one male per female). Over the 17-year period of record, the average number of adults appears to be near 500, which is approximately 20% of the recovery target of 2600 for this population (Table 4.3). The long-term trend is slightly downward, though not significant (Table 4.3; Figures 4.1g and 4.2g). Within the past six years, the population appears to have increased from a low reached in the 2008–2009 season.

Monitoring in the Russian River basin was initiated in 2003–2004 to assess the effectiveness of the hatchery program at Warm Springs. The spatial extent of sampling has increased through time as the number of streams receiving hatchery plants has grown. Likewise, methods for deriving adult estimates have also varied through time (M. Obedzinski, UC Davis, personal communication.) As a consequence, these data are not appropriate for assessing trends. However, they do provide a basis for estimating adult abundance in the Russian River watershed from the mouth to the Dry Creek watershed, inclusive, for the last four years. These estimates, which are based on a combination of information from adult traps, spawner surveys, PIT tag detections, video counts (to discriminate between fish of hatchery and natural origin), juvenile surveys, and smolt traps (to derive a minimum number of spawners in certain tributaries), indicate that population size has ranged from 206 to 536 fish, most of which are returning hatchery-origin fish. These numbers suggest the Russian River population is far below the proposed recovery target (Table 4.3)

Coho salmon were believed extirpated from the Walker Creek drainage; however, recent efforts have been made to reintroduce coho salmon to the watershed by releasing excess Olema Creek-origin adult broodstock (year 2003–2004 to 2008–2009), smolts (year 2007), and juveniles (years 2010–2014) reared at the Warm Springs Hatchery. Recent surveys have documented a total eight coho salmon carcasses and one live female during the past three spawning seasons (E. Ettlinger, MMWD, personal communication). These observations likely represent a combination of returns of hatchery smolts and natural production that has resulted from previous plantings.

Population monitoring has also been conducted by the National Park Service for two dependent populations in the stratum: Redwood Creek and Pine Gulch. As with the Lagunitas Creek surveys, no methods for expanding redd counts to adult estimates have been developed and so we have assumed a ratio of two adults per redd. Average abundance over the last 17 years has been approximately 47, which is about 17% of the recovery target of 272 (Table 4.4; Figures 4.3f and 4.4f). Coho salmon have been observed intermittently in Pine Gulch, with an average of just one adult per year over 14 years (Table 4.4; Figures 4.3e and 4.4e). Additionally, as with Walker Creek, both juvenile (years 2008) and excess broodstock adult coho salmon (years 2008–2014) have been released into Salmon Creek. These have included both Olema Creek and Russian River adults. Following the release of adults in both 2008 and 2014, juvenile coho salmon were collected from the Salmon Creek watershed, indicating successful reproduction by the released broodstock fish (M. Kittel, CDFW, personal communication).

Santa Cruz Mountain Stratum. For the last viability assessment, adult data was limited to that associated with the life-cycle monitoring station on Scott Creek. Beginning in 2012, implementation of CMP spawner surveys was initiated in the Santa Cruz Mountain Diversity Stratum in 2012 and has expanded over the past two years. However, methods for assigning unidentified redds (coho salmon vs. steelhead) have resulted in a high percentage of misassignments. Consequently, for the two independent populations in this stratum, Pescadero Creek and San Lorenzo River, expanded estimates of abundance based on redd counts are not considered reliable. In 2013–2014, a total of 19 returning jack males were collected by seine from the lower San Lorenzo River and brought to the Kingfisher Flat Hatchery in the Scott Creek watershed for use in the captive broodstock program. All of these fish were determined through coded wire tags to be hatchery fish from the Scott Creek program. In 2014–2015, three carcasses, all of hatchery origin, were recovered in Pescadero Creek, and another possible carcass was recovered in the San Lorenzo River; however, ongoing juvenile surveys (summer 2015) have not yet provided evidence of successful reproduction in either watershed. Thus both populations appear to be extirpated or nearly so.

Adult coho salmon in Scott Creek have been estimated since 2002–2003 (Figure 4.3g, 4.4g). Population abundance has averaged 71 adults over the 13 years of record (Table 4.4); however the vast majority of returning fish have been of hatchery origin, predominately 2-year old males. An estimated 163 adults (mostly hatchery fish) returned in 2014–2015 making this the largest return in a decade. This increase appears due to a combination of modified mating strategies that incorporated broodstock from Warm Springs Hatchery to combat growing concerns over inbreeding depression, coupled with implementation of a staggered release strategy, which preliminary data suggest has improved marine survival. Spawner surveys have produced only occasional observations of coho salmon in any of the dependent populations of coho salmon south of the Golden Gate over the last three seasons.

Adult coho salmon were also detected this past year in San Vicente and Waddell creeks, and subsequent summer surveys have indicated presence of juveniles in both these systems, as well as in Soquel and Laguna creeks (B. Spence and J. Kiernan, NMFS SWFSC, personal communication). Fish in most dependent populations in this stratum were considered extirpated or nearly so in the last assessment (Spence and Williams 2011).

Harvest Impacts[6]

No direct information exists on the harvest of CCC-Coho Salmon. However, it is reasonable to expect that they have a similar or more southerly distribution than Southern Oregon/Northern California Coast (SONCC)-Coho Salmon, which are primarily distributed off the coast of California and southern Oregon. Because coho salmon-directed fisheries and coho salmon retention have been prohibited off the coast of California since 1996, the CCC-Coho Salmon ocean exploitation rate is likely very low and attributable to non-retention impacts in California and Oregon Chinook-directed fisheries, non-retention impacts in Oregon mark-selective coho salmon fisheries, and impacts in Oregon non-mark selective fisheries.

The SONCC (Rogue/Klamath) natural-origin coho salmon ocean exploitation rate time series provides the best available proxy measure of trends in the CCC-Coho Salmon ocean exploitation rate. This rate has been low and relatively stable since the early 1990s (average of 5.3% for years 1994–2014), which contrasts sharply with the much higher rates estimated for the 1980s and early 1990s (average of 50.8% between 1986 and 1993) (Figure 4.5, L. LaVoy and R. Kope, NMFS, personal communication).

Freshwater fishery impacts on CCC-Coho Salmon are likely minor given California’s statewide prohibition of coho salmon retention. In summary, the available information indicates that the level of CCC-Coho Salmon ESU fishery impacts has not changed appreciably since the 2010 salmon and steelhead assessment (Williams et al. 2011).

Summary and Conclusions

In summary, assessing changes in the viability of the CCC-Coho Salmon ESU remains a challenge due to the scarcity of long-term datasets for most populations. However, implementation of the CMP across significant portions of the ESU has resulted in a number of shorter time series that have substantially improved our understanding of

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[6] Harvest impacts section prepared by Michael O’Farrell

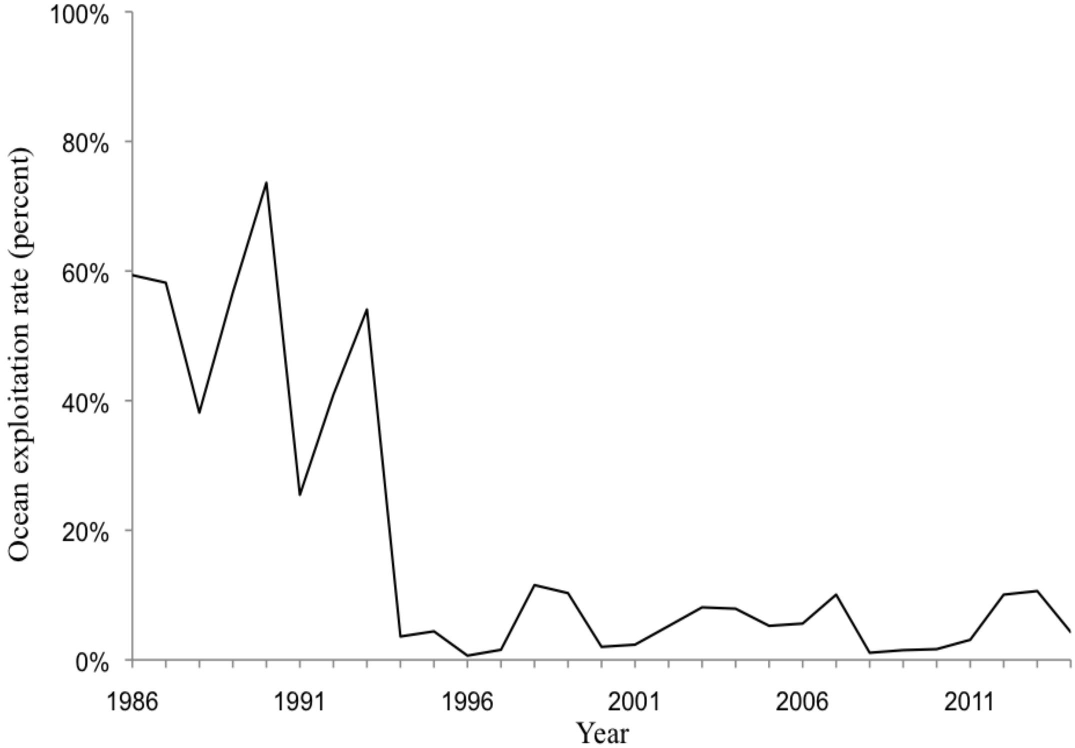

Figure 4.5. Natural-origin Rogue/Klamath coho salmon ocean exploitation rate estimates for years 1986–2014 (L. LaVoy and R. Kope, NMFS, personal communication).

current viability. The existing data indicate that all independent and dependent populations are well below recovery targets and, in some cases, exceed high-risk thresholds established by the TRTs. Although the longer-term (12–17 year) trends tend to be downward, data from the past 5 years suggest that some populations reached their lowest levels around 2008–2009 and have rebounded slightly since then. An area of particular concern is the downward trends in abundance of virtually all dependent populations across all diversity strata. These trends suggest that dependent populations are less able to maintain connectivity or act as buffers against declines in neighboring independent populations, suggesting that the independent populations are becoming more isolated with time. Populations continue to be the strongest in the Mendocino County watersheds from the Navarro River northward, and weaker to the south, with the exception of Lagunitas Creek. The viability of coho salmon in the Santa Cruz Mountain Diversity Stratum, where virtually all observed salmon have been the result of hatchery operations, remains especially dire. We conclude that the CCC-Coho Salmon ESU continues to be in danger of extinction.

4.2 California Coastal Chinook Salmon ESU

ESU Boundary Delineation

The initial status review for Chinook salmon (Myers et al. 1998) proposed a single ESU for Chinook salmon populations inhabiting coastal watersheds from Cape Blanco, Oregon, south to but not including San Francisco Bay, and including tributaries of the Klamath River downstream of its confluence with the Trinity River. Subsequent review led to division of the originally proposed ESU into the Southern Oregon and Northern California Coastal (SONCC) ESU, and the California Coastal (CC) ESU, the latter including populations spawning in coastal rivers from Redwood Creek (Humboldt County) south to the Russian River, inclusive (NMFS 1999).

The previous viability assessment (Williams et al. 2011) discussed the fact that populations that lie between the lower boundary of the Central Valley Fall-run ESU (Carquinez Straits) and the southern boundary of California Coastal Chinook Salmon ESU (Russian River) were not included in either ESU, despite the fact that Chinook salmon had been reported in several basins. Available genetic evidence indicated fish from the Guadalupe and Napa rivers in San Francisco and San Pablo bays had close affinity with Central Valley Fall-run Chinook (Garza and Pearse 2008), and it was recommended that fish from these two watersheds be included in the Central Valley Fall-run Chinook Salmon ESU. Evidence for fish in Lagunitas Creek was equivocal, with 17 samples assigned almost equally between California Coastal Chinook Salmon and Central Valley Fall-run Chinook Salmon. The review team tentatively concluded that Lagunitas Creek Chinook salmon should be considered part of the California Coastal ESU pending additional data (Williams et al. 2011). NMFS subsequently indicated that a boundary change was under consideration (76 FR 50447); however, no action has been taken to date. There is no new genetic information that helps resolve this issue (C. Garza, NMFS SWFSC, personal communication).

Summary of Previous Assessments

Myers et al. (1998) and Good et al. (2005) concluded that California Coastal Chinook salmon were likely to become endangered. Good et al. (2005) cited continued evidence of low population sizes relative to historical abundance, mixed trends in the few available time series of abundance indices available, low abundance and extirpation of populations in the southern part of the ESU, and the apparent loss of the spring-run life-history type throughout the entire ESU as significant concerns. In the most recent viability assessment, Williams et al. (2011) concluded that there was no evidence to indicate a substantial change in conditions since the previous review of Good et al. (2005). They noted that the lack of population-level estimates of adults continued to hinder assessments of status, and that although all independent populations of Chinook salmon in the North-Coastal and North Mountain Interior strata continue to persist, there is high uncertainty about the current abundance of all of these populations. Further, they cited the apparent extirpation of populations in the North-Central Coastal stratum and the loss of all but one population (Russian River) in the Central Coastal stratum as significant concerns since this gap reduced connectivity among strata across the ESU.

New Data and Updated Analyses

Abundance and Trends

At the time of the last assessment (Williams et al. 2011), population-level estimates of the abundance of Chinook salmon in this ESU were almost entirely lacking. Data were limited to time series of (1) spawner indices (maximum live/dead counts) at three sites in the Eel and Mad river basins where data have been collected since the 1970s, (2) weir counts at Freshwater Creek that began in 1994, (3) dam counts at Van Arsdale Fish Station in the upper Eel River, (4) spawner estimates for Prairie Creek, a tributary to Redwood Creek (Humboldt County), and (5) video counts of adults at Mirabel in the Russian River that began in 2000. Only the Russian River video counts likely provided some indication of total population abundance, though these counts do not include fish spawning below the counting facility. The remaining sampling efforts either provide only indices of relative abundance and not population estimates (e.g., Mad and Eel river sites), or sample only a portion of the population (e.g., Prairie Creek, Freshwater Creek, and Van Arsdale Station). Most of these sampling efforts have continued, with the exception of the Prairie Creek surveys, which were discontinued in 2012.

Since publication of the previous assessment (Williams et al. 2011), new information has become available as a result of CMP implementation in Mendocino County and portions of Humboldt County. Because some of these survey efforts have targeted coho salmon, they have not necessarily covered the full spatial and temporal extent of Chinook salmon spawning. Nevertheless, these efforts have significantly improved our understanding of the viability of Chinook salmon in this ESU. Summaries of available data are presented by diversity stratum below.

North Coastal Stratum. Population-level estimates of adult abundance for independent populations of Chinook salmon in the North-Coastal stratum remain scarce. The CMP has been implemented in Redwood Creek, Humboldt Bay tributaries, and the Mattole River for two to four years, producing estimates of the total number of Chinook salmon redds in these watersheds (Table 4.5). However, to date, methods for expanding redd counts to population estimates have not yet been developed (S. Ricker, CDFW, personal communication). Additionally, sampling generally targets the spawning period and habitat for coho salmon and thus may not encompass the entirety of the spawning period and space for Chinook salmon (Ricker et al. 2014d; Ricker and Anderson 2014; Ricker et al. 2015h). With these caveats in mind, the data indicate that Redwood Creek has produced 921 Chinook salmon redds annually (range 752–1042) over the last four years. The average redd estimate for the Mattole River for the past two seasons was 250 (range 128–373). The Humboldt Bay tributaries produced an average of only three Chinook salmon redds (range 0–13) over the past 4 seasons (Table 4.5). Without methods for expanding redd counts to adult estimates, these numbers cannot be directly compared to

Table 4.5. Viability metrics for independent populations of Chinook salmon in the CC-Chinook Salmon ESU. NA indicates not available or applicable. Trends are shown only for populations where time series is at least six years, **bold** indicates significant trend. IPkm includes only habitats that are currently accessible. $N_{a(arith)}$ target refers to the low-risk viability target identified by the Technical Recovery Team (Spence et al. 2008).

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{C}$	$\hat{T}$ *(95% CI)*	IPkm	$\hat{D}_{dep}$	$\hat{D}_{ssd}$	$\hat{D}_{ssd}$ target	$\overline{N}_{a(arith)}$ target
North Coastal											
Redwood Creek[a]	4	921	915	2824	NA	NA	116.1	7.8	7.9	29.3	3400
Little River	-	-	-	-	-	-	18.6	-	-	40.0	700
Mad River	-	-	-	-	-	-	94.0	-	-	31.8	3000
Humboldt Bay[a]	4	3	2	0	NA	NA	76.7	0.0	0.0	33.7	2600
Lower Eel River	-	-	-	-	-	-	514.9	-	-	20.0	10300
Bear River	-	-	-	-	-	-	39.4	-	-	37.8	1500
Mattole River[1]	2	250	219	-	NA	NA	177.5	-	-	22.5	4000
North Mtn. Interior											
Lower Eel River	-	-	-	-	-	-	-	-	-	-	-
Upper Eel River	-	-	-	-	-	-	495.3	-	-	20.0	11100
North-Central Coastal											
Ten Mile River[b]	6	14	5	51	NA	-0.215 (-1.520, 1.091)	67.2	0.1	0.2	34.8	2300
Noyo River[b]	6	13	8	24	NA	**-0.624 (-0.951, -0.296)**	62.2	0.1	0.2	35.3	2200
Big River[b]	6	15	8	33	NA	-0.588 (-1.476, 0.300)	104.3	0.1	0.1	30.6	3200
Central Coastal											
Navarro River[b]	6	3	2	0	NA	-0.274 (-1.110, 0.562)	131.5	-	-	27.6	3600
Garcia River[b]	6	5	3	13	NA	0.048 (-0.888, 0.983)	56.2	0.1	0.1	36.0	2000
Gualala River[b]	-	-	-	-	-	-	175.6	-	-	22.7	4000
Russian River[c]	14	3257	2806	8664	0.67	0.019 (-0.067, 0.104)	496.4	6.1	2.8	20.0	11700

a – Numbers indicate the estimated number of redds in the population (expanded from counts).
b – Numbers indicate the estimated number of adults based on fish/redd expansions from life-cycle monitoring stations.
c – Numbers are based on video counts at Mirabel Dam; a small but unknown percentage of adults spawn below this location, so the estimate does not include entire population.

viability targets; however, it is evident that none of these three populations are approaching viability targets at this time.

Besides these population level estimates, longer time series of partial population estimates or index reach maximum live/dead counts are available for Prairie Creek (part of the Redwood Creek population), Cannon Creek (part of the Mad River population), Freshwater Creek (part of the Humboldt Bay population), the South Fork Eel River (part of the Lower Eel River population), and Sproul Creek (part of the Lower Eel River Population) (Table 4.6). The Prairie Creek time series showed an average of 272 adult Chinook salmon (range 38–710) in this subwatershed over the 14-year period of record, with a significant ($p = 0.015$) negative trend at the time the survey was discontinued (Table 4.6; Figures 4.6a, 4.7a). Spawner surveys have been performed on Cannon Creek since 1981, with data reported as maximum live/dead counts (Table 4.6). The 34-year trend for this dataset has been positive, but not significantly so ($p = 0.212$), while the 16-yr trend has been negative but not significant ($p = 0.235$) (Table 4.6; Figure 4.6b, 4.7b). Counts of Chinook salmon have been made at a weir on Freshwater Creek since 2001 (Ricker 2015); these counts are partial counts as fish can pass over the weir during periods of high flow and smaller jacks may pass through the weir. On average, 21 natural-origin adults[7] have been counted annually over the 15-year period of record. The trend over this period has been negative and significant ($p < 0.001$; Table 4.6; Figures 4.6c, 4.7c). Estimates of Chinook salmon redds have been made four last four years in the South Fork Eel River (Ricker et al. 2015a-d); the average estimate has been 772 (range 149–1345) during this period (Table 4.6). Finally, spawner surveys have been performed on Sproul Creek since 1975, with data reported as maximum live/dead counts. The 39-year trend for this dataset has been negative but not significant ($p = 0.150$), whereas the more recent 16-year trend has been positive but also not significant ($p = 0.453$) (Table 4.6; Figures 4.6d, 4.7d).

North Mountain Interior Stratum. The North Mountain Interior stratum contains the upper Eel River Chinook salmon population, as well as the portion of the lower Eel River population that inhabits watersheds of the interior mountains of the Eel River basin, including the Van Duzen River and Larabee Creek basins. For the upper Eel River population, there are no population-level estimates of abundance available. However, two time series of partial abundance data are available: maximum live/dead counts for an index reach in Tomki Creek (since 1976) and weir counts at Van Arsdale Station (since 1947). Counts at both of these locations appear highly influenced by flow conditions in the mainstem, which in turn are affected by water releases from Cape Horn and Scott dams. In years of low flow, fish appear less inclined to enter Tomki Creek or ascend the Eel River as far as Van Arsdale Station and instead spawn in areas downstream; thus, the reliability of these counts as indices of abundance is somewhat questionable (S. Harris, CDFW, personal communication). Beginning in 2004, mandated increases in minimum flow releases from Cape Horn Dam have been implemented (NMFS 2002; J. Jahn, Table

[7] A small hatchery program for Chinook salmon on Freshwater Creek was discontinued in the early 2000s.

4.6. Population information for CC-Chinook salmon populations with only index data or partial population estimates. NA indicates not available or applicable. Trends are shown only for populations where time series is at least six years, **bold** indicates significant trend. Short-term (16-yr) trends are shown along with long-term trends for those datasets spanning 30 or more years.

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{T}$ *(95% CI)*
North Coastal					
Prairie Creek[a]	14	272	190	436	**-0.140 (-0.248, -0.032)**
Cannon Creek[b]	34	102	61	161	0.027 (-0.016, 0.069)
	16	122	92	355	-0.054 (-0.147, 0.039)
Freshwater Creek[c]	15	21	8	16	**-0.240 (-0.349, -0.130)**
SF Eel River[d]	4	772	585	2190	NA
Sproul Creek[e]	39	226	125	394	-0.025 (-0.060, 0.010)
	16	145	100	398	0.043 (-0.077. 0.453)
North Mtn. Interior					
Tomki Creek[f]	34	554	104	150	**-0.100 (-0.152, -0.048)**
	16	78	48	210	0.013 (-0.125, 0.151)
Van Arsdale Station[g]	63	370	40	21	**0.078 (0.049, 0.108)**
	16	906	608	1340	0.087 (-0.004, 0.179)

a – Prairie Creek represents a portion of the Redwood Creek population. Numbers are population estimates based on Area-under-the-curve (AUC) method. Surveys were discontinued when basin-scale monitoring of Redwood Creek was initiated in 2012.
b – Cannon Creek is an index reach in the Mad River basin. Numbers are maximum live/dead counts. Survey effort varies annually.
c – Freshwater Creek represents a portion of the Humboldt Bay population. Numbers are weir counts of natural-origin fish; populations were too small to develop reliable population estimates.
d – SF Eel River represents a portion of the Lower Eel River population. Numbers are expanded estimates of the number of redds; they are not population estimates.
e – Sproul Creek represents a portion of the Lower Eel River population. Numbers are maximum live/dead counts. Survey effort varies annually.
f – Tomki Creek represents a portion of the Upper Eel River population. Numbers are maximum live/dead counts. Survey effort varies annually.
g – Van Arsdale Station counts represent a portion of the Upper Eel River population. Numbers are counts of fish passed over the dam and represent a variable fraction of the total population, as the proportion of individuals reaching the dam appears highly flow dependent. Values for the last 16 years are based on naturally produced fish only; hatchery fish were excluded.

NMFS Southwest Region, personal communication), resulting in a general increase in the amount of water available in the mainstem Eel River below the dam. The increase in flow has likely influenced the distribution of spawners in the Eel River, possibly drawing more fish as far as Van Arsdale Station. With these caveats in mind, maximum live/dead counts in Tomki Creek have averaged 554 (range 3–3,666) over the 34-year period of record, but only 78 (range 5–226) over the last 16 years (Table 4.6). The long-term trend in these counts is negative ($p < 0.001$); however, the short-term trend has been positive though marginally significant ($p = 0.060$), primarily because of three relatively strong years in succession from 2010–2011 to 2012–2013 (Figures 4.6e, 4.7e). Counts at Van Arsdale are also confounded by the fact that between 1996 and 2004, an average of

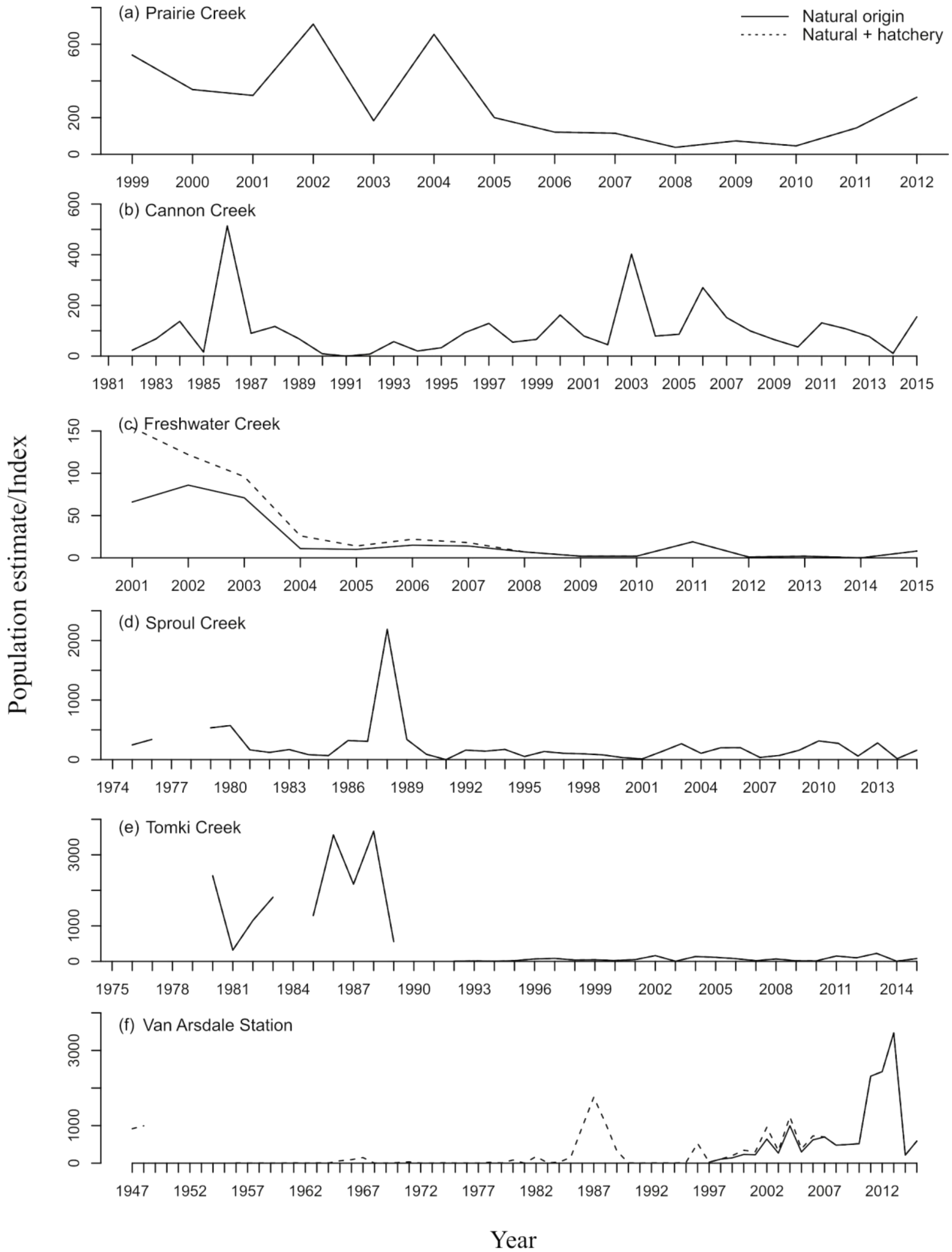

Figure 4.6. Time series of population indexes or partial population estimates for independent populations of CC-Chinook Salmon. Values for Cannon, Sproul, and Tomki creeks are maximum live-dead indexes. Van Arsdale Station and Freshwater Creek are weir counts. Prairie Creek is based on area-under-the-curve (AUC) estimates for the watershed.

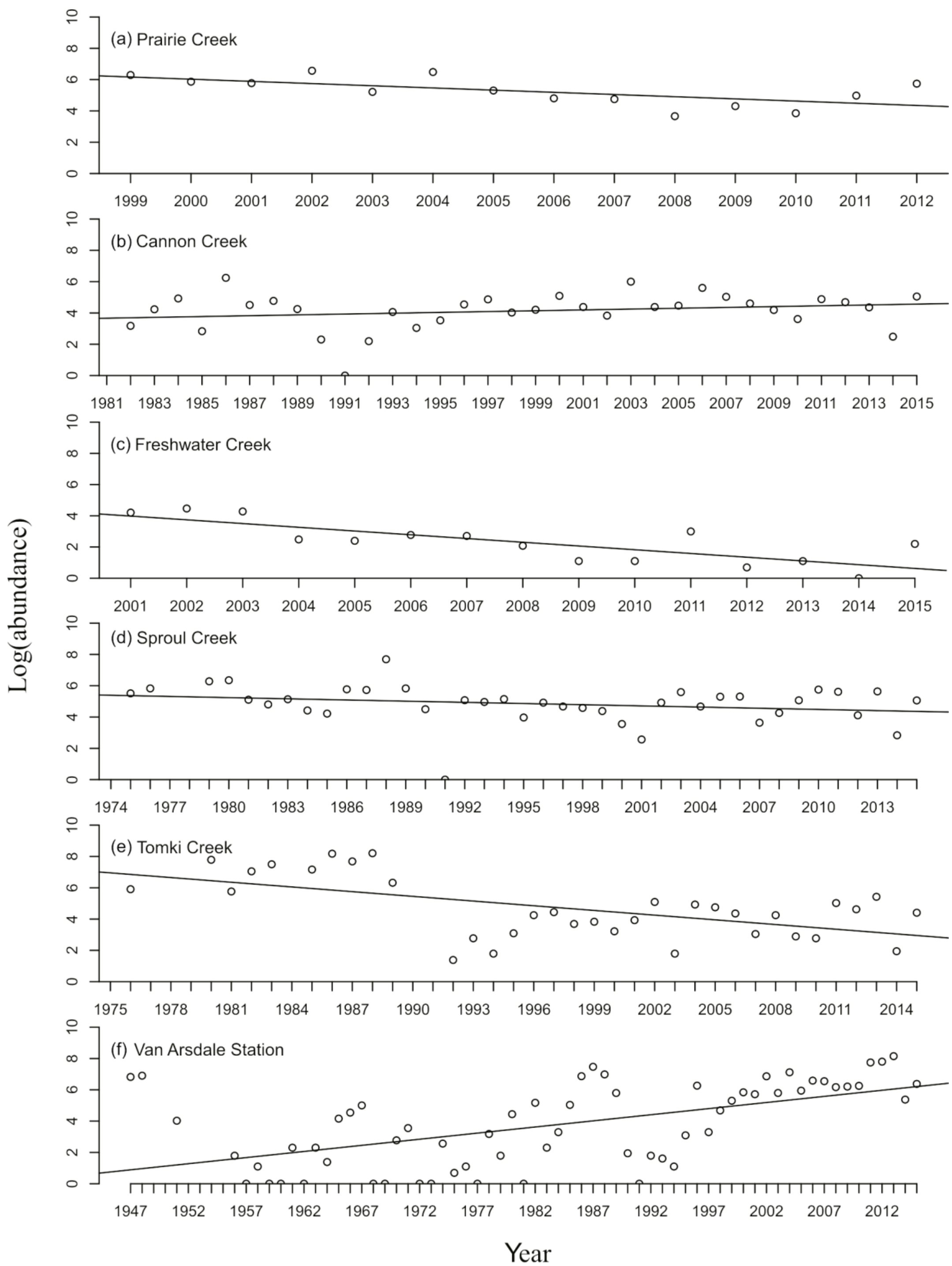

Figure 4.7. Population trends (log abundance) for indexes or partial population estimates for independent populations of CC-Chinook Salmon. Values for Cannon, Sproul, and Tomki creeks are based on maximum live-dead indexes. Van Arsdale Station and Freshwater Creek are weir counts. Prairie Creek is based on area-under-the-curve (AUC) estimates for watershed.

38,822 hatchery Chinook salmon were released into the Eel River annually. Over the last 16 years, counts of natural-origin adults have averaged 906 (range 215–3,446), and there has been a significant positive trend (Table 4.6; Figures 4.6f, 4.7f)). However, although trends were calculated based only on natural origin fish, an unknown proportion of these fish are likely recent descendants of hatchery-origin fish. Thus, it is unclear whether the recent positive trend reflects increases in wild spawners, redistribution of fish associated with changes in flow releases from upstream dams, or legacy effects of past hatchery plantings.

In addition to these longer time series of abundance information, attempts have also been made to conduct spawner surveys in the mainstem Eel River as well as several major tributaries, including the Middle Fork Eel River, Outlet Creek, and Tomki Creek. For the 2013–2014 spawning season, these efforts produced an estimate of 3,152 adult Chinook salmon, inclusive of fish captured at Van Arsdale Station (Harris and Thompson 2014). A similar effort in the 2009–2010 spawning season produced an estimate of approximately 3,500 fish for portions of the mainstem Eel River, Tomki Creek, Outlet Creek and one of its tributaries, and Van Arsdale Station (Harris 2010). Attempts to estimate Chinook salmon abundance in 2012–2013 were unsuccessful due to significant rains that resulted in poor survey conditions (Harris and Thompson 2013). Nevertheless, these data indicate that the Van Arsdale and Tomki Creek estimates constitute only a relatively small fraction of the total Upper Eel River Chinook salmon population.

North-Central Coastal Stratum. The previous viability assessment noted the apparent extirpation of Chinook salmon populations in watersheds of the North-Central Coastal Stratum (Williams et al. 2011). Implementation of the CMP throughout this stratum beginning in 2009 has produced data that indicate this is not true. Estimates based on expanded redd counts indicate that the Ten Mile, Noyo, and Big rivers continue to produce small numbers of Chinook salmon in most years, with each of these watersheds averaging 13–15 fish per year over the last six years (Table 4.5; Figures 4.8a-c, 4.9a-c). Although in all cases these numbers are less than 1% of the viability targets and fall below the depensation thresholds for high risk, they nevertheless provide evidence that Chinook salmon are still regularly using these watersheds to spawn.

Central Coastal Stratum. Population monitoring is currently occurring for three of four independent populations of Chinook salmon in the Central Coastal Stratum. Monitoring of the Navarro and Garcia river populations was initiated in 2009. This monitoring has confirmed presence of very low numbers of Chinook salmon, with estimates averaging 3 and 5 adults for these two watersheds, respectively, in the past six years (Table 4.5; Figures 4.8d-e, 4.9d-e). Monitoring of adult Chinook salmon using video counts at Mirabel Dam on the Russian River has been conducted since 2001. An average of 3,257 Chinook salmon have been counted annually over the 14-year period of record and there has been essentially no trend in abundance ($p = 0.644$) (Table 4.5; Figures 4.8f, 4.9f). The average count represents about 28% of the viability target for the Russian River; however, some spawning by Chinook salmon does occur below Mirabel Dam, so the population is likely closer to the target than these numbers indicate.

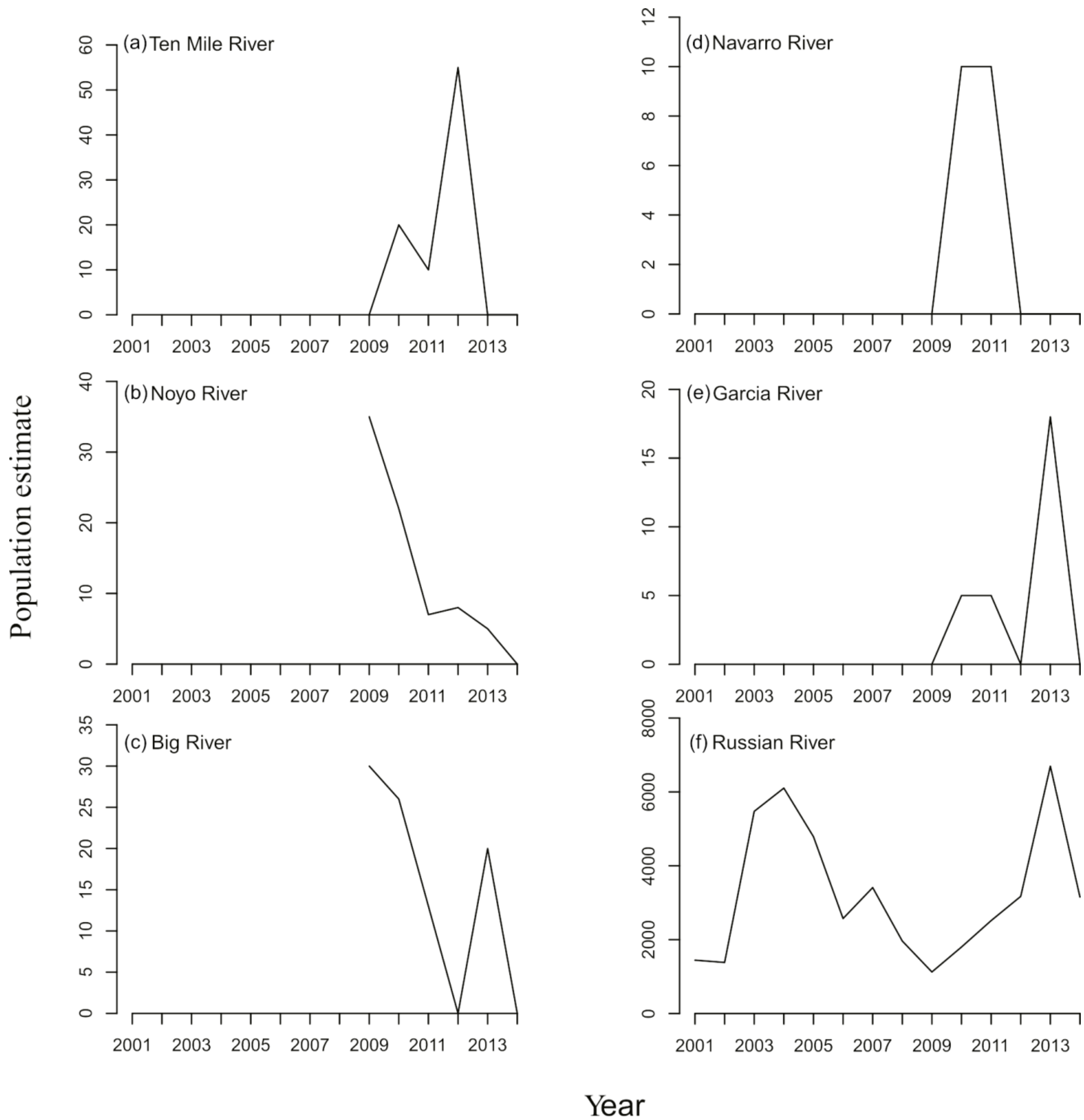

Figure 4.8. Time series of population abundance estimates for independent populations of CC-Chinook Salmon. Values for Russian River are video counts at Mirabel Dam. All other estimates are based on fish/redd expansions from life-cycle monitoring stations.

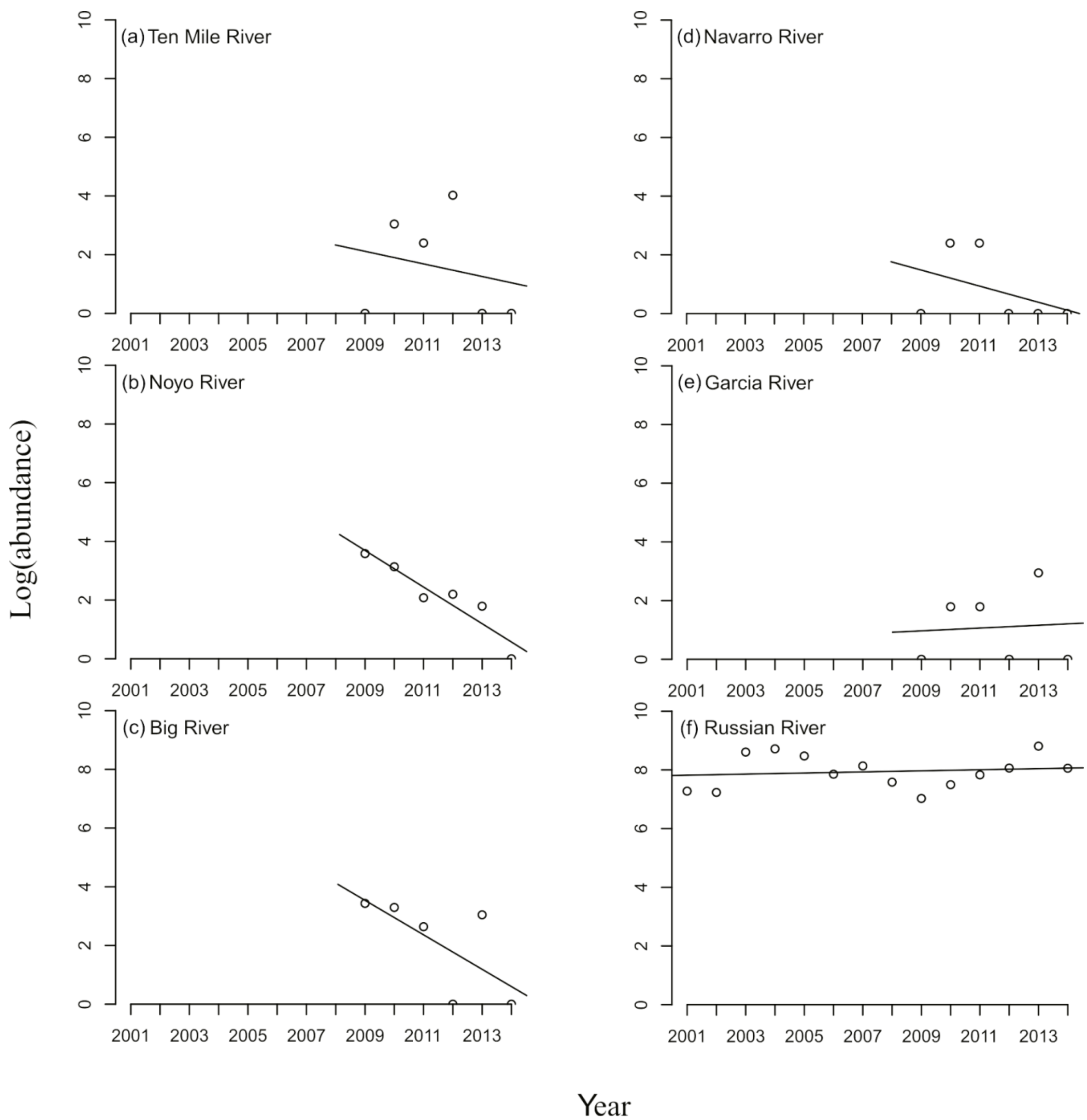

Figure 4.9. Population trends (log abundance) for independent populations of CC-Chinook Salmon. Values for Russian River are video counts at Mirabel Dam. All other estimates are based on fish/redd expansions from life-cycle monitoring stations.

Harvest Impacts[8]

Very limited data exits on the harvest of California Coastal Chinook Salmon (CC-Chinook Salmon). Owing to this data deficiency, the Klamath River Fall-run Chinook salmon (KRFC) age-4 (fully vulnerable) ocean harvest rate is used as a fishery management proxy to limit harvest impacts on CC-Chinook Salmon. The CC-Chinook Salmon ocean fishery consultation standard is a maximum predicted KRFC age-4 ocean harvest rate of 16%.

The KRFC age-4 ocean harvest rate fell sharply from its average value of 44% over the period 1981–1990 to estimates that have largely remained below 20% since 1991. Very low KRFC age-4 ocean harvest rates were observed between 2008 and 2012, partially reflecting the widespread fishery closures in California and Oregon between 2008 and 2010 (Figure 4.10). The average KRFC age-4 ocean harvest rate estimated over the years since the last viability assessment (2011–2014) is 13%, which falls below the 16% CC-Chinook salmon consultation standard.

Freshwater fishery impacts on CC-Chinook Salmon are likely relatively minor because retention of Chinook salmon is prohibited.

In summary, the available information indicates that the level of CC-Chinook Salmon fishery impacts has not changed appreciably since the 2010 salmon and steelhead assessment (Williams et al. 2011).

Summary and Conclusions

The lack of long-term population-level estimates of abundance for Chinook salmon populations in the CC ESU continues to hinder viability assessment, though the situation has improved with implementation of the CMP in the Mendocino Coast Region and portions of Humboldt County. The available data, a mixture of short-term (6-year or less) population estimates or expanded redd estimates and longer-term partial population estimates and spawner/redd indexes, provide no indication that any of the independent population are approaching viability targets. However, there remains high uncertainty regarding key populations, including the Upper and Lower Eel River populations and the Mad River population, due to incomplete monitoring across the spawning habitat of Chinook salmon in these basins (O'Farrell et al. 2012). Because of the short duration of most time series for independent populations, little can be concluded from trend information. The longest time series, video counts in the Russian River, indicates that the population has remained fairly steady of the 14-year period of record. The longer time series associated with index reaches or partial populations suggest mixed patterns, with some showing significant negative trends (Prairie Creek, Freshwater Creek, Tomki Creek), one showing a significant positive trend (Van Arsdale Station), and the remainder no significant trends. Overall, there is a lack of compelling evidence to suggest that the viability of these populations has improved or deteriorated appreciably since the previous assessment (Williams et al. 2011)

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[8] Harvest impact section prepared by Michael O'Farrell

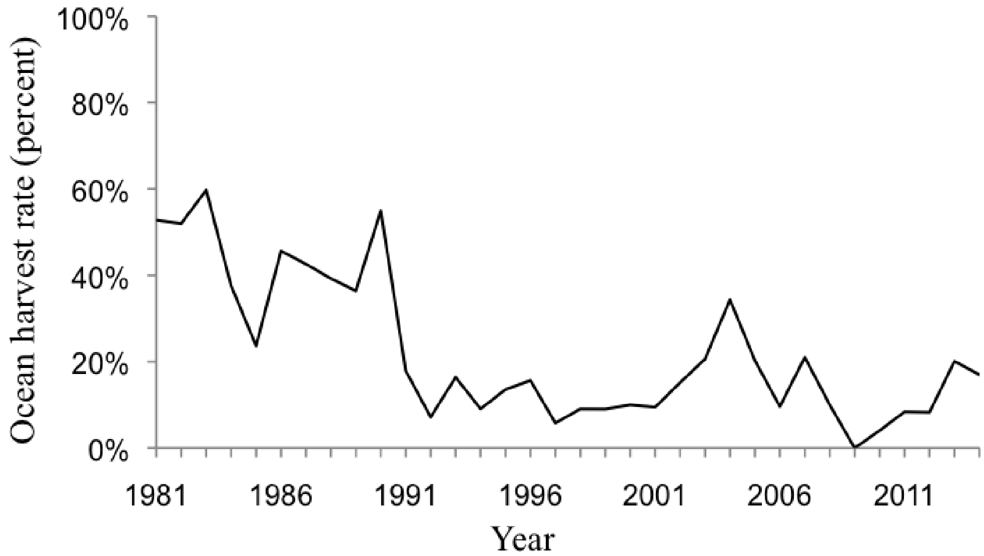

Figure 4.10. Klamath River Fall-run Chinook salmon age-4 ocean harvest rate for years 1981–2014 (PFMC 2015a).

At the ESU level, the loss of the spring-run life-history type represents a significant loss of diversity within the ESU, as has been noted in previous status reviews and viability assessments (Good et al. 2005; Williams et al. 2011). Concern remains about the extremely low numbers of Chinook salmon in most populations of the North-Central Coast and Central Coastal Diversity strata, which diminishes connectivity across the ESU. However, the fact that Chinook salmon have regularly been reported in the Ten Mile, Noyo, Big, Navarro, and Garcia rivers represents a significant improvement in our understanding of the viability of these populations in watersheds where they were thought to have been extirpated. These observations suggest that spatial gaps between extant populations are not as extensive as previously believed. In summary, the new information available since the last assessment (Williams et al. 2011) does not appear to suggest there has been a change in extinction risk for this ESU.

4.3 Northern California Steelhead ESU/DPS

DPS Boundary Delineation

See discussion of steelhead DPS boundary issues in introduction.

Summary of Previous Assessments

Busby et al. (1996) and Good et al. (2005) concluded that the Northern California (NC) Steelhead ESU/DPS was not presently in danger of extinction, but was likely to become endangered in the foreseeable future. Concerns raised by both of these biological review teams included low population abundance relative to historical estimates, recent downward trends in most stocks for which data were available, and the low abundance of summer steelhead populations. They also cited continued habitat degradation, the increasing abundance of a nonnative predator (Sacramento pikeminnow, *Ptychocheilus grandis*) in the Eel River, the influence of artificial propagation on certain wild populations, and the lack of data for this DPS as concerns and sources of risk (Busby et al. 1996; Good et al. 2005). In the most recent assessment, Williams et al. (2011) concluded that there was little evidence to indicate that the viability of the NC-Steelhead DPS had changed appreciably in either direction since publication of the previous status review (Good et al. 2005). They noted that the assessment was hindered by the scarcity of population-level estimates of abundance for either winter- or summer-run populations within this DPS. The available information suggested mixed trends in abundance, with more populations showing decreases than increases. However, they suggested that these declines were likely the result of a combination of drought conditions that prevailed between 2007 and 2009 coupled with apparent poor ocean conditions (Williams et al. 2011).

New Data and Updated Analyses

Abundance and Trends

At the time of the last assessment, population-level estimates of abundance were available for less than 10% of independent populations of winter- and summer-run steelhead within the DPS (Williams et al. 2011). Since that time, the CMP has been more broadly implemented in Mendocino County as well as selected watersheds in Humboldt County. Data from the CMP are now available for 17 independent populations, as well as six dependent populations or partial populations (most associated with life-cycle monitoring stations). The majority of these datasets span a period of six or fewer years; however, they do provide the first comprehensive estimates of adult abundance or redds for a number of populations. Significant data gaps do remain, however, particularly in the Lower Interior and North Mountain Interior diversity strata, which encompass most of the Eel River populations, excluding the South Fork Eel River. In addition to these newer datasets, several longer time series of adult abundance for partial populations remain available, though in two instances, these monitoring efforts have been discontinued. Summaries of available data are presented below by diversity stratum.

Northern Coastal Stratum. Implementation of the CMP for winter-run steelhead has been initiated in four watersheds in the Northern Coastal Stratum: Redwood Creek, Humboldt Bay, the South Fork Eel River, and Mattole River. These efforts have produced estimates of total redd numbers in each of these waters for the past 2–4 years (Table 4.7). However, methods for expanding redd counts to population estimates have not yet been developed (S. Ricker, CDFW, personal communication). Additionally, sampling targets the spawning period and habitat for coho salmon and thus may not encompass the entirety of the spawning period and space for steelhead (Ricker et al. 2014d, 2015d, 2015h). With these caveats in mind, the average steelhead redd estimate for Redwood Creek has been 154 (range 52–389) over the last four years. The average redd estimate for Humboldt Bay over the same period has been 88 (range 17–183). For the South Fork Eel River, redd counts have averaged 643 (range 352–1113) over the last four years. Only two years of data are available for the Mattole River, with an average steelhead redd estimate of 298 (range 194–402). Because surveys do not encompass the entire spawning period in some years and methods have not been developed for expanding redd estimates to adult abundance estimates, these numbers cannot be directly compared to viability targets. Nevertheless, it appears evident that all four of these populations are well below viability targets (Table 4.7).

A longer time series of adult abundance estimates is available for Prairie Creek (14 years), although this monitoring effort was recently discontinued (2012) and replaced with the CMP effort that spans the entire Redwood Creek watershed. These surveys produced estimates averaging 40 spawners annually, with a slight positive but nonsignificant trend ($p = 0.545$) (Table 4.8; Figure 4.11a, 4.12a). Estimates of steelhead abundance in Freshwater Creek have been generated using mark-recapture methods since 1999. Over this 15-year period, an estimated average of 170 steelhead (range 51–432) have returned to Freshwater Creek annually, and the trend has been negative but not significantly so ($p = 0.108$) (Table 4.8; Figures 4.11b, 4.12b). Information is not available for the Maple Creek/Big Lagoon, Little River, Mad River, Price Creek, or Bear River winter-run steelhead populations.

Information on the abundance of summer-run steelhead populations is collected in two systems in the Northern Coastal Stratum: Redwood Creek and the Mattole River. Dive surveys covering an index reach of approximately 25.9 km of Redwood Creek have been conducted annually since 1981. Mean counts have averaged only 10 fish during the period of record (range 0–44), during which there has been a negative but non-significant ($p = 0.720$) trend (Table 4.9; Figures 4.13a, 4.14a). The recent (16-year) trend has been positive and marginally significant ($p = 0.077$); however, the population remains at critically low abundance. Dive counts of summer steelhead have also been made annually on the Mattole River since 1996 by the Mattole Salmon Group. Over this 19-year period, an average of 73 fish (range 35–129) have been observed annually (Table 4.9; Figures 4.13c, 4.14c), with about 33% being adults and the remaining 67% half-pounders (MSG 2015). Because the spatial extent of the survey has varied among years, analysis of trends was deemed inappropriate. Summer dive surveys were conducted on the Mad River

Table 4.7. Viability metrics for independent winter-run populations of steelhead in the NC-Steelhead DPS. NA indicates not available or applicable. Trends shown only for populations where time series is at least six years, **bold** indicates significant trend. IPkm includes only habitats that are currently accessible. $N_{a(arith)}$ target refers to the low-risk viability target identified by the Technical Recovery Team (Spence et al. 2008).

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{C}$	$\hat{T}$ *(95% CI)*	IPkm	$\hat{D}_{dep}$	$\hat{D}_{ssd}$	$\hat{D}_{ssd}$ target	$\overline{N}_{a(arith)}$ target
Northern Coastal											
Redwood Creek[a]	4	154	112	529	NA	NA	270.9	NA	NA	20.0	5400
Maple Cr/Big Lagoon	-	-	-	-	-	-	71.7	-	-	32.3	2300
Little River	-	-	-	-	-	-	63.0	-	-	33.5	2100
Mad River	-	-	-	-	-	-	453.7	-	-	20.0	5800
Humboldt Bay[a]	4	88	62	283	NA	NA	212.1	NA	NA	20.0	4200
Price Creek	-	-	-	-	-	-	18.2	-	-	39.7	700
SF Eel River[a]	4	643	574	1752	NA	NA	1017.0	NA	NA	20.0	20300
Bear River	-	-	-	-	-	-	107.8	-	-	27.2	2900
Mattole River[a]	2	298	279	NA	NA	NA	541.1	NA	NA	20.0	10800
Lower Interior											
Jewett Creek	-	-	-	-	-	-	16.8	-	-	39.9	700
Pipe Creek	-	-	-	-	-	-	17.4	-	-	39.8	700
Chamise Creek	-	-	-	-	-	-	36.2	-	-	37.2	1300
Bell Springs Creek	-	-	-	-	-	-	18.1	-	-	39.7	700
Woodman Creek	-	-	-	-	-	-	35.0	-	-	37.4	1300
Outlet Creek	-	-	-	-	-	-	192.6	-	-	20.0	3500
Tomki Creek	-	-	-	-	-	-	90.8	-	-	29.6	2700
Bucknell Creek	-	-	-	-	-	-	19.1	-	-	39.6	800
North Mtn. Interior											
Van Duzen River	-	-	-	-	-	-	317.4	-	-	20.0	6300

Table 4.7. continued.

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{C}$	$\hat{T}$ (95% CI)	IPkm	$\hat{D}_{dep}$	$\hat{D}_{ssd}$	$\hat{D}_{ssd}$ target	$\overline{N}_{a(arith)}$ target
Larabee Creek	-	-	-	-	-	-	88.4	-	-	29.9	2600
Dobbyn Creek	-	-	-	-	-	-	49.1	-	-	35.4	1700
Kekawaka Creek	-	-	-	-	-	-	30.7	-	-	38.0	1200
NF Eel River	-	-	-	-	-	-	318.2	-	-	20.0	6400
MF Eel River	-	-	-	-	-	-	503.5	-	-	20.0	10000
Upper Mainstem Eel R.	-	-	-	-	-	-		-	-	NA	NA
North-Central Coastal											
Usal Creek[b]	6	61	42	201	NA	0.366 (-0.271, 1.002)	17.6	2.3	3.5	39.8	700
Cottaneva Creek[b]	4	77	28	NA	NA	NA	23.2	NA	3.3	39.0	900
Wages Creek[b]	4	63	33	226	NA	NA	17.7	4.3	3.6	39.8	700
Ten Mile River[b]	6	407	153	893	NA	1.069 (-0.084, 2.222)	181.3	0.8	2.2	20.0	3600
Pudding Creek[b]	13	100	66	165	0.91	**-0.170 (-0.305, -0.034)**	24.3	0.7	4.0	38.9	900
Noyo River[b]	13	343	307	995	0.25	0.027 (-0.047, 0.101)	157.6	1.6	2.2	20.0	3200
Big River[b]	6	633	323	838	NA	**0.714 (0.435, 0.993)**	256.1	0.4	2.5	20.0	5100
Albion River[b]	6	60	37	104	NA	**0.457 (0.023, 0.892)**	48.6	0.3	1.2	35.5	1700
Big Salmon Creek[b]	3	91	41	NA	NA	NA	18.3	NA	5.0	39.7	700
Central Coastal											
Navarro River[b]	6	366	302	890	NA	**0.338 (0.099, 0.577)**	379.9	0.5	0.9	20.0	8000
Elk Creek[b]	2	31	13	NA	NA	NA	21.5	NA	1.4	39.2	800
Brush Creek[b]	6	13	6	22	NA	0.421 (-0.574, 1.417)	23.8	0.1	0.5	38.9	900
Garcia River[b]	6	326	258	1127	NA	0.193 (-0.332, 0.717)	137.2	2.1	2.4	23.2	3200
Gualala River	-	-	-	-	-	-	400.4	-	-	20.0	8000

a – Numbers indicate the estimated number of redds in the population (expanded from counts).
b – Numbers indicate the estimated number of adults based on fish/redd expansions from life-cycle monitoring stations.

Table 4.8. Population information for dependent populations of winter-run NC-Steelhead or populations with only index data or partial population estimates. NA indicates not available or applicable. Trends are shown only for populations where time series is at least six years, **bold** indicates significant trend.

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{T}$ *(95% CI)*
Northern Coastal					
Prairie Creek[a]	14	40	20	52	0.051 (-0.126, 0.227)
Freshwater Creek[b]	15	170	146	446	-0.055 (-0.124, 0.014)
North Mtn. Interior					
Van Arsdale Station[c]	78	1854	931	2157	**-0.033 (-0.043, -0.022)**
	16	328	278	832	**0.068 (0.011, 0.125)**
North-Central Coastal					
SF Noyo River[b]	15	81	72	233	0.018 (-0.052, 0.087)
Hare Creek[b]	9	51	14	257	**-0.451 (-0.686, -0.215)**
Caspar Creek[b]	13	54	37	122	-0.113 (-0.253, 0.027)
Little River[b]	13	18	13	41	-0.092 (-0.212, 0.028)
Central Coastal					
NF Navarro River[b]	2	358	342	NA	NA
Greenwood Creek[b]	2	7	4	NA	NA
Wheatfield Fk Gualala River[d]	9	1735	1163	5271	-0.102 (-0.407, 0.202)

a – Numbers based on AUC estimates. Surveys were discontinued after 2012 when basin-wide surveys for Redwood Creek were initiated.
b – Numbers indicate the estimated number of adults based on fish/redd expansions from life-cycle monitoring stations.
c – Numbers based on fish counts at Van Arsdale Station. Represents a partial composite of Upper Eel River and Soda Creek populations. Statistics on 78-year time series include an unknown number of hatchery-origin fish; recent (16-year) statistics are for natural-origin fish only.
d – Numbers based on observations of live fish during boat surveys. Surveys were discontinued after 2010.

between 1980 and 2005 when the effort was discontinued. However, beginning in 2012, snorkel surveys were re-initiated with the goals of implementing consistent protocols and covering the river from Kadle Hole (near Hwy 101) to R.W. Matthews Dam. Over this three-year period, an average of 427 summer steelhead have been counted annually (range 308–558), with adults constituting 73% of fish counted and half-pounders the remaining 27% (Pounds et al. 2015; D. Feral, Mad River Alliance, personal communication). Assuming the last few years are representative of current viability, the population is at roughly half its viability target (Table 4.9).

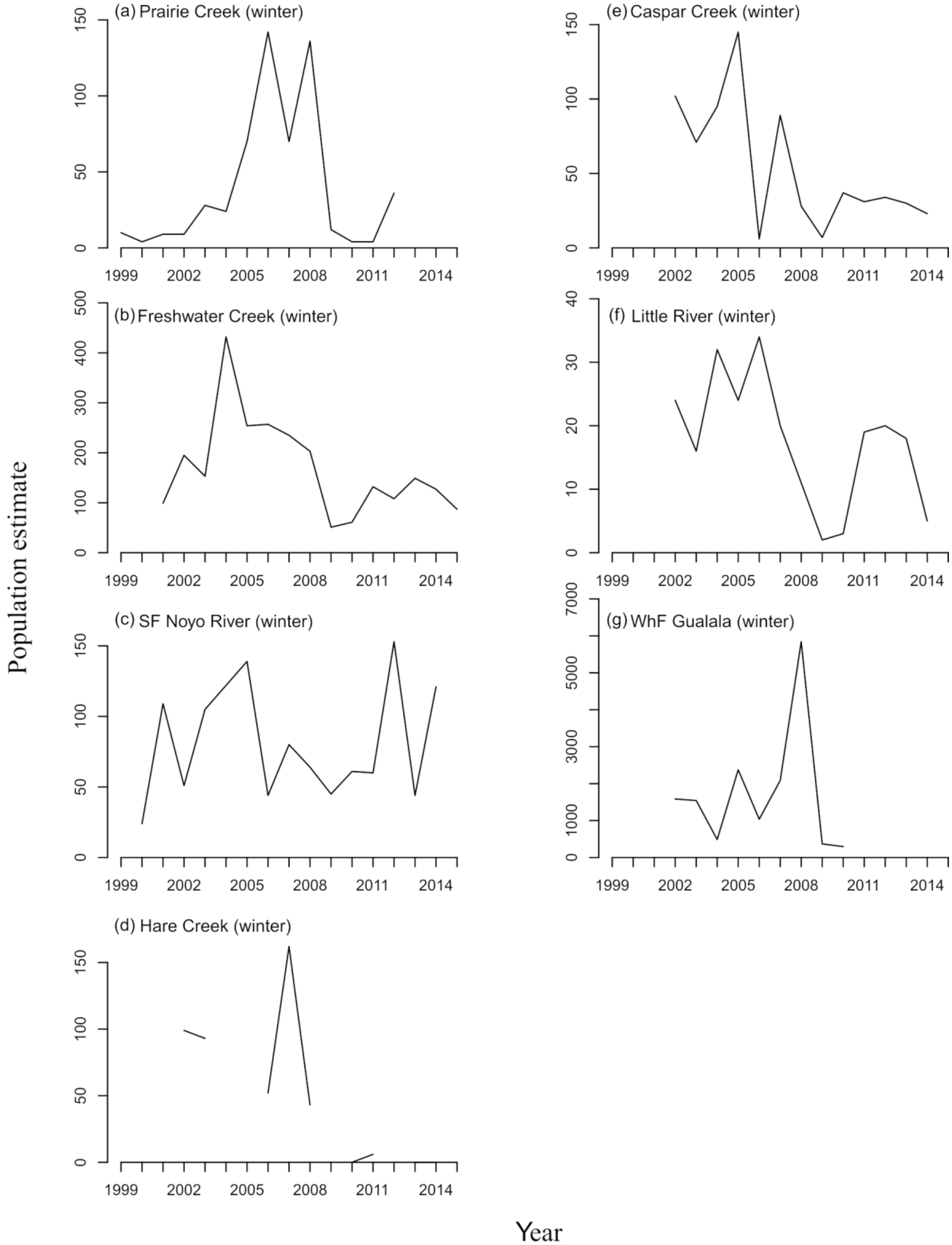

Figure 4.11. Time series of population abundance estimates for dependent populations or partial populations of winter-run NC-Steelhead. Estimates for Prairie Creek are based on the area-under-the-curve (AUC) method. Estimates for Wheatfield Fork Gualala River are based on counts of live fish observed from boat surveys. All other estimates are based on fish/redd expansions or mark-recapture estimates from life-cycle monitoring stations.

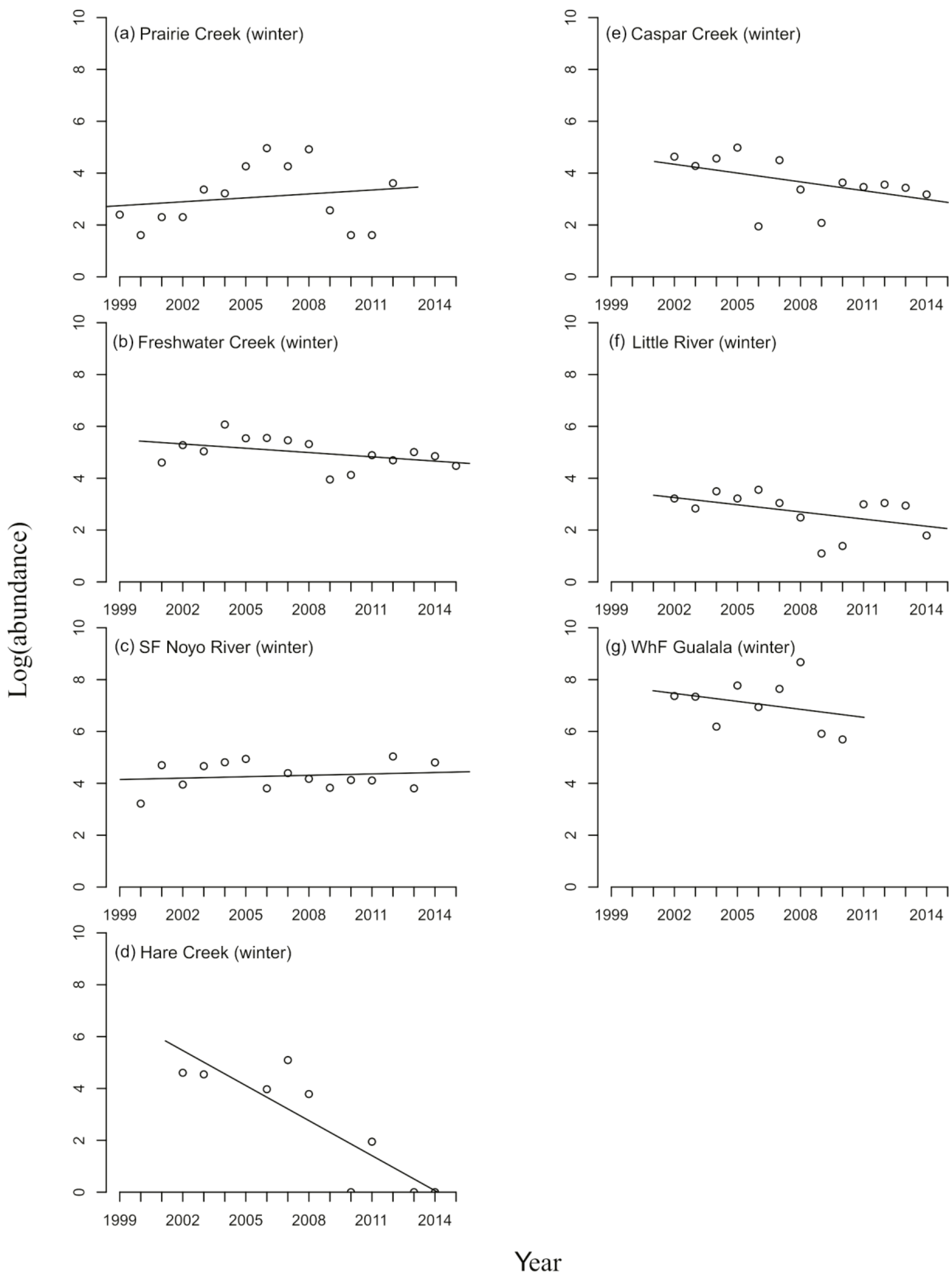

Figure 4.12. Population trends for dependent populations or partial populations of winter-run NC-Steelhead. Estimates for Prairie Creek are based on the area-under-the-curve (AUC) method. Estimates for Wheatfield Fork Gualala River are based on counts of live fish observed from boat surveys. All other estimates are based on fish/redd expansions or mark-recapture estimates from life-cycle monitoring stations.

Table 4.9. Population information for summer-run NC-Steelhead or populations with only index data or partial population estimates. NA indicates not available or applicable. Trends are shown only for populations where time series is at least six years, **bold** indicates significant trend.

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{T}$ (95% CI)	$\overline{N}_{g(harm)}$ target
Northern Coastal						
Redwood Creek[a]	34	10	7	18	-0.006 (-0.038, 0.027)	2500
	16	9	7	17	0.073 (-0.009, 0.154)	
Mad River	3	427	414	-	-	2500
SF Eel River	-	-	-	-	-	2500
Mattole River[b]	19	73	67	203	NA	2500
North Mtn. Interior						
Van Duzen River[c]	5	132	115	413	NA	2500
Larabee Creek	-	-	-	-	-	2500
NF Eel River	-	-	-	-	-	2500
Up-Mid Mainstem Eel River	-	-	-	-	-	2500
MF Eel River[d]	48	789	703	2107	-0.002 (-0.013, 0.008)	2500
	16	638	601	1428	0.049 (0.016, 0.081)	

a – The Redwood Creek summer steelhead population contributes to both the Northern Coastal and North Mountain Interior diversity strata. Estimates are from dive counts of a standardized reach and thus represent only a partial population estimate.
b – The Mattole River surveys cover only a portion of available rearing habitat and are thus a partial population estimate. Total stream miles surveyed is inconsistent from year to year; thus, calculation of trends was deemed inappropriate.
c – The Van Duzen River summer steelhead survey likely covers most of the available summer holding pools for the population.
d – The Middle Fork Eel River summer steelhead survey likely covers most of the available summer holding pools for the population.

Lower Interior Stratum. The Lower Interior Stratum includes eight populations of winter-run steelhead in tributaries that enter the Eel River primarily from the west and south between Jewett Creek and Soda Creek, inclusive. We are aware of no information on the status or viability of these populations (Table 4.7).

North Mountain Interior Stratum. The North Mountain Interior Stratum includes tributaries that enter the Eel River from the east from the Van Duzen River to the Middle Fork Eel River, and including the upper mainstem Eel River. The only dataset available for winter-run steelhead in this region are counts of steelhead at Van Arsdale Station, which represents a composite of the Bucknell Creek and Soda Creek populations (both considered part of the Lower Interior Stratum), as well as a small portion of the historical range of the Upper Mainstem Eel River population. Analysis of counts at Van Arsdale Station is confounded by a long history of hatchery activity within the basin and the inability to discriminate between hatchery-origin and natural-origin fish in the years preceding 1997. Over the 78-year period of record, an average of 1,854 steelhead have

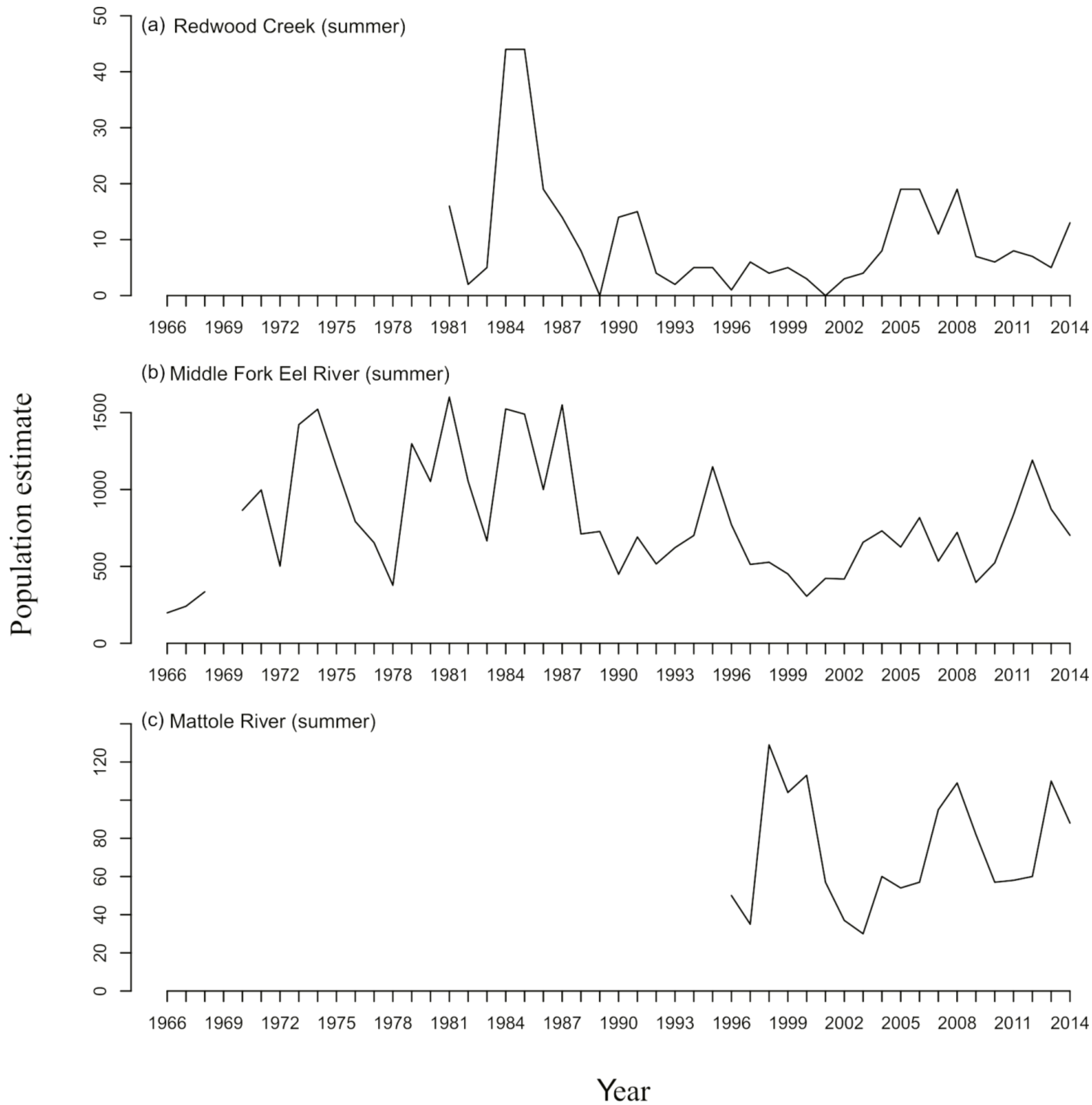

Figure 4.13. Time series of population abundance estimates for independent populations of summer-run NC-Steelhead. Estimates for Redwood Creek and Mattole River are summer dive counts for index reaches. Estimates from Middle Fork Eel River are based on summer dive counts covering most available oversummering habitat.

been counted at Van Arsdale (Table 4.8); however, the more recent (16-year) average has been 631 fish, with 328 of these being of natural origin. The long-term trend (combined natural-origin and hatchery-origin fish) has been negative ($p < 0.001$); however, the recent (16-year) trend for natural-origin fish has been positive ($p = 0.024$) (Table 4.8; Figures 4.15, 4.16). Without knowing which of the three populations these fish represent, it is difficult to evaluate these numbers against viability criteria for these populations.

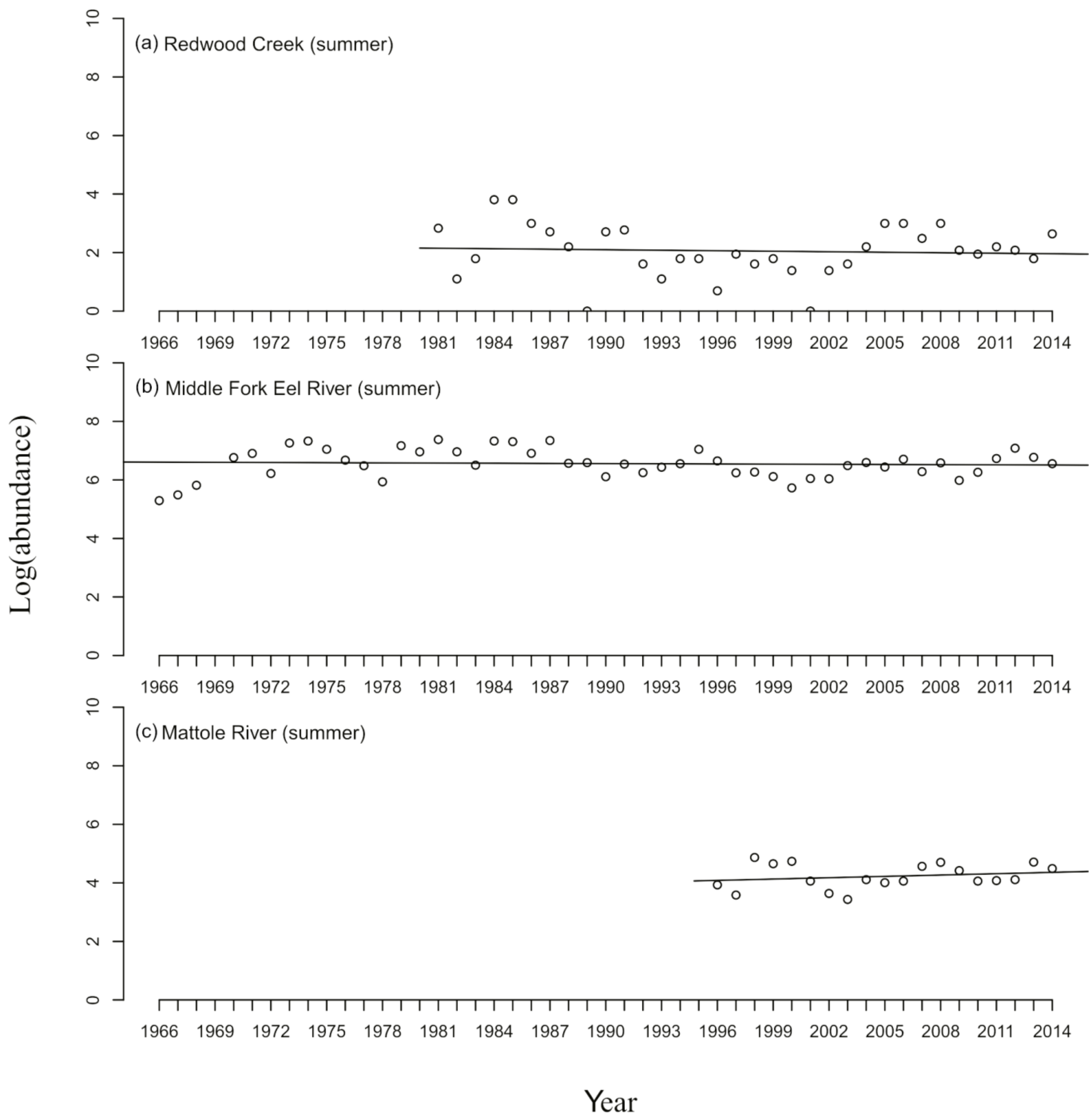

Figure 4.14. Population trends for independent populations of summer-run NC-Steelhead. Estimates for Redwood Creek and Mattole River are summer dive counts for index reaches. Estimates from Middle Fork Eel River are based on summer dive counts covering most available oversummering habitat.

Nevertheless, it is clear that neither Bucknell Creek nor the Upper Mainstem Eel River population is approaching viability targets. In the latter case, this is not surprising given that the majority of historical habitat lies above an impassable dam and the remaining habitat is insufficient to support a viable population.

For summer steelhead in this stratum, dive counts dating back to 1966 are available for the Middle Fork Eel River population. The long-term average abundance was 789 spawners with essentially no trend over the period of record ($p = 0.699$) (Table 4.9; Figures 4.13b, 4.14b). The recent (16-year) average has been slightly lower at 638 with a significant positive trend during that time ($p = 0.006$) (Table 4.9). Overall, the population is currently at about 60% of the viability target for this population. Recently, CDFW initiated summer dive surveys on the Van Duzen River. These surveys cover the reach between Little Larabee Creek and Eaton Roughs (generally considered the upper extent of anadromy on the mainstem Van Duzen River), which is thought to encompass the majority of available holding pools in the river[9] (S. Thompson, CDFW, personal communication). Over the past five years, an average of 132 (range 54–255) steelhead has been counted each year (Table 4.9). The population is currently at about 17% of the viability target for this population.

North-Central Coastal Stratum. The availability of information on steelhead abundance in the North-Central Coastal stratum has improved considerably since the CMP was fully implemented in 2009. Population estimates are now available for all nine independent populations in the stratum, though time series exceeding 6 years are available for only two of these populations (Pudding Creek and Noyo River). For most of the smaller watersheds, including Usal Creek, Cottaneva Creek, Wages Creek, Pudding Creek, and Big Salmon Creek, population estimates over the last 3–13 years have averaged between 60 and 100 fish, which ranges from 9% to 13% of the viability targets (Table 4.7). Of these five populations, trends were estimated only for those with 6 or more years of record. For Usal Creek, the trend was positive but not significant ($p = 0.186$) (Table 4.7; Figures 4.17a, 4.18a). For Pudding Creek, the trend over the last 13 years has been negative and significant ($p = 0.019$) (Table 4.7; Figures 4.17c, 4.18c). This trend is driven by four consecutive years (2009–2012) of returns of fewer than 30 spawners, which also accounts for the population falling below the high-risk depensation threshold ($D_{dep} = 0.7$) (Table 4.7).

For the four largest watersheds in the stratum, estimates of population abundance have been generally higher. In the Ten Mile River, estimates of steelhead adults have averaged 407 (range 0–869) over the last 6 years, with the short-term trend being positive and marginally significant ($p = 0.062$) (Table 4.7; Figures 4.17b, 4.18b). This population has fallen below the high-risk depensation threshold ($D_{dep} = 0.8$) but has since rebounded. Estimates of steelhead adults in the Noyo River over the last 13 years have averaged 343 fish (range 79–593), and have shown essentially no trend ($p = 0.435$) (Table 4.7; Figures

[9] Almost all observations of summer steelhead over the last 30 years have been made in this reach; however, in 2015, 29 adult summer steelhead were observed in the lower river near the mouth of Yager Creek. It is believed that this unusual occurrence was likely due to extreme drought conditions that limited upstream migration of summer steelhead this year (S. Thompson, CDFW, personal communication). Nevertheless, it raises the possibility that the dive counts may underestimate total population size in some years.

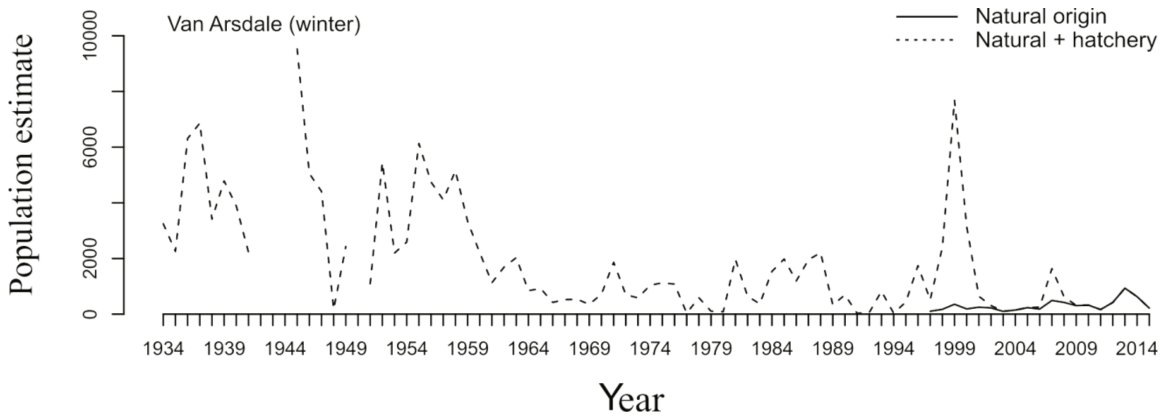

Figure 4.15. Time series of population abundance estimates for dependent populations or partial populations of winter-run NC-Steelhead. Estimate for Van Arsdale Station is a dam count potentially representing portions of multiple populations.

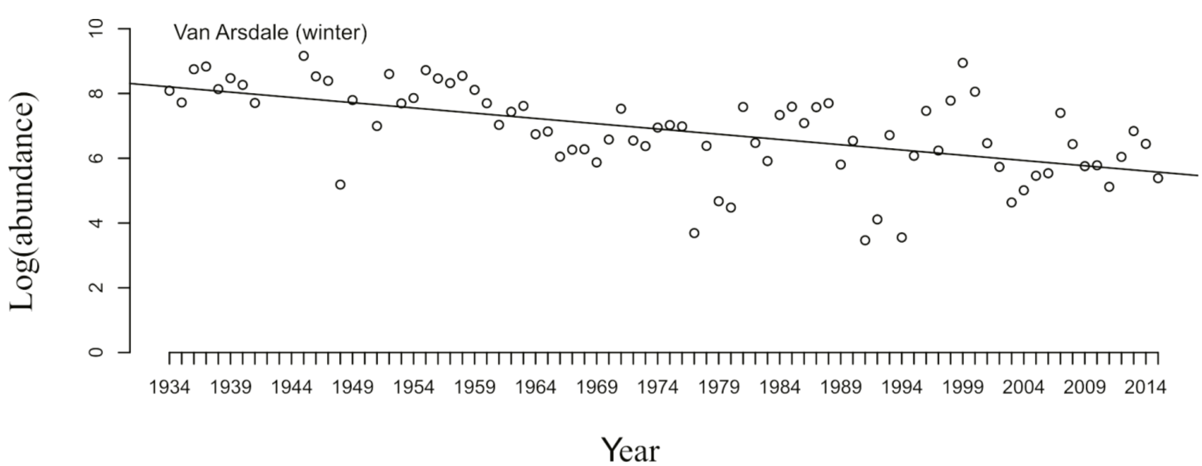

Figure 4.16. Population trends for dependent populations or partial populations of winter-run NC-Steelhead. Estimate for Van Arsdale Station is a dam count potentially representing portions of multiple populations.

4.17d, 4.18d;). Estimates for Big River have averaged 633 (range 52–1,820) over the past 6 years. The population trend has been positive ($p = 0.002$) (Table 4.7; Figures 4.17e, 4.18e); however, the population also falls below the high-risk depensation threshold ($D_{dep} = 0.4$) as a consequence of low abundance in the first three years of the time series (Table 4.7). Finally, the Albion River has averaged 60 adults (range 13–182) over the last 6 years. This population has also shown a positive short-term trend ($p = 0.043$) but has also dipped below the high-risk depensation threshold ($D_{dep} = 0.3$) (Table 4.7; Figures 4.17f, 4.18f;). For all four of these populations, the estimated abundances lie between 4% and 12% of viability targets.

Data are also available for four dependent or partial populations in this stratum. Population estimates for three dependent populations, Hare Creek, Caspar Creek, and Little River, over the last 9–13 years have averaged between 18 and 54 fish (Table 4.8), and trends for all three have been negative, though significantly so only for Hare Creek ($p = 0.003$) (Table 4.8; Figures 4.11d-f, 4.12d-f). The estimate from the South Fork Noyo River (part of the Noyo River population) has averaged 81 adults (range 24–153), with essentially no trend over the 15 years of record ($p = 0.585$) (Table 4.8; Figures 4.11c, 4.12c).

Central Coastal Stratum. Population estimates are now available for four of five independent populations in the Central Coastal Stratum, though in all cases, the time series span 6 or fewer years. The estimated return of steelhead adults to the Navarro River has averaged 366 (range 102–781) over 6 years (Table 4.7). The trend over that time has been positive and significant ($p = 0.017$); however, the population remains at only 5% of the viability target and fell below the high-risk depensation threshold in the early part of the time series (Table 4.7; Figures 4.17g, 4.18g). Elk Creek has been sampled only two of the past 6 years, producing an average of 31 adult steelhead during those years (range 3–59) (Table 4.7). Brush Creek has produced an average of 13 steelhead adults in the past 6 years (range 0–41), with a positive but nonsignificant ($p = 0.305$) trend (Table 4.7, Figures 4.17h, 4.18h). This population is also well below the high-risk depensation threshold ($D_{dep}=0.1$). Finally, the Garcia River has produced an estimated 326 steelhead adults annually (range 65–773) for the past 6 years and also shows a positive but nonsignificant trend ($p = 0.366$) (Table 4.7; Figures 4.17i, 4.18i).

Population estimates for only two years are available for the North Fork Navarro River (part of the Navarro River population) and Greenwood Creek. The North Fork Navarro River has produced an estimated 358 spawners annually (range 251–466), while Greenwood Creek has produced an average of 7 spawners (range 0–14) (Table 4.8). Outside of the CMP effort, estimates of adult steelhead in the Wheatfield Fork of the Gualala River based on direct observation of adults in holding pools were generated from 2002 to 2010 (DeHaven 2010). These efforts produced estimates averaging 1,735 adults annually (range 296–5,843) (Table 4.8). These data indicate a negative but nonsignificant ($p = 0.452$) trend. Though only a partial population estimate, these data suggest that the Gualala River population is perhaps the largest remaining in the Central Coastal Stratum and perhaps the DPS as a whole. Regrettably, this monitoring effort was discontinued after 2010 and there is no new information on this population.

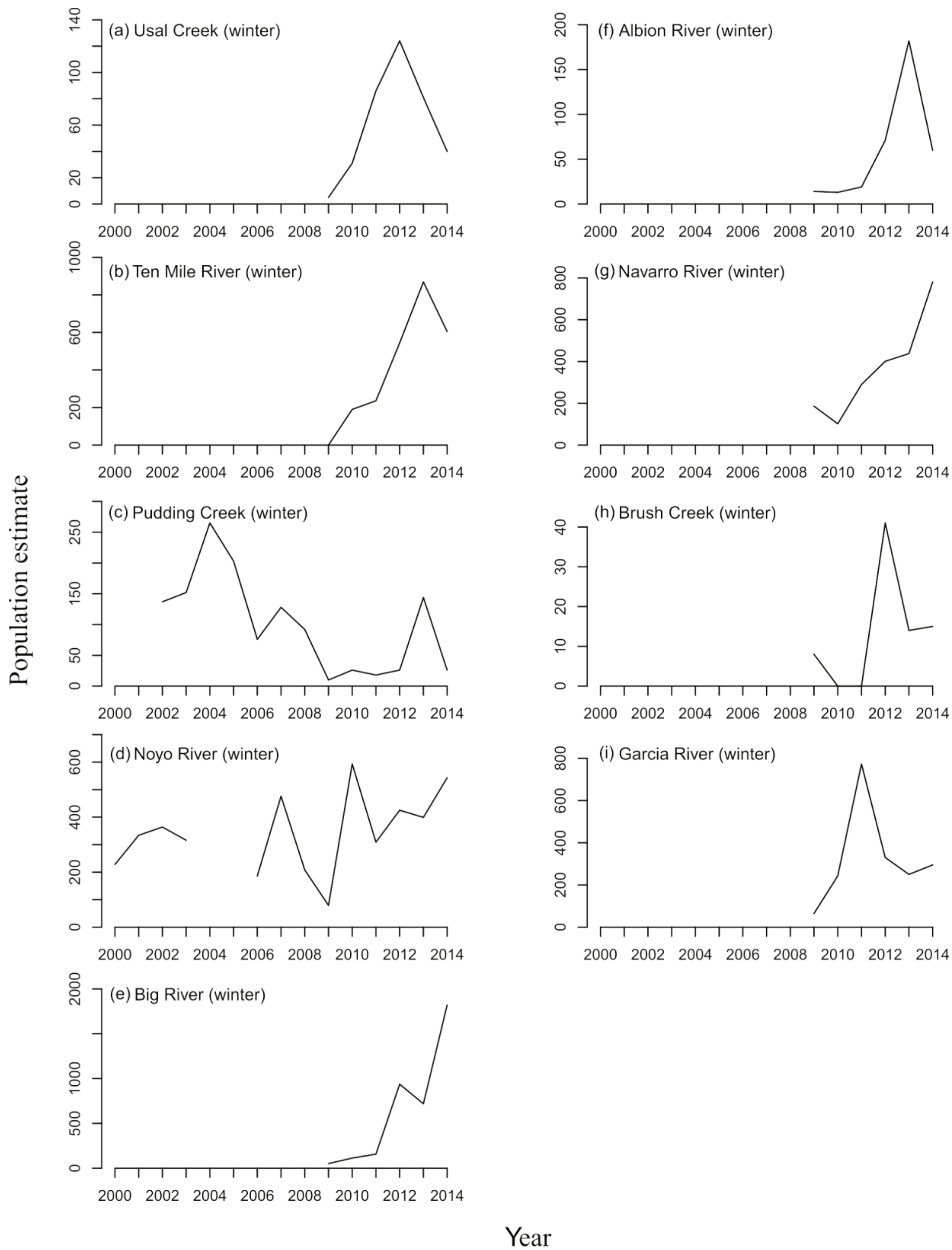

Figure 4.17. Time series of population abundance estimates for independent populations of winter-run NC-Steelhead. All estimates are based on fish/redd expansions from life-cycle monitoring stations.

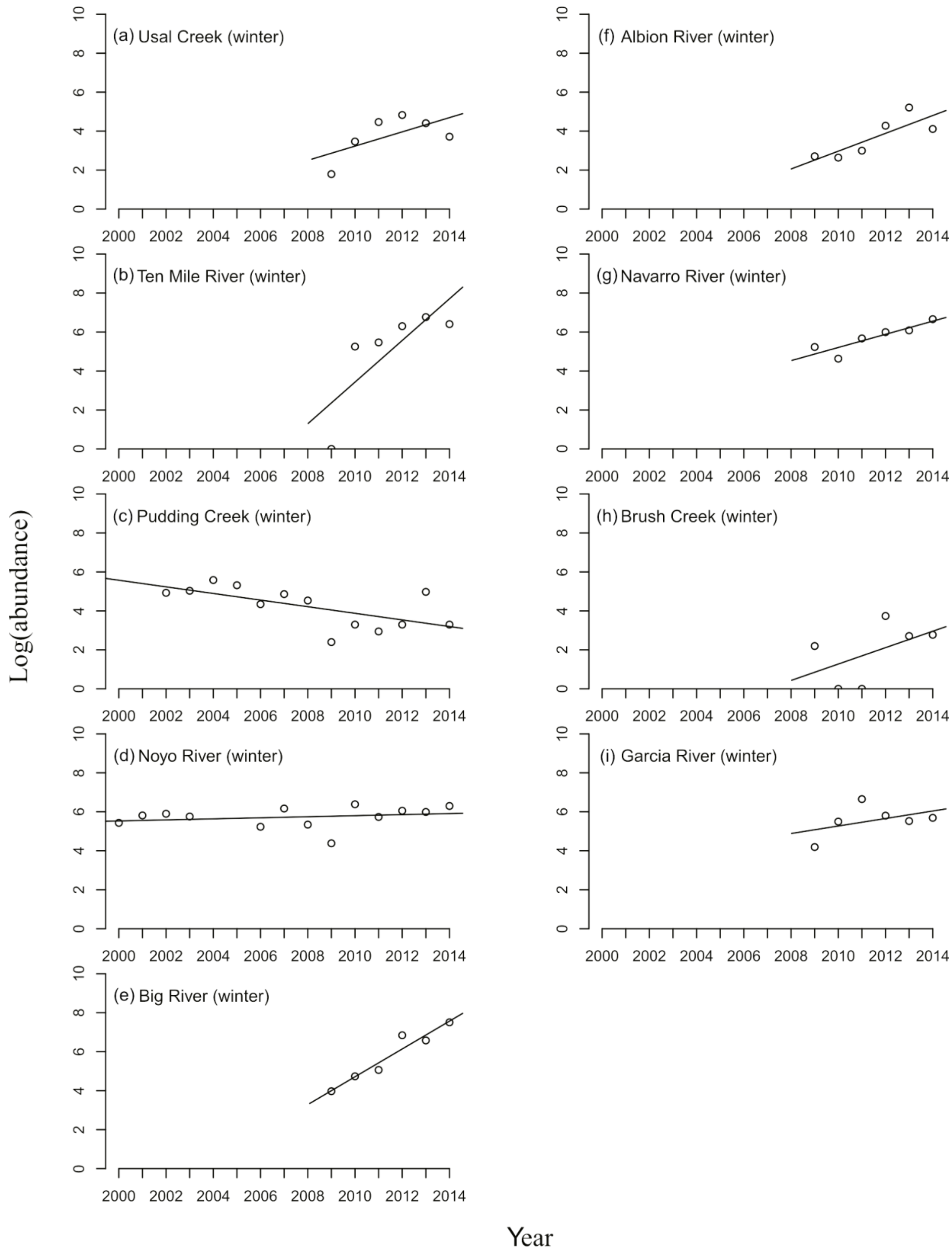

Figure 4.18. Population trends (log abundance) for independent populations of winter-run NC-Steelhead. All estimates are based on fish/redd expansions from life-cycle monitoring stations.

Harvest Impacts[10]

Ocean harvest of steelhead is extremely rare, and is in particular an insignificant source of mortality for NC-steelhead. While insufficient data exist to estimate NC-steelhead freshwater exploitation rates, these rates are likely relatively low given that retention of natural-origin steelhead is prohibited in California. Fishing effort estimates based on angler self-report cards are available for 2000–2014 (Figure 4.19). Beginning in 2013, fishing regulations for many streams changed from allowing no steelhead retention to allowing a daily bag limit of two hatchery-origin steelhead per day. In summary, while no direct information is available on the level of NC steelhead fishery impacts, it is reasonable to conclude that the level of impact has either not appreciably changed since the 2010 salmon and steelhead assessment (Williams et al. 2011), or potentially increased due to increased bag limits for hatchery-origin fish.

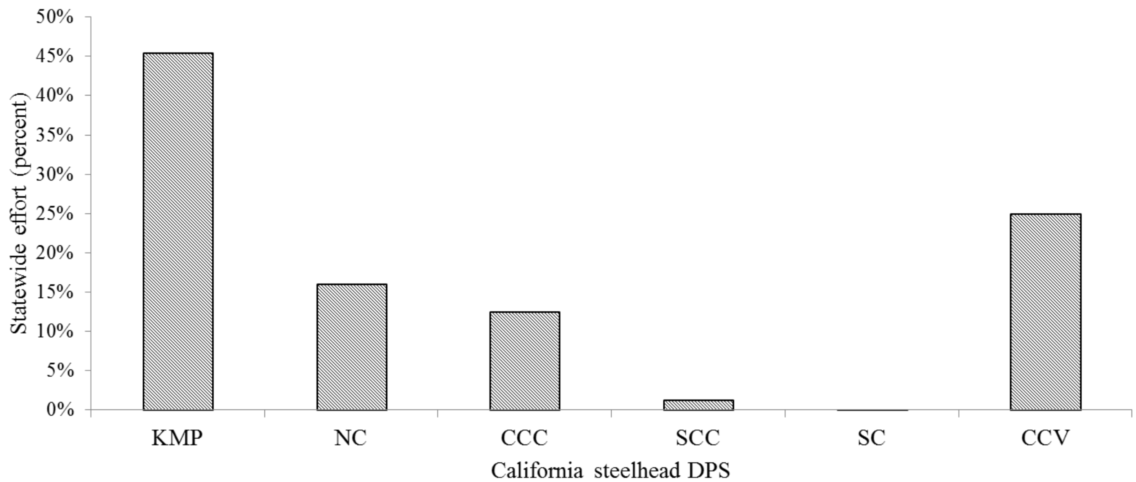

Figure 4.19. Distribution of California statewide steelhead fishing effort by DPS for years 2000−2014 (Jackson 2007; Farhat in preparation).

Summary and Conclusions

The availability of information on steelhead populations in the NC-Steelhead DPS has improved considerably in the past 5 years, thanks to implementation of the CMP across a significant portion of the DPS. Nevertheless, significant gaps in information still remain, particularly in the Lower Interior and North Mountain Interior diversity strata, where there is very little information from which to assess viability. Overall, the available data for winter-run populations—predominately in the North Coastal, North-Central Coastal, and Central Coastal strata—indicate that all populations are well below viability targets, with most being between 5% and 13% of these goals. For the two Mendocino Coast

[10] Harvest impacts section prepared by Michael O'Farrell

populations with the longest time series, Pudding Creek and the Noyo River, the 13-year trends have been negative and neutral, respectively (Figures 4.18c, 4.18d). However, the short-term (6-year) trend has been generally positive for all independent populations in the North-Central Coastal and Central Coastal strata, including the Noyo River and Pudding Creek (Figure 4.18). Data from Van Arsdale Station likewise suggests that, although the long-term trend has been negative, run sizes of natural-origin steelhead have stabilized or are increasing. Thus, we have no strong evidence to indicate conditions for winter-run have worsened appreciably since the last assessment (Williams et al. 2011).

Summer-run populations continue to be of significant concern. The Middle Fork Eel River population has remained remarkably stable for nearly five decades and is closer to its viability target than any other population in the DPS (Table 4.9). Although the time series are short, the Van Duzen River and Mad River appear to be supporting populations numbering in the low hundreds. However, the Redwood Creek and Mattole River populations appear small, and little is known about other populations including the various tributaries of the Eel River (i.e., Larabee Creek, North Fork Eel River, and South Fork Eel River).

In summary, the available information for winter-run and summer-run populations of NC Steelhead do not suggest an appreciable increase or decrease in extinction risk since publication of the last viability assessment (Williams et al. 2011). Most populations for which there are population estimates available remain well below viability targets; however, the short-term increases observed for many populations, despite the occurrence of a prolonged drought in northern California, suggests this DPS is not at immediate risk of extinction.

4.4 Central California Coast Steelhead

DPS Boundary Delineation

See discussion of steelhead DPS boundary issues in introduction.

Summary of Previous Assessments

The original BRT concluded that the Central California Coast (CCC) Steelhead DPS was in danger of extinction (Busby et al. 1996), citing extreme risk for populations in Santa Cruz County and tributaries to San Francisco and San Pablo bays, as well as apparent substantial declines in numbers and threats to genetic integrity (caused by hatchery activities) in the Russian River. A subsequent status review (NMFS 1997) concluded that the ESU was not presently in danger of extinction but was likely to become so in the foreseeable future; the change in opinion of the BRT was prompted by new data showing that steelhead remained present in most watersheds in the Santa Cruz Mountains and were more abundant than previously thought. This DPS was listed as threatened in late 2007 (62 FR 43937). Good et al. (2005) similarly concluded that the DPS was not presently in danger of extinction, but was likely to become so in the foreseeable future, and the DPS's status as threatened was reaffirmed (71 FR 834). The general paucity of data was identified as a continuing source of uncertainty in these reviews. In the most recent assessment, Williams et al. (2011) concluded that there was little information available to indicate a change in the viability of this DPS, though again acknowledged the high uncertainty surrounding most populations, particularly those entering San Francisco and San Pablo bays.

New Data and Updated Analyses

Steelhead populations in the CCC-Steelhead DPS are the most poorly monitored salmonid populations in the NCCC Recovery Domain. Population-level estimates of adult abundance are entirely lacking for 28 populations that constitute the North Coastal, Interior, Coastal San Francisco Bay, and Interior San Francisco Bay diversity strata. Only in the Santa Cruz Mountain stratum has implementation of the CMP been initiated, and here only recently. Thus, with the exception of the life-cycle monitoring station in Scott Creek, estimates of abundance span only 1–3 years for populations in this stratum. More limited monitoring efforts have produced data for a few partial populations, but the lack of data continues to make it extraordinarily difficult to assess the status, trends, and viability of populations in the DPS. We summarize the limited information below by stratum.

North Coastal Stratum. This stratum includes tributaries in the lower Russian River watershed downstream of the confluence of Mark West Creek, as well as coastal watersheds of Sonoma and Marin counties. There are no comprehensive efforts to monitor any of the independent or dependent populations in this stratum. Spawner surveys have been conducted in the Lagunitas Creek watershed since 2001-2002; however, these target coho salmon and do not encompass the full spawning period of steelhead. Consequently, the redd counts are not considered reliable indicators of trends. With those caveats in mind, redd counts for this period, which perhaps serve as a minimum estimate for spawners, have averaged approximately 155 (range 23–320) (Ettlinger et al. 2015). Given the incomplete nature of these surveys and lack of developed methods for expanding redd counts to adult estimates, it is difficult to compare these values with viability targets. However, these redd counts suggest that the population is well below its viability target of 1900 adults (Table 4.10).

Redd surveys for two dependent populations in this stratum, Redwood Creek and Pine Gulch, are conducted by the National Park Service. As with the Lagunitas Creek surveys, these surveys target coho salmon and thus do not encompass the full spawning period for steelhead. A rough estimate of returning adults has been made by multiplying the redd count by two (assumes one redd per female, and one male per female). Over 14 years, the average estimate has been 17 for Pine Gulch and 13 for Redwood Creek (Table 4.11). Trends for both of these time series have been positive but nonsignificant (Table 4.11; Figures 4.20a-b, 4.21a-b).

Interior Stratum. The Interior Stratum of this DPS consists of populations in the upper Russian River basin, upstream and inclusive of Mark West Creek. We know of no systematically collected data on naturally produced steelhead adults for this stratum (Table 4.10). Warm Springs Hatchery and Coyote Valley Fish Facility continue to produce approximately 660,000 yearling steelhead annually as part of mitigation for the loss of steelhead habitat behind Warm Springs and Coyote dams (Clifford 2015, unpublished data), and these fish are distributed throughout the upper and lower watershed. In the last 15 years, an average of approximately 6,300 steelhead have returned to the hatchery annually (Coey 2015), the majority of these (> 95%) being marked fish of hatchery origin. The lack of spawner surveys on natural spawning grounds within the upper Russian River basin make it impossible to assess either the abundance of natural-origin fish or the fraction of fish on spawning grounds that are of hatchery origin.

Coastal San Francisco Bay Stratum. Population-level estimates of adult abundance are not available for any of the seven independent populations within this stratum. Nor is there any population information for dependent populations within this stratum. Adult steelhead are periodically reported in several creeks, including San Francisquito Creek (M. Stoecker, Stoecker Ecological, personal communication) and Miller Creek (Marin County Watershed Program 2015). However, information is insufficient to evaluate whether there has been any change in viability.

Interior San Francisco Bay Stratum. Population-level estimates of adult abundance are also lacking for all 10 independent populations of steelhead in the Interior San Francisco Bay Stratum. Spawner surveys have been conducted in recent years in selected portions of the Napa River watershed and have produced occasional sightings of steelhead redds,

Table 4.10. Viability metrics for independent populations of steelhead in the CCC-Steelhead DPS. NA indicates not available or applicable. Trends shown only for populations where time series is at least six years, **bold** indicates significant trend. IPkm includes only habitats that are currently accessible. $N_{a(arith)}$ target refers to the low-risk viability target identified by the Technical Recovery Team (Spence et al. 2008).

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{C}$	$\hat{T}$ (95% CI)	IPkm	$\hat{D}_{dep}$	$\hat{D}_{ssd}$	$\hat{D}_{ssd}$ target	$\overline{N}_{a(arith)}$ target
North Coastal											
Austin Creek	-	-	-	-	-	-	95.4	-	-	29.0	2800
Green Valley Creek	-	-	-	-	-	-	37.0	-	-	37.1	1400
Salmon Creek	-	-	-	-	-	-	36.6	-	-	37.1	1400
Americano Creek	-	-	-	-	-	-	35.4	-	-	37.3	1300
Stemple Creek	-	-	-	-	-	-	45.1	-	-	36.0	1600
Walker Creek	-	-	-	-	-	-	57.8	-	-	34.2	2000
Lagunitas Creek							53.8			34.7	1900
Interior											
Mark West Creek	-	-	-	-	-	-	271.9	-	-	20.0	5400
Dry Creek	-	-	-	-	-	-	116.4	-	-	20.0	3000
Maacama Creek	-	-	-	-	-	-	76.1	-	-	31.6	2400
Upper Russian River	-	-	-	-	-	-	542.4	-	-	20.0	10800
Santa Cruz Mtns											
Pilarcitos Creek	-	-	-	-	-	-	20.7	-	-	39.4	800
San Gregorio Creek[a]	2	136	135	NA	NA	-	55.2	-	2.5	34.6	1900
Pescadero Creek[a]	3	591	361	1773	NA	-	66.4	8.9	8.9	33.0	2200
Waddell Creek[a]	2	74	73	NA	NA	-	13.7	-	5.4	40.0	500
Scott Creek[b]	12	202	174	518	0.55	**-0.136 (-0.197, -0.075)**	18.9	5.4	10.7	39.6	700
Laguna Creek	-	-	-	-	-	-	13.1	-	-	40.0	500
San Lorenzo River[a]	3	525	423	1575	NA	-	153.0	3.4	3.4	21.0	3200

Table 4.10. continued.

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{C}$	$\hat{T}$ (95% CI)	IPkm	$\hat{D}_{dep}$	$\hat{D}_{ssd}$	$\hat{D}_{ssd}$ target	$\overline{N}_{a(arith)}$ target
Soquel Creek[a]	1	8	8	NA	NA	-	54.2	-	0.1	34.7	1900
Aptos Creek[a]	1	70	70	NA	NA	-	29.7	-	2.4	38.1	1100
Coastal SF Bay											
Corte Madera Creek	-	-	-	-	-	-	26.4	-	-	38.6	1000
Novato Creek	-	-	-	-	-	-	39.1	-	-	36.8	1400
Guadalupe River	-	-	-	-	-	-	87.2	-	-	30.1	2600
Saratoga Creek	-	-	-	-	-	-	2.4	-	-	-	-
Stevens Creek	-	-	-	-	-	-	14.5	-	-	-	-
San Francisquito Creek	-	-	-	-	-	-	28.8	-	-	38.2	1100
San Mateo Creek	-	-	-	-	-	-	7.7	-	-	-	-
Interior SF Bay											
Petaluma River	-	-	-	-	-	-	147.7	-	-	21.7	3200
Sonoma Creek	-	-	-	-	-	-	198.1	-	-	20.0	4000
Napa River	-	-	-	-	-	-	357.0	-	-	20.0	7100
Green Valley/Suisun Cr	-	-	-	-	-	-	82.4	-	-	30.8	2500
Walnut Creek	-	-	-	-	-	-	5.6	-	-	-	-
San Pablo Creek	-	-	-	-	-	-	10.1	-	-	-	-
San Leandro Creek	-	-	-	-	-	-	11.9	-	-	-	-
San Lorenzo Creek	-	-	-	-	-	-	24.6	-	-	38.8	1000
Alameda Creek	-	-	-	-	-	-	24.8	-	-	38.8	1000
Coyote Creek	-	-	-	-	-	-	140.5	-	-	22.7	3200

a – Numbers indicate the estimated number of adults based on fish/redd expansions from life-cycle monitoring stations.
b – Mark-recapture estimates from Scott Creek life-cycle monitoring station.

Table 4.11. Viability metrics for dependent populations of steelhead in the CCC-Steelhead DPS. NA indicates not available or applicable. Trends shown only for populations where time series is at least six years, **bold** indicates significant trend. $N_{a(arith)}$ targets have not been defined yet.

Stratum/population	Years	$\overline{N}_{a(arith)}$	$\overline{N}_{a(geom)}$	$\overline{N}_{g(harm)}$	$\hat{T}$ *(95% CI)*	$\overline{N}_{a(arith)}$ target
North Coastal						
Pine Gulch[a]	14	17	8	29	0.131 (-0.070, 0.332)	-
Redwood Creek[a]	19	13	6	-	0.188 (0.102, 0.274)	-
Santa Cruz Mtn						
San Pedro Creek[b]	1	38	38	NA	-	-
Gazos Creek[b]	3	58	30	175	-	-
San Vicente Creek[b]	3	61	35	182	-	-

a – Estimates are redd counts multiplied by 2.
b – Numbers indicate the estimated number of adults based on fish/redd expansions from life-cycle monitoring stations.

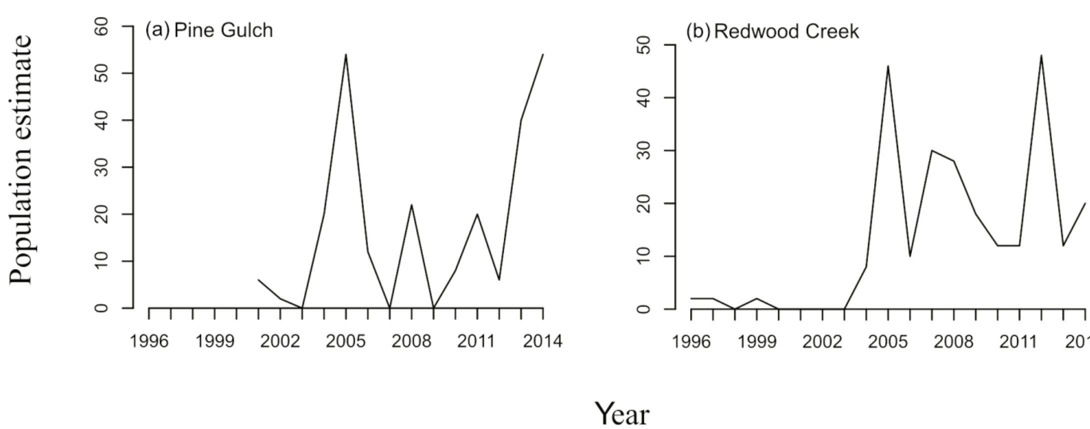

Figure 4.20. Time series of population abundance estimates for dependent populations of winter-run CCC-Steelhead. Estimates are two times the total redd count for the watershed.

live fish, or carcasses in the mainstem Napa Creek as well as three tributaries: York Creek, Heath Creek, and Redwood Creek (Koehler 2008; Koehler and Blank 2013). Additionally, a rotary screw trap operated near the upper limit of tidal influence has resulted in capture of 31 to 251 smolts annually since 2009 (Koehler 2014). These efforts confirm the occurrence of steelhead in this watershed. However, the highly limited spatial

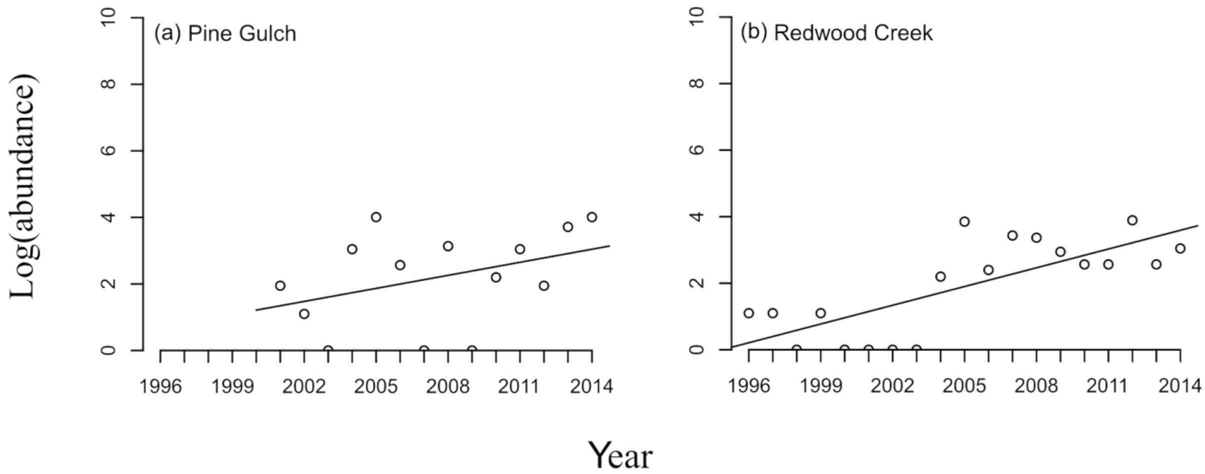

Figure 4.21. Population trends (log abundance) for dependent populations of winter-run CCC-Steelhead. Estimates are based on two times the total redd count for the watershed.

and temporal extent of the adult surveys and the lack of mark-recapture estimates that would allow expansion of smolt counts to population estimates do not allow any conclusions to be drawn about population status or trends. Likewise, limited spawner surveys in selected tributaries of the Petaluma River produced 6 live steelhead, 2 carcasses, and 6 redds, all in Adobe Creek during the 2013–2014 spawning season (Morrison et al. 2014). Again these limited surveys confirm steelhead presence in the watershed, but do not allow conclusions to be drawn about current viability.

Santa Cruz Mountains Stratum. The Scott Creek LCM station provides the only population estimates of adult steelhead abundance in the entire CCC Steelhead DPS for a period spanning more than 3 years. Over the past twelve years, an average of 202 steelhead adults have returned to this watershed, which is approaching 30% of the viability target. However, the population trend has been negative ($p < 0.001$) (Table 4.10; Figures 4.22, 4.23). Implementation of the coastal monitoring plan has produced estimates of steelhead in several other watersheds in this stratum, but only for the past 1–3 years. Results from these surveys indicate that populations in the three largest watersheds number in the hundreds of fish, from 136 in San Gregorio Creek to more than 500 in Pescadero Creek and the San Lorenzo River (Table 4.10). These values range from 7% (San Gregorio) to 27% (Pescadero) of the viability targets for these populations. Estimates for the smaller watersheds range from 8 fish in Soquel Creek (based on a single year of data) to over 70 fish in Waddell and Aptos creeks (Table 4.10). These values range from <1% to 15% of the populations' viability targets.

Harvest Impacts[11]

Ocean harvest of steelhead is extremely rare, and is in particular an insignificant source of mortality for CCC-steelhead. While insufficient data exists to estimate CCC-Steelhead freshwater exploitation rates, these rates are likely relatively low given California's retention prohibition of natural-origin steelhead. Fishing effort estimates based on angler self-report cards are available for 1993–2005, which suggest that effort declined in the second half of the period in this DPS (Figure 4.19). Fishing effort estimates for more recent years are not available but there has been little change in the fishing opportunity status quo. However, beginning in 2013, fishing regulations for many streams changed from allowing no steelhead retention to allowing a daily bag limit of two hatchery-origin steelhead per day. Additionally, recent drought conditions have affected some steelhead fishing opportunities for this DPS. For example, the California Fish and Game Commission imposed an emergency fishery closure on the Russian River in February of 2014. The closure ended in April of that year. In summary, while no direct information is available on the level of CCC-Steelhead fishery impacts, it is reasonable to conclude that the level of impact has either not appreciably changed since the 2010 salmon and steelhead viability assessment (Williams et al. 2011), or potentially increased due to increased bag limits for hatchery-origin fish.

Summary and Conclusions

The scarcity of information on steelhead abundance in the CCC-Steelhead DPS continues to make it difficult to assess whether conditions have changed appreciably since the previous assessment of Williams et al. (2011), which concluded that the population was likely to become endangered in the foreseeable future. In the North Coastal and Interior strata, steelhead still appear to occur in the majority of watersheds, though in the Russian River basin, the ratio of hatchery fish to natural-origin fish returning to spawn remains largely unknown and continues to be a source of concern. New information from three years implementation of the CMP in the Santa Cruz Mountains Diversity Stratum indicates that population sizes are perhaps higher than previously thought. However, the downward trend in the Scott Creek population, which has the most robust estimates of abundance, is a source of concern. The viability of populations in the two San Francisco Bay diversity strata remains highly uncertain, and it is likely that many populations where historical habitat is now inaccessible due to dams and other passage barriers are likely at high risk of extinction.

In summary, while data availability for this DPS remains poor, we find little new evidence to suggest that the extinction risk for this DPS has changed appreciably in either direction since publication of the last viability assessment (Williams et al. 2011).

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[11] Harvest impacts section prepared by Michael O'Farrell

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VIABILITY ASSESSMENT FOR PACIFIC SALMON AND STEELHEAD LISTED UNDER THE ENDANGERED SPECIES ACT: SOUTHWEST

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