KLAMATH MOUNTAINS PROVINCE SUMMER STEELHEAD

Oncorhynchus mykiss irideus

Critical Concern. Status Score = 1.9 out of 5.0. Klamath Mountain Province (KMP) summer steelhead are in a state of long-term decline in the basin. These stream-maturing fish face a high likelihood of extinction in California in the next fifty years.

Description: Klamath Mountains Province (KMP) summer steelhead are anadromous rainbow trout that return to select freshwater streams in the Klamath Mountains Province beginning in April through June. Summer steelhead are distinguishable from winter steelhead by (1) time of migration (Roelofs 1983), (2) the immature state of gonads at migration (Shapovalov and Taft 1954), (3) location of spawning in higher-gradient habitats and smaller tributaries than other steelhead (Everest 1973, Roelofs 1983), and more recently, genetic variation in the Omy5 gene locus (Pearse et al. 2014). Summer steelhead are nearly identical in appearance to the more common winter steelhead (see Northern California coastal winter steelhead).

Taxonomic Relationships: For general relationships of steelhead, see Northern California coastal winter steelhead account. In the Klamath River Basin, salmonids are generally separated primarily by run timing, which has been shown recently to have a genetic basis (Kendall et al. 2015, Arciniega et al. 2016, Williams et al. 2016, Pearse et al. *In review*). The National Marine Fisheries Service (NMFS) does not classify Klamath River basin steelhead "races" based on run-timing of adults, but instead recognizes two distinct reproductive "ecotypes." Steelhead ecotypes are populations adapted to specific sets of environmental conditions in the Klamath Basin based upon their reproductive biology and timing of spawning (Busby et al. 1996). However, differences in run-timing of steelhead are not accounted for in current NMFS Distinct Population Segment (DPS) criteria, which lumps all Klamath Mountains Province steelhead together for management purposes.

Genetic and non-genetic factors (physical, physiological, ecological, and behavioral) indicate that the ocean-maturing ecotype (winter-run) steelhead are distinct from the stream-maturing ecotype (summer-run) fish. Genetic samples from fish collected between the Klamath River estuary and the river's confluence with the Trinity River support discrete migrating populations based primarily on timing of freshwater entry and state of maturity (Papa et al. 2007). Studies of the KMP steelhead Distinct Population Segment (DPS) indicate that KMP summer steelhead are more closely related to winter steelhead in the KMP than to summer steelhead from other basins (Reisenbichler et al. 1992, Pearse et al. 2014). Studies of summer and winter steelhead demonstrate greater levels of differentiation between spatially isolated reproductive populations (Papa et al. 2007, Pearse et al. 2007, Prince et al. 2015). Recent evidence suggests that early run timing has evolved, presumably independently, in several basins throughout California, including in the Klamath Mountains Province, and further indicates that summer-run life history evolved from winter-run fish in the same basin (Arciniega et al. 2016).

Pearse et al. (2007) analyzed genetic samples from 30 sites throughout the Klamath River watershed and three Trinity River sites. Results indicated that geographically proximate populations were most similar genetically, even when taking the influence of hatcheries into account from Iron Gate Hatchery on the Klamath and the Trinity River Hatchery. Steelhead sampled from the mouth of the Klamath were most similar to those in other coastal streams (Smith River, Wilson Creek), and samples from downstream of the Trinity River confluence (Turwar, Blue, Pecwan, Cappell, and Tully creeks) expressed limited gene flow with steelhead sampled upstream. Further, populations sampled in the middle regions of the Klamath River basin had genetics that clustered closely together with fish from the Trinity River and the Trinity River Hatchery, perhaps due to a history of egg transfers to the hatchery (Busby et al. 1994). At the upper portion of the watershed in California, fish from the Shasta and Scott rivers were genetically distinct from steelhead sampled in other mid-Klamath basins, and clustered closely to steelhead from Iron Gate Hatchery, suggesting that influence of hatchery gene flow (possibly from straying) to these nearby tributaries with summer-run fish. These fish have a section of the genome that has evolved separately in both steelhead and spring-run Chinook salmon (Pearse et al. 2016). Over time, positive selection and straying likely have caused this favorable mutation to radiate outward and give rise to steelhead and salmon along the West Coast of the United States that express a continuum of run timings to exploit habitats during different times of the year. In the future, KMP stream-maturing steelhead, labeled summer steelhead here, should be recognized as a distinct DPS and managed separately from winter steelhead based on differing life histories, morphologies, genetics, susceptibilities to environmental changes, and conservation needs (Hodge et al. 2013, Prince et al. 2015). A question remains, however, as to the assignment of the distinct fall run steelhead in the Klamath and Trinity rivers (Box 1).

The decision not to include fall-run fish as a discrete run with their own account, but in addition to the discussion of summer-run fish, was made based on a review of historical timing of adult steelhead returns in the Klamath/Trinity Basin, reports from NMFS and CDFW, literature review, and discussion with biologists. Busby, Wainwright, and Waples (1994) summarized the complex task of discerning discrete steelhead runs in the KMP:

> "Run-type designation for steelhead in the Klamath and Trinity Rivers continues to be perplexing, particularly with respect to what is historically called fall-run steelhead. Everest (1973) and Roelofs (1983) contend that spring and fall steelhead of the Rogue, Klamath, Mad, and Eel Rivers are in fact summer steelhead based on lack of segregation at spawning, and the observation that sport fisheries for fall steelhead are limited to rivers with summer steelhead. However, other biologists classify fall steelhead separately (e.g., Heubach 1992) or as winter steelhead." pg. 18.

The authors also note that, "In the Klamath River Basin, some biologists refer to fall-run steelhead; disagreement exists as to whether fall-run steelhead should be considered as summer-run, winter-run, or as a separate entity. In this status review, we consider fall-run steelhead from the Klamath River Basin to be part of the summer run" (pg. 51), citing the shared stream-maturing ecotype of summer- and fall-run fish. The authors also agreed at the time that the winter-run (ocean-maturing) steelhead encompassed the most abundant runs in the basin.

However, Hopelain (1998) used scale analysis to determine run timing and life history strategies in KMP steelhead, albeit with small sample sizes. However, he assumed that the race of each steelhead examined could be assigned based on river location and time of capture. He also noted that the fall steelhead run is by far the largest of the three runs (summer, fall, winter) of steelhead in the basin, which contradicts the consensus finding just 4 years prior.

More recently, NMFS (2009) noted that "populations in the Basin are… comprised of three distinct runs; summer, fall and winter" (pg. 7) in their annual report to Congress. There is still confusion over how names are assigned to steelhead with a diversity of life histories and run timings. Without updated scale analyses or genetics studies, fall-run steelhead in the KMP lack sufficient information to be scored and discussed in a separate account.

It is likely that the steelhead that made it into the upper Klamath Basin before construction of Copco Dam were summer steelhead. The other alternative is that the upper basin steelhead were anadromous or fluvial redband trout (*O. mykiss newberrii*). The genetic relationship of KMP steelhead to these redband trout, which show migratory and resident life history variations, has also not been determined. With the four lower Klamath dams (Copco 1, Copco 2, J.C. Boyle, and Iron Gate) scheduled for removal beginning in 2020, this relationship bears further study because redbands will again have unimpeded access to the Pacific Ocean and summer steelhead will have access to some of their presumed historical spawning grounds.

Box 1. Fall-Run Steelhead: The Klamath-Trinity's Unrecognized Run?

Steelhead in the Klamath Mountains Province return to fresh water in every month of the year (W. Sinnen, CDFW, pers. comm. 2016) and represent a continuum of life history strategies and run timings (Hodge et al. 2016). The presence of an apparently distinct fall run of steelhead in the Klamath and Trinity rivers represents an interesting problem in evolution and management. It is unclear if a discrete run of fall-run steelhead historically existed in the basin. In the 1990s, steelhead that entered freshwater between August and November were referred to only occasionally as "fall steelhead" (Burgner et al. 1992). This peak occurs considerably later than summer steelhead, as revealed by snorkel surveys in tributaries (which occur in August), and earlier than the bulk of winter-run, ocean-maturing fish that peak in January. While summer-run adults typically migrate far upstream into headwater reaches of tributaries, fish returning in the fall cannot access these waters due to low flows, and thus hold mostly in mainstem river habitats until stream flow increases (W. Sinnen, CDFW, pers. comm. 2016). These stream-maturing fish have undeveloped gonads, and have thus been classified as summer steelhead by NMFS (Busby et al. 1996).

It is not clear whether hatchery-origin fish support this run, although thousands of unmarked fish of presumed wild origin are counted each year at Willow Creek Weir on the mainstem Trinity River during fall (W. Sinnen, CDFW, pers. comm. 2016). These fish are considered fall-run steelhead by CDFW because the weir cannot be left in place during the highest flows of the year when winter-run fish return (TRP 2014). Very small populations of steelhead with fall-run timing also exist in upper Klamath tributaries, though these fish may be offspring of hatchery strays (W. Sinnen, CDFW, pers. comm. 2016). Selection pressures from dam and hatchery operations (Abadia-Cardoso et al. 2013), intra- and inter-basin transfers of fish over decades, and associated straying of returning adults have likely played a role in the run-timing of adult steelhead in the KMP.

It is unknown if fall-run fish exemplify a shift in early maturation and run-timing of winter steelhead, or a protracted migration window of stream-maturing ecotype summer steelhead in response to alterations to streamflow over the last several decades of dam operations. The latter is most likely given that the early maturation phenotype is the result of a rare set of genes that are unlikely to have been 'invented' in steelhead more than one or two times in the basin. Spatial and temporal overlap of this intermediate life history strategy with the more discrete summer- and winter-run fish has likely muddled previous analyses and created more uncertainty. Regardless of the origins, conservation and management implications of fall-run life history displayed in KMP steelhead require further study; additional information, especially regarding genetics and scale analyses, is needed to warrant a separate account and scoring of these fish.

Life History: Steelhead are coastal rainbow trout that undergo physiological changes as juveniles, become anadromous, and migrate from the ocean to return to spawn in freshwater. Steelhead are iteroparous and can spawn several times throughout their lives, though after each successive spawning run decreases (W. Duffy, HSU, pers. comm. 2017). The Klamath and Trinity rivers are unusual for California in that they allow juvenile and adult steelhead to enter and exit the estuary in every month of the year (W. Sinnen, CDFW, pers. comm. 2016). The diversity of habitats, from inland spring-fed systems such as the Shasta River to snowmelt-driven tributaries of the Trinity River, underpin the variability in life history strategies in KMP steelhead. The cues for early migration and smoltification in steelhead that determine when they arrive on spawning grounds have been linked to a specific portion of their genome known as Omy5 (Pearse et al. 2016). This finding indicates that the basic life history diversity expressed in a given run of steelhead has its basis in a common ancestor and can be passed on to offspring. Across the spectrum of run-timing strategies, two basic reproductive strategies exist in KMP steelhead: ocean-maturing and stream-maturing. Ocean-maturing winter steelhead are most common. They enter fresh water with well-developed gonads and spawn relatively soon thereafter, while stream-maturing fall or summer steelhead enter fresh water with immature gonads, requiring several months to mature and then spawn (Burgner et al. 1992, Busby et al. 1996). These two ecotypes often overlap in spawning timing, which can confound differentiating between summer, fall, and winter steelhead for management. For example, it is likely that summer, fall, and winter fish appear at the Trinity River fish weir simultaneously.

In the KMP, summer-run steelhead are uncommon compared to ocean-maturing winter-run fish, but continue to persist in sub-basins of the Klamath Mountains Province. These fish are distinguishable from winter steelhead on the basis of adult migration and their morphological and physiological differences. They typically enter rivers in spring (April-June) and migrate upstream through early summer. In the Trinity River, however, summer steelhead enter between May and October. Summer steelhead are found in the Trinity River tributaries by June and in the mainstem Trinity above Lewiston by August. In the Klamath River, summer steelhead ascend into summer holding areas during a similar period. These holding areas are typically deep bedrock pools in canyon reaches of streams with some overhead cover and subsurface flow to keep temperatures cool. Once in upper reaches of cool tributaries, summer steelhead mature over several months in deep pools (Busby et al. 1996, Shapovalov and Taft 1954). They spawn in upstream regions that are largely not used by winter steelhead (Roelofs 1983) including smaller tributary/headwater streams. Spawning in the Trinity River peaks in February, earlier than winter steelhead, which peak in March. Spawning begins in late December and peaks in January (Roelofs 1983) throughout the Klamath Mountains Province (Figure 1). Maximum-recorded age of steelhead in recent studies is seven years, and female fecundity has been estimated at 2,000 to 3,000 eggs per fish (Hodge et al. 2015). In the Klamath drainage, 40 to 64% of the total spawning population are repeat spawners (Hopelain 1998). In the Salmon River, fully one-third of returning adult steelhead are repeat spawners, compared to about 15% in other tributaries (Hodge et al. 2015).

Steelhead race	KRSIC (1993)	Hopelain (1998)	USFWS (1979)	Busby et al (1996)	Moyle (2002)
Spring/Summer	May- July	March-June	April-June		April- June
Fall	August- October	July-October	August-November		
Winter	November- February	November-March	November-February		November-April
Stream-maturing				April- October	
Ocean-maturing				September-March	

Figure 1. Classification of different run-timings and reproductive ecotypes of steelhead found in the Klamath River Basin. From: Moyle 2002, Figure 3, pg. 4.

Early life history of summer steelhead in the Klamath River basin is presumably similar to the better-understood summer steelhead in the Eel River (see Northern California coastal summer steelhead account). Based on their occupancy of headwater streams with relatively low (<50 CFS) winter flows (Roelofs 1983), the fry move out of these smaller natal streams into larger tributaries soon after emerging. Scale studies suggest the majority of juvenile fish from the Middle Fork Eel River become smolts at two years old and return at age 3 and 4 (Puckett 1975). Average lengths for steelhead smolts entering the ocean ranges from 200mm (Trinity River) to 270mm (Shasta River) (Hodge et al. 2015).

Half-pounders: Winter and summer steelhead are all known to give rise to offspring that may exhibit a "half-pounder" life history strategy. While the half-pounder life history seems to be most closely associated with summer steelhead (Lee, 2016), they do not mature or reproduce while in the river. The presence of half-pounders over-summering with adult summer steelhead is not typically considered in the literature (Kesner and Barnhardt 1972, Hopelain 1998). However, annual snorkel surveys of summer steelhead in late summer in the Salmon, New, and South Fork Trinity rivers and their tributaries regularly encounter apparent half-pounders (L. Cyr, USFS, pers. comm. 2016). Frequently, the half-pounders outnumber adult steelhead during these surveys, but it is also possible that they are mistaken for resident rainbow trout, which confounds abundance estimates of these fish (D. Lee 2016). A relatively low proportion of half-pounder-sized steelhead are resident fish in all but the Scott River (Hodge et al. 2014). In the Klamath River, half-pounders are considered stream-maturing fish like summer steelhead because they are not mature when they enter freshwater holding habitat (Lee 2016). The relative contribution of winter-run and summer-run steelhead to offspring that exhibit the half-pounder life history is unknown, but seems to be more common to summer-run fish (Lee, 2016). However, differences in run timing between half-pounder fish and summer steelhead require more study. The presence of half-pounder fish is uncommon above Seiad Valley on the Klamath River, (Hopelain 1998) and summer steelhead are also not found in tributaries above this area. Individuals expressing these two life histories are often counted together because they both oversummer in pool habitat censused during snorkel surveys in the Salmon, South Fork Trinity, and New rivers and Wooley Creek in July-August (L. Cyr, USFS, pers. comm. 2016).

Habitat Requirements: Juvenile habitat requirements of summer-run steelhead seem to be similar to the more common winter steelhead (see Northern California coastal winter steelhead account). However, over-summering habitat for adult summer steelhead is critical for survival of these fish during periods of climatically and hydrologically unfavorable conditions. They are often found in the same cool tributaries as half-pounder fish and spring-run Chinook salmon, where their habitats overlap (L. Cyr, USFS, pers. comm. 2016). For example, adult summer steelhead in the New River occupy confluence and other pools of moderate size (200-1,000 m^2) with depths of 1.0 to 1.4m. Although localized areas of cool water (i.e., 0.2 to 3.8°C lower than the mean hourly pool temperature of 18.0°C) are observed in some pools, Nakamoto (1994) found that more important factors influencing summer steelhead habitat use are pool size, low substrate embeddedness (<35%), presence of riparian habitat shading, and instream cover associated with increased velocity through the occupied pools (Baigun 2003). Cover was used by 99% of the summer steelhead observed during the day on the New River, with bedrock ledges and boulders the most frequently used habitat types (Nakamoto 1994).

Spawning habitat for summer steelhead is variable and their consequent temporal and spatial isolation from other steelhead runs maintain some level of genetic differentiation from winter steelhead in the same watershed (Barnhart 1986, Papa 2007, Prince et al. 2015). Summer steelhead often spawn in intermittent headwater streams when sufficient flows are available, from which the juveniles emigrate into perennial streams soon after hatching (Everest 1973). Roelofs (1983) suggested that use of small streams for spawning may reduce egg and juvenile mortality because the embryos are less susceptible to scouring by high flows and predation on juveniles by adults is decreased due to lower densities of predators in smaller streams. Water velocity and depth measured at redds are 23-155 cm sec-1 and 10-150 cm, respectively, and diameters of the gravels are typically 0.64-13 cm. The concept of spawning spatial segregation is based largely on summer steelhead distribution and habitat utilization and inferred from genetic variation, since little is known about the spawning distribution of winter-run steelhead throughout the KMP due to high, turbid flows during spawning.

After feeding for several years in a narrow range of sea surface temperatures in the ocean (typically 8-14°C), a steelhead's spawning migration is triggered and they return to their natal rivers (Harding 2015, Hayes et al. 2016).

Distribution: The KMP summer steelhead range in California encompasses a variety of different habitats from cool fog-belt redwood forests on the coast near the mouth of the Klamath, to hot and arid inland valleys at the headwaters of the snowmelt-fed Scott and spring-fed Shasta rivers, allowing steelhead to adapt various life history strategies to make use of them. For example, the Trinity River is largely fed by snowmelt and runoff, while the Klamath and Shasta rivers are spring-fed at their sources, causing distinct differences in hydrographs and thus summer steelhead distribution and abundance (CDFW 2015). The Smith River is undammed and relies on runoff to fill its banks. The KMP summer steelhead range includes 23 streams including the Klamath River and its main tributaries: the Trinity, Salmon, Scott, and Shasta rivers and other streams north to the Elk River near Port Orford, Oregon (Nelson 2016). In the Klamath River, the upstream limit of steelhead migration is Iron Gate Dam, near the Oregon border. Their historical range likely included tributaries to Upper Klamath Lake, prior to dam construction (Hamilton et al. 2005). In the Trinity River, upstream migration is blocked by Lewiston Dam (Moffett and Smith 1950). Their range also encompasses the Smith River in California and the Rogue River in Oregon. In California, KMP summer steelhead currently inhabit the larger tributaries of the mid-Klamath subbasin (Bluff, Red Cap, Camp, Dillon, Clear, Elk, Indian, and

Thompson creeks), the Salmon River, and the Trinity River. In the Salmon River they are found in the North Fork, South Fork, and Wooley Creek. In the Trinity River drainage, populations of summer steelhead are present in Canyon Creek, Hayfork Creek, North Fork Trinity, East Fork Trinity, South Fork Trinity, and New rivers. In addition, the Smith River also supports summer steelhead.

While the majority of a steelhead's life is spent at sea, relatively little is known about their oceanic distribution. Many age-0 California steelhead juveniles apparently spend a year feeding in the California Current off the Klamath-Trinidad region, then move northwest to cooler waters offshore in the North Pacific. NOAA Fisheries' Southwest Fisheries Science Center has been conducting salmon trawling surveys since 2010 along lateral transects from shore from the Gulf of the Farallones to Southern Oregon. In general, steelhead were most abundant in trawls off of the Klamath-Trinidad transect, and catch per unit effort for both juvenile and adult steelhead increased with distance offshore compared to both coho and Chinook salmon (Harding 2015). These surveys show that while at sea, steelhead feed on krill, fish, and amphipods in low densities and in surface waters further offshore than either coho or Chinook salmon prefer (Hayes et al. 2016). The fact that steelhead are rarely caught in commercial fisheries for both coho and Chinook salmon lend further evidence of their differentiated habitat use in the ocean (Hayes et al. 2016).

Trends in Abundance: Little is known about the historical abundance of summer steelhead in the KMP; quantitative records of summer steelhead numbers exist only for recent decades (Roelofs 1983). While the stock status of this stream-maturing run of fish is uncertain (Nelson 2016), given the limited amount of habitat now available since large portions of the upper Klamath and Trinity basins were blocked by dams, it is likely that summer steelhead in the Klamath Basin currently represent only a small fraction of their original numbers and are currently in decline. Some summer steelhead populations (e.g., Salmon River) have declined precipitously in the past 30-40 years (Quiñones et al. 2013), while others have shown increases in recent years (e.g., New and North Fork Trinity rivers; USFS and CDFW 2016). Snorkeling counts, which provide the only abundance estimates for summer steelhead, are prone to numerous problems such as counting half-pounders as adult steelhead, incomplete spatial surveys due to access problems associated with private landownership, illegal marijuana cultivation throughout the KMP, and observational bias by surveyors. Thus survey numbers likely represent the minimum fish present in reaches during specific times, and so are mainly useful for trend analysis. However, the majority of estimates for California populations have been less than 100 fish each for the past decade (new data here).

Despite the highest documented diversity of life history strategies expressed by steelhead in the KMP (Hodge et al. 2016), resiliency has proven elusive for the population as a whole. In 1989-1991, the three-year average exceeded 500 fish in the North Fork Trinity River and New River and Dillon Creek in the middle Klamath River, which also each had more than 500 fish in 1999-2001 and 2002-2004. These two tributaries averaged more than 800 fish in 2009-2012. Three-year averages also exceeded 500 fish for some years in Dillon Creek (2000-2004) and Clear Creek (2001-2003) (T. Jackson, CDFW, pers. comm. 2011) on the order of hundreds of fish and even over one or two thousand fish in some years. For example, the New River had an estimated 2,108 summer steelhead counted in snorkel surveys in 2003. The most recent data in 2006 suggests that no tributary contains more than 1,000 summer steelhead. Out of 1,820 summer steelhead populations surveyed in the Klamath-Trinity basins, eleven averaged <100 fish annually and nine averaged < 20 fish each for the years they were surveyed only Wooley, Dillon, and Clear creeks, the Salmon, North Fork Trinity, and New rivers have averaged more than 100 fish throughout the survey series (Table 1).

Year	Adults	Half pounders	Total Steelhead	Bluff	Red Cap	Camp	Wooley	Dillon	Clear	Elk	Indian	Thompson	Grider	Other
1985	457	-	**457**	5	-	-	290	-	162	-	-	-	-	-
1986	428	-	**428**	-	-	-	-	-	428	-	-	-	-	-
1987	900	17	**917**	-	-	-	285	77	524	31	-	-	-	-
1988	1433	36	**1585**	91	25	-	362	299	693	69	46	-	-	-
1989	1503	36	**1620**	58	23	18	245	38	934	150	154	-	-	-
1990	271	72	**343**	-	-	-	73	74	117	57	21	-	-	1
1991	199	220	**419**	212	2	1	25	88	39	44	8	-	-	-
1992	119	360	**480**	149	31	7	38	-	100	72	82	-	-	1
1993	242	337	**579**	-	-	-	112	161	178	61	67	-	-	-
1994	185	251	**436**	15	4	2	54	-	134	110	117	-	-	-
1995	209	259	**469**	20	3	2	42	122	175	61	39	4	-	1
1996	73	270	**343**	15	6	1	15	91	102	96	-	14	-	3
1997	123	287	**410**	2	1	0	54	180	85	33	42	13	-	0
1998	108	667	**775**	15	6	4	41	151	68	490	-	-	0	0
1999	116	219	**335**	5	3	0	30	209	65	23	-	-	-	-
2000	489	511	**1000**	9	0	0	49	679	186	77	-	-	-	0
2001	1153	753	**1906**	9	2	2	214	929	538	212	-	-	-	-
2002	1728	993	**2721**	35	9	4	288	1108	1034	200	-	-	29	14
2003	913	375	**1288**	31	23	5	288	576	238	55	4	46	0	22
2004	587	456	**1043**	20	20	3	110	437	268	112	-	17	44	12
2005	243	214	**457**	10	10	13	50	216	108	34	-	9	3	4
2006	384	330	**714**	7	6	0	-	448	158	37	30	13	8	7
2007	187	270	**457**	18	4	15	59	58	129	33	87	21	16	17
2008	200	184	**384**	11	0	0	-	-	222	68	71	9	2	1
2009	154	290	**444**	23	2	7	90	107	78	56	42	36	1	2
2010	170	256	**426**	10	2	2	64	119	97	38	51	27	7	9
2011	233	296	**529**	11	2	1	47	166	141	87	70	0	0	4
2012	115	306	**421**	3	4	1	80	119	142	37	29	3	0	3
2013	195	506	**701**	11	1	4	73	113	299	91	36	14	0	59
2014	572	654	**1226**	4	1	2	219	494	269	67	111	27	19	13
2015	236	502	**738**	4	0	1	60	324	99	85	117	23	0	25

Table 1. "Summer Steelhead Totals." Data collected by the Klamath Basin Collaborative Partnership Orleans/Happy Camp Ranger Districts, USFS. *In 1988-89, Bluff and Red Cap counts combined half-pounders and adults. "Other" represents small tributaries between Aikens and Beaver Creek on the Klamath River. From: Cyr, L., USFS, pers. comm. 2016.

The "effective" (breeding) population sizes are likely less than the actual counts, so many populations may be close to or below the minimum size needed for long-term persistence (Lindley et al. 2007). These estimates are of fish holding in pools in midsummer and the number surviving to spawn in winter probably is considerably less because of natural mortality and poaching, which is a major cause for concern due to the low, clear water in most holding habitat. Most of the populations were severely affected by the extraordinary floods of 1964, which filled in many deep pools with sediment and presumably scoured out redds. Although their habitat is gradually recovering from this disaster, the number of summer steelhead has fluctuated widely without any upward trends. The ongoing drought has likely negatively impacted summer steelhead survival to spawning due to lower flows and higher stream temperatures than average over the last several years. Summer steelhead population estimates from each stream in the DPS have likely been less than 1,000 individuals over the last several years (W. Sinnen, CDFW, pers. comm. 2016). The status of each major population is a follows:

Mainstem Trinity River. Moffett and Smith (1950) indicate that summer steelhead were common in the snowmelt-fed upper mainstem Trinity River in the 1940s. This population apparently persisted through the early 1960s but is probably now extirpated (B. Curtis, 1992, CDFG files) due to the effects of Trinity and Lewiston dams. Suitable water temperatures downstream of Lewiston Dam provides habitat for summer steelhead, although the abundance of these fish is not known. It is likely that a large proportion of fish observed in the upper mainstem Trinity River recently originate from the Trinity River Hatchery or their offspring.

North Fork Trinity River. There is little historical information on summer steelhead in this stream, but recent data indicate that the population fluctuates between 200 and 700 fish per year. Summer steelhead distribution has changed relatively little during the recent period of monitoring and the majority of holding habitats have remained in the middle reaches. Their distribution at the upper extent seems to be conditional based upon sufficient flows, while temperature may be limiting in the reaches closest to the mainstem Trinity River confluence (Everest 1997). This stream has been heavily altered by mining, and therefore runs were likely much higher in the past (Roelofs 1983). Canyon Creek, a tributary near the North Fork Trinity River, continues to see small numbers of summer steelhead return each year.

South Fork Trinity River. There is no historical information on summer steelhead in this stream. Recent counts were as low as 34 fish, although in 2006 and 2007 more than 100 fish were observed. It is the only one of 18 stream reaches surveyed in KMP that displays a general upward trend in the snorkel survey abundance index, suggesting it could be a valuable refuge habitat as conditions continue to degrade in surrounding watersheds. Recent surveys on the South Fork Trinity River show summer steelhead were less common than half-pounder steelhead, although similarly distributed (Garrison 2002). This trend is repeats itself throughout the compiled survey data from the entire KMP (Table 1).

New River. This tributary of the Trinity River is home to the largest summer steelhead population in California, although it is highly accessible to humans and was heavily dredged for gold in the past. The estimated average abundance for 1979-2006 was 647 summer steelhead, with an average of 2108 fish in 2003, and 977 in 2004-2006. Availability of cool canyon pools of various types and overhead cover allow summer steelhead adults to successfully oversummer in remote reaches of this stream.

Klamath River tributaries. Summer steelhead populations averaging less than 70 fish are found in six small tributaries: Bluff, Red Cap, Camp, Indian, Thompson, Grider creeks, most with populations of less than 100 fish. Summer steelhead populations in Elk Creek averaged about 110 fishes during the years they were surveyed. Dillon and Clear creeks retain the largest summer steelhead populations on the Klamath River, averaging more than 300 fish annually during the years they were surveyed (1978 and 1980, respectively, Figure 2). While there is no clear trend among the smaller populations, summer steelhead populations on Dillon and Clear creeks became more abundant through the 1990s and were estimated to be over 1000 fishes in 2003. The estimates have decreased significantly over the past few years, and the 2005-2009 counts were 207 and 139, respectively.

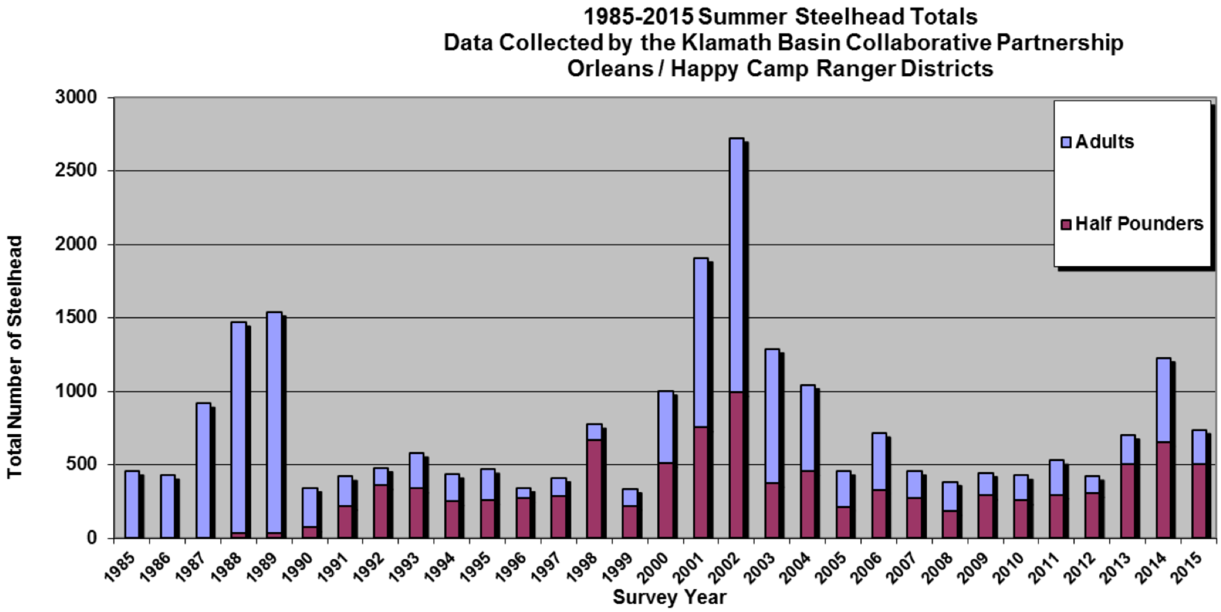

Figure 2. Compiled summer steelhead and half-pounders in the KMP from 1985-2015. The most important tributaries are Wooley Creek (Salmon River), Dillon Creek, and Clear Creek by contribution of returning adults. From: Cyr, L. USFS, pers. comm. 2017.

Salmon River. Despite the presence of suitable spawning and holding areas, the two forks of the Salmon River combined now only support less than 100 summer steelhead fish per year and have included half-pounder fish that could be mistaken as adults. These watersheds were heavily mined during the late 19th century and still impacts runoff and the prevalence of heavy metal contaminants (Klamath National Forest and Salmon River Restoration Council 2002). The 1990 complete census of the Salmon River showed 48 summer steelhead (DesLaurier and West 1990) and the number observed remained very low with a recent increase since 2000. Since 2001, between 100 and 350 summer steelhead and oversummering half pounders have returned to the Salmon River. Correlation trend data between Iron Gate Hatchery steelhead and Salmon River summer steelhead suggest that hatchery stocks are influencing adult escapement trends (Quiñones et al. 2013). Further investigation is needed to explore adult escapement and population trends between hatchery and wild steelhead in the basin.

Wooley Creek. Like the Salmon River, to which Wooley Creek is tributary, this rather inaccessible (to humans) stream has maintained a run of steelhead that is usually 100-400 fish per year. This population did not experience a gradual increase during the 1990s like larger KMP summer steelhead populations, but instead declined to average 50 individuals annually between 1990-2000. The estimated run size recently peaked at 288 fish in both 2003 and 2004, although more recent estimates have returned to approximate the 1990s average.

Smith River. Only 10-20 fish are estimated to occur in each of five tributaries in recent years (Reedy 2005), less than 100 fish total, but this river may never have supported summer steelhead in large numbers (Roelofs 1983, J. Garwood, CDFW, pers. comm. 2016), so these counts may be in line with historical averages. New information continues to become available through dedicated and comprehensive monitoring, which will be formalized in the draft Smith River Fishery Management Plan scheduled for release in 2017.

Overall, KMP summer steelhead numbers in recent decades appear to have ranged between 1,400 and 4,000 fish in the entire KMP system per year. They have since dwindled to likely less than 2,000 returning adults to the entire basin for the past decade. These estimates almost certainly represent only a small fraction of historical numbers, based on the fact that large areas of formerly accessible habitats are now blocked above dams, that summer steelhead generally utilize these same types of blocked habitats (e.g., smaller tributary headwater streams), and human land and water uses have altered many remaining accessible habitats. Increases in numbers have been documented in some tributaries, such as the South Fork Trinity River in recent years, presumably due to a combination of good ocean conditions, recovering stream habitats, and restrictive sport fishing regulations.

Factors Affecting Status: Summer-run steelhead are exceptionally vulnerable to human activities because adults are conspicuous in their summer holding pools and are present in rivers for extended periods of time. All salmonids are subject to the legacy effects of 19th century hydraulic mining and logging in the KMP, which devastated many watersheds. While steelhead populations may have recovered somewhat from these legacy effects, by the time there was much interest expressed in summer steelhead, their numbers were low again, presumably depressed by pervasive 20th century mining and logging. There is no hatchery production of summer steelhead, so their populations truly reflect local conditions. In contrast, fluctuations in the more recently documented fall-run fish are likely responses to a combination of recent stressors and selection pressures on hatchery-origin fish in the Trinity basin. Other more general factors are discussed under North Coast winter steelhead and Upper Klamath-Trinity River spring Chinook; the latter often share habitat with summer steelhead.

Dams. Three dams that directly affect KMP steelhead in the Klamath basin are Iron Gate (Klamath), Dwinnell (Shasta), and Lewiston (Trinity) dams. All are part of larger projects and these three dams have blocked access to large portions of formerly utilized KMP steelhead habitats, especially important spawning and rearing grounds in the middle and upper portions of both systems. These fish probably ascended higher in each watershed than any other salmonid based on their morphological adaptations to hold in lower, faster water and leap higher than other steelhead or Chinook salmon (Hodge et al. 2011). These dams negatively affect all salmonids by limiting access to critical spawning, rearing, and migration habitats, as well as altering flows and increasing water diversions (Lewis et al. 2004) and degrading water quality (Hamilton et al. 2011). Dam operations have decreased the variability, magnitude, duration, and altered timing of flows in the Klamath River. Peak flow timing has also shifted to at least a month earlier than prior to dam construction (Hamilton et al. 2011). Lower flows are of particular concern in the summer because daytime water temperatures can reach 24-26°C across large portions of the Klamath system, reducing available rearing habitat.

However, removal of Iron Gate and other upstream dams under the Klamath Basin Hydroelectric Agreement, and concordant Klamath Basin Restoration Agreement, will open up hundreds of kilometers of potential steelhead habitat in the future; the dam removal project is slated to begin by 2020.

Dwinnell Dam has blocked access to greater than 30km of habitat in the upper Shasta River since its construction in 1928. The dam, in combination with multiple diversions, has decreased the quality and quantity of habitat by reducing flows and disrupting the natural hydrograph, eliminating peak flows that could improve habitat conditions for steelhead and other salmonids (Lewis et al. 2004). Minimum daytime water temperatures in summer below the dam are usually higher than 20°C, peaking above 22-24°C, which can stress steelhead.

Lewiston Dam has blocked access to >170 km of habitat on the Trinity River since 1963. Unlike the precipitation runoff-fed Klamath and Scott rivers or the spring-fed Shasta River, the headwaters of the Trinity in the Trinity Alps is a snow-fed system. Along with Trinity Dam, located just upstream, the dams have greatly reduced flows, but emergency releases in summer months have also decreased water temperatures, and disrupted the natural hydrograph of the main stem Trinity River. In an effort to restore main stem habitat, the Trinity River Restoration Program (initiated in 2000 as part of the Trinity River Record of Decision) was implemented with the goal of restoring up to 48% of flows into the Trinity River. Since its implementation, summer flows have been augmented, habitat improved, the stream channel and floodplain reconnected, and spawning gravel supplemented.

Hatcheries. Two hatcheries currently operated by the California Department of Fish and Wildlife operate in the KMP as mitigation for lost habitat above Iron Gate and Lewiston Dams. While neither hatchery rears summer-run fish, the Trinity River Hatchery primarily uses native brood stock to support steelhead populations and fisheries for them. These fish are likely comprised almost entirely by Trinity River Hatchery fish or their offspring, and their persistence may depend almost entirely on hatchery operations. Numerous documented transfers of fish from outside the watershed have led to potential hybridization and selection against natural gene flow among fall- and winter- run fish (Prince et al. 2015). The hundreds of thousands of smolts released per year over time from Iron Gate and Trinity River Hatchery have been supporting recreational fisheries, but not contributing to stability of the overall population.

The behavioral (competition and predation) and genetic interactions of juvenile hatchery steelhead with wild steelhead on the Klamath and Trinity Rivers have not been fully evaluated in the KMP and require further attention. Abadia-Cardoso et al. (2013) found that hatchery operations in Northern California selected for fish that matured more quickly and returned to spawn at age-2 rather than at age-3 as their natural-origin counterparts in the wild, and shifted the size and percentage of steelhead exhibiting the half-pounder life history in the Trinity River over time (Peterson 2011). Offspring of hatchery fish were also less likely to return to spawn multiple times over their lifetime. These changes all occurred in a relatively short timeframe, on the order of only a few generations. Naman and Sharpe (2012) conducted a review of predation impacts of hatchery-origin steelhead on wild juvenile salmonids in the Trinity River and found predation rates that were orders of magnitude higher than are found in other watersheds throughout the Pacific Northwest. Over 6% of natural-origin Chinook and coho subyearlings in a year class were consumed by hatchery-origin juvenile steelhead in the study reach below Trinity River Hatchery. Hatchery steelhead are released on March 15 every year proximate to thousands of spawning redds, and during a window where few subyearling fish had emigrated, creating conditions for a highly vulnerable source of prey. In addition, despite the fact that access to cold headwater tributaries for summer steelhead has been severely restricted by dams and water operations, which causes more overlap and genetic exchange between remaining constricted populations that can lead to maladaptation in future runs, NMFS lumps all KMP steelhead together for management (Arciniega et al. 2016).

Where possible, the spatial and temporal overlap between predators (hatchery-origin steelhead) and prey (subyearling Chinook and coho salmon) should be reduced by hatchery operations to reduce high rates of predation. Future investigations should drive completion of a

Hatchery Genetics Management Plan, adaptation of Trinity Hatchery operations, and fisheries reintroduction plan after the four lower Klamath dams are removed. Under such a plan, future hatcheries operations should consider implementing operations that take fish of different run timings and into broodstock to maintain phenotypic differentiation, rather than relying on fish only of a specific run-timing (Arciniega et al 2016).

Logging. Both private and public forest lands in the Klamath Basin have been heavily logged in the past century. In the Smith River basin and other protected coastal streams in the KMP, current logging practices are well managed but legacy effects from past, unregulated, timber harvest may continue to reduce steelhead production in some areas. Contemporary logging, along with associated roads and widespread legacy effects from extensive historical timber harvest, has increased erosion rates of steep hillsides that are prone to landslides and mass wasting in this region, greatly increasing sediment loads in KMP streams (Lewis et al. 2004). Logging with its associated roads and legacy effects (see coho salmon accounts) has increased erosion on steep hillsides, greatly increasing sediment loads in the rivers. High sediment loads cause deep pools to fill with gravel, embed spawning gravels in fine materials, and create shallower runs and riffles. All this decreases the amount of adult holding habitat and increases the vulnerability of the fish to poachers and predators. Such practices, by increasing the rate of run-off, may also decrease summer flows, raising water temperatures to levels that may be stressful or even lethal. Poor watershed conditions caused by logging (and mining) were exacerbated by the effects of the 1964 floods in almost all summer steelhead drainages. These floods deposited enormous amounts of gravel that originated from landslides and mass wasting, especially from areas with steep slopes. The action of the floods not only filled in pools, but also widened stream beds and eliminated riparian vegetation that served as cover and kept streams cooler. The gravel accumulated from late 19th century mining and logging and from the flood is gradually being scoured out of pools, but much of it remains. Potential for further mass wasting along the Trinity, Salmon, and Klamath rivers is high, because logging is still occurring on steep slopes and recent forest fires may be contributing to soil instability (increased by road building).

One indirect effect of habitat loss is increased vulnerability of remaining adult fish to predation. As adult populations are reduced and habitat becomes more restricted, it is more difficult for them to withstand the effects of poaching and natural predation, particularly from river otters. Otter predation on summer steelhead is heaviest when populations of suckers and crayfish, the preferred food of otters, are low, such as occurred in the Middle Fork Eel River following the 1964 flood (A. Naylor, CDFW, pers. comm. 1995). The impact of otters on summer steelhead therefore probably varies from year to year, but could be serious during years when steelhead numbers are already low from other causes.

Juvenile KMP summer steelhead spend critical portions of their lives in tributaries where cool, high-quality water was historically common. Recent reports have documented degradation of this habitat and potential impacts to juvenile salmonid production (KNF and SRRC 2002, Cramer Fish Sciences et al. 2010). Accumulation of gravel in streambeds in recent years has reduced the amount of suitable habitat for summer steelhead by reducing available pool habitat and cover. The shallower, more braided streams also may be warmer, potentially reaching lethal temperature levels. During low flow years, emigrating juveniles can suffer heavy mortality when moving downstream, especially if they become trapped in areas with poor water quality and insufficient flows.

Mining. As indicated above, the legacy effects of mining are often hard to distinguish from the effects of logging and other land use that creates roads, removes vegetation, and generally destabilizes the steep slopes of the coastal mountains. Evidence of direct impacts from mining, historical and current, is apparent in many watersheds in the region especially the Salmon River (e.g., extensive tailing piles, active mining claims and associated equipment or refuse piles, cable crossings, etc.), indicating that mining may still affect KMP steelhead habitats by removing spawning gravels, simplifying and channelizing stream reaches, and reducing rearing habitat (Cramer et al. 2010). As a result, the Scott River has been listed as impaired due to excessive sediment and decreased water quality for nearly two decades. Suction dredge mining has been put on hold in California since 2009, banned in 2016 through SB 637, and recently upheld in the state Supreme Court, striking a decisive victory for salmonids throughout the state (see UKTR spring Chinook account) (CDFW 2016). Unfortunately, some illicit suction dredge mining still probably occurs in remote areas in the basin, far from the public view.

Fire. The lower KMP tributaries are within the marine fog belt, with cooler temperatures and higher fuel moisture levels that inhibit wildfires. However, inland portions of KMP watersheds are subject to frequent and intense fires (e.g., Forks, Salmon, and Corral complex fires, 2013) that, under predicted climate change scenarios, are likely to increase in frequency and intensity. Fires can increase water temperatures of important holding and rearing headwater streams, cause landslides, increase sediment loading, and remove shading canopy cover, all to the detriment of steelhead. Large rainfall events can quickly mobilize the debris from steep slopes and bury spawning and rearing habitats in headwater reaches.

Recreation. Recreational activities in KMP steelhead streams include: angling, boating, gold panning, swimming, hiking, and other outdoor activities. The impacts from recreation upon steelhead, especially at the population level, are likely minimal. Intensive motorized boating (e.g., lower Klamath River) may disrupt movement patterns and, potentially, habitat utilization, but this has not been substantiated.

Harvest. Current fishing regulations prohibit the take of wild steelhead and only hatchery (adipose fin-clipped) steelhead may be harvested. Commercial fisheries operating in the Pacific Ocean rarely contact steelhead (Hayes et al. 2016); likewise, the influence of recreational angling on steelhead abundance is not known, but is assumed to be minimal. Angling pressure on steelhead in the Lower Klamath and the Trinity River near Lewiston can be very high, and likely contributes to some mortality through improper handling and stress during legal catch and release fishing. Tribal net fisheries generally do not target steelhead; however, nets are an indiscriminate method of fishing and may capture both wild and hatchery steelhead, especially larger fish, due to the large net mesh size typically deployed for Chinook salmon. Klamath Mountain Province summer steelhead are particularly susceptible to poaching during summer months, because they are large and conspicuous, and aggregate in canyon pools that preclude exit by low stream flows. In these susceptible habitats, steelhead can be snagged by anglers from the banks or speared by divers. Roelofs (1983) indicated that the most stable populations of summer steelhead are in the most inaccessible streams on public lands, whereas those that are showing signs of severe decline are in areas that are most easily accessible. Roelofs also indicated that poaching was a factor affecting populations of summer steelhead in, at least, the North Fork of the Trinity, New River, and some tributaries to the Klamath River, although current levels of poaching are largely unknown.

The impact of marine (commercial and recreational) fisheries on steelhead is poorly known as they are rarely contacted in ocean fisheries (Hayes et al. 2016); however, these activities may account for some mortality. There are likely hundreds of wild steelhead hooked and handled by recreational fishermen in the KMP each year; these actions can stress fish, alter behaviors temporarily, or even lead to mortality if water temperatures are in excess of 20 degrees Celsius, which they often are in the KMP during summer months (Taylor and Barnhart 2010).

Agriculture. Agriculture, especially for alfalfa irrigation, has affected many KMP streams by altering flows and degrading water quality. Flows in many streams within the KMP steelhead range have been decreased by agricultural diversions and pumping from wells adjacent to streams. In some streams, this may be the biggest factor affecting steelhead abundance. Diversions for intense agriculture, particularly in the low-gradient Scott and Shasta rivers, decrease flows and return "excess" water to rivers (Lewis et al. 2004), thereby reducing the amount of suitable habitat. Return water is typically much warmer than that in the river, after passing through ditches and fields, and is also often polluted with pesticides, herbicides, fertilizers, or animal wastes. Although many diversions in the Scott and Shasta valleys are screened to prevent juvenile salmonid entrainment, screening has not been adequately evaluated. Better agricultural practices and appropriate mitigation measures could dramatically improve salmonid production in the Shasta and Scott valleys (Lewis et al. 2004).

Large-scale marijuana cultivation on public lands in the KMP, which is one of the most heavily used areas of the state for illegal cultivation, may be significantly impacting riparian and aquatic habitats through water diversion, increased sediment inputs, fertilizer and herbicide or pesticide inputs and solid waste inputs (trash dumps or abandoned growing supplies). Cannabis water usage estimates vary widely, but demands for water during the hot summer growing season contribute directly to reduced surface flows, groundwater flows and recharge, and reduction of habitat availability and quality. In a neighboring watershed, this cultivation and illegal withdrawal of water was estimated to reduce low flows by nearly a quarter compared to the seven day average for the summer months, which are critical to summer steelhead. This issue requires further investigation and is confounded by safety risks and subject to insufficient law enforcement involvement, limiting the opportunities to document and reduce impacts from this widespread activity (Bauer et al. 2015). With marijuana cultivation legalization likely in the near future in California, more effort must be placed on understanding, quantifying, and reducing the extent and magnitude of impacts on steelhead habitat in the Klamath Mountains Province.

Grazing. Livestock grazing is common throughout KMP watersheds and, in certain areas, contributes to degradation of aquatic and riparian habitats. Stream bank trampling and removal of riparian vegetation by livestock can cause bank sloughing, stream channel lie-back and head-cutting in meadows, leading to increased sediment loads and higher water temperatures in streams (Spence et al. 1996). Impacts may also include reduction in canopy cover (shading) over stream channels, siltation of pools necessary for juvenile rearing (Moyle 2002), or sedimentation of spawning gravels. Feral cattle near Blue Creek in the lower Klamath may trample riparian habitats and degrade water quality, though these impacts are highly localized (Beesley and Fiori 2008). In areas grazed by large herds or where grazing occurs for extended periods without rotation or exclusion fencing, fecal matter from livestock can also impair water quality and increase nutrient loading, leading to eutrophication (Power et al. 2015).

Transportation. Most KMP steelhead streams are paralleled or crossed by roads, often in many locations. Unsurfaced and unimproved roads (mining, logging, rural residential access) are abundant in the Klamath and Trinity basins and culverts associated with road crossings block access to habitat in many streams, while runoff of fine sediments and pollutants associated with roads can degrade water and habitat quality.

Alien species. Naman and Sharpe (2012) attempted to evaluate the impacts of hatchery releases of juvenile salmonids on natural-origin juveniles in the Trinity River. While they could not quantify predation by invasive brown trout (*Salmo trutta*) on juvenile Chinook, coho, or steelhead in the basin, the impacts are likely small. In addition to direct predation, brown trout may compete with other native salmonids at all life stages for food, rearing and spawning habitat (NMFS 2014). In addition, there is a run of American shad (*Alosa sapidissima*) in the mainstem Klamath River that supports a small recreational fishery, though the impacts of these potential predators on juvenile steelhead are not known at this time (W. Duffy, HSU, pers. comm. 2017).

Factor	Rating	Explanation
Major dams	High	Major dams block access to large areas of spawning and rearing habitat on the Klamath, Trinity, and Shasta rivers, altering stream temperatures, flow, habitat availability and quality.
Agriculture	High	Agriculture and water diversions in the KMP, especially for marijuana cultivation, reduce flows and degrade water quality.
Grazing	Medium	Cattle/livestock grazing may have substantial but localized impacts, especially in the Shasta and Scott river valleys.
Rural/ residential development	Low	Rural development widely dispersed but increasing in the region.
Urbanization	Low	Minimal urban development within the KMP.
Instream mining	Low	Suction dredging is now banned throughout California, but KMP watersheds still suffer legacy effects of past gold mining.
Mining	Low	Impacts from hardrock mines and effluent appear to be low, but legacy impacts from hydraulic mining and dredging (Scott River) have changed its productivity and suitability for spawning.
Transportation	Medium	Most primary streams have roads along almost their entire length and many crossings; roads along rivers degrade water quality and simplify habitats, leading to erosion and runoff of fine sediments.
Logging	Medium	Logging is pervasive in KMP watersheds and degrades habitats; legacy effects in areas without recent logging continue to limit steelhead production through sedimentation and loss of cover.
Fire	Medium	Wildfires are common in KMP watersheds and can result in high sedimentation, exacerbating other habitat alteration stressors; fire frequency and intensity predicted to increase with climate change.
Estuary alteration	Medium	The Klamath River estuary is relatively unaltered; however, the Smith River estuary has lost ~50% of its historical rearing habitat (Quiñones and Mulligan 2005).
Recreation	Low	Habitats used by summer steelhead for holding are particularly sensitive to recreational use because they provide few hides.
Harvest	Low	The sport fishery in the KMP is well regulated; it is illegal to take wild steelhead, though poaching may be limiting in some areas.
Hatcheries	Medium	KMP hatcheries produce nearly one-million juvenile steelhead a year; interactions between wild and hatchery steelhead are detrimental to the recovery of wild stocks.
Alien species	Low	Alien species are somewhat common within KMP watersheds, but impacts to steelhead are unknown.

Table 2. Major anthropogenic factors limiting, or potentially limiting, viability of populations of KMP summer steelhead. Factors were rated on a five-level ordinal scale where a factor rated "critical" could push a species to extinction in 3generations or 10 years, whichever is less; a factor rated "high" could push the species to extinction in 10 generations or 50 years whichever is less; a factor rated "medium" is unlikely to drive a species to extinction by itself but contributes to increased extinction risk; a factor rated "low" may reduce populations but extinction is unlikely as a result. A factor rated "n/a" has no known negative impact. Certainty of these judgments is moderate. See methods for explanation.

Effects of Climate Change: Climate change is likely the single largest contributing factor to the long-term decline of stream-maturing life history expression found in summer steelhead in the KMP. Climate change is already having significant impacts on summer steelhead by reducing stream volume, increasing stream temperatures, and altering seasonal flow patterns of water in watersheds containing summer steelhead, which will likely lead to further reduction in suitable upper watersheds that steelhead occupy. The timing of peak flows in the basin has already shifted nearly a month earlier than existed historically (Cayan et al. 2001, Stewart et al. 2005). Flows in snowmelt-fed rivers (e.g., Salmon River, some tributaries to the upper Trinity River) in the Klamath Basin usually peak in winter with a second, smaller, peak in spring and then gradually decrease to their lowest levels in summer. If changes in flow regimes continue at the current rate, then streamflows in the Klamath River Basin are expected to decrease by 10-50% in the spring and summer, while the frequency of extreme high and low flows are predicted to increase by 15-20% (Leung et al. 2004, Kim 2005). Altered flow regimes, due to changes in precipitation patterns, may impair salmonid embryo development and juvenile survival. Extreme high flows can scour redds, flush juveniles into suboptimal habitats before they reach critical size, and alter juvenile outmigration timing to miss the spring oceanic phytoplankton bloom (Mote et al. 2003). Fine (< 4 mm) sediment introduced by intense storm events and associated runoff can smother redds, preventing oxygen from reaching developing embryos or acting as a physical barrier to fry emergence (Furniss et al. 1991). Decreases in summer and fall flows may increase mortality of migrating adult stream-maturing fish and juvenile mortality through stranding. Changes in the timing of peak spring and fall base flows may reduce survival of juveniles emigrating from rivers into the ocean (Lawson et al. 2004).

Salmonids rely on cold water pockets as thermal refuges in rivers during juvenile rearing and adult migration and holding when water temperatures exceed 22°C (Strange 2010). In summer, use of thermal refuges may make juveniles less susceptible to disease (Foott et al. 1999). Climate change influences could diminish or eliminate cold-water pockets as temperatures increase. The reduction of suitable freshwater habitat is also expected to result in a northward and/or higher elevational shift in the range of cold water fishes (Haak et al. 2010). As a result, steelhead in the KMP may experience local extinctions and range contractions, particularly since most higher elevation, headwater streams are inaccessible behind large dams or due to lower summer and fall flows. Once the four lowermost Klamath dams are removed, access to cooler water in historical northern tributaries will be restored.

While multiple large populations of KMP summer steelhead are found in diverse portions of the Klamath and Trinity river basins, persistence of all these populations is likely only with increased protection and with restoration efforts to improve stream flows, allow accessibility to prime holding and spawning habitat, and maintain cool temperatures in headwater tributaries for both spring Chinook salmon and summer steelhead. Ongoing drought in California has likely contributed to a dip in populations of summer steelhead in the KMP, as lower flows and warmer summer water temperatures likely caused increased mortality before fish could spawn. The cumulative impact of these changes is a likely a continued reduction in suitable habitat available for spawning and over-summering (Moyle et al. 2013). More recent research similar to Yamamoto's (2004) habitat utilization study in the New River should be undertaken to determine if emerging temperature/hydrologic regimes under climate change and drought are impacting summer steelhead habitat use, survival, and productivity.

Status Score = 1.9 out of 5.0. Critical Concern. Only 2-3 summer steelhead populations are large enough to expect persistence for more than 10-25 years under present conditions. Most of the smaller stream-maturing populations are likely to disappear in the near future due to shrinking availability of suitable habitat associated with lower streamflows and higher temperatures throughout the summer months in headwater tributaries in the KMP. The long-term decline experienced by KMP summer steelhead is continuing and their eventual extinction as a distinct life history strategy seems likely in the next 50 years if present trends continue.

KMP summer steelhead have a high likelihood of going extinct within the next 50-100 years in California because of lack of strong protection combined with climate change affecting adult holding and juvenile rearing habitat (Table 3). There is a general lack of coordinated basin-wide management actions to protect them, increasing the likelihood of local extirpations. KMP steelhead are recognized as a US Forest Service Sensitive Species and are a Species of Special Concern of CDFG. However, they are not listed by NMFS because they are considered part of the larger KMP steelhead ESU and therefore not separated from the more abundant winter-run steelhead. The most recent genetic data indicates that perhaps this lumping of all KMP steelhead together for management purposes should be revisited based on their differential susceptibilities to anthropogenic and environmental stresses.

Metric	Score	Justification
Area occupied	2	Much diminished from historical distribution.
Estimated adult abundance	2	Populations are very small and isolated.
Intervention dependence	3	No intervention is being undertaken to assist in persistence, but is badly needed.
Environmental tolerance	2	Adults require coldwater refuges and pool habitat with cover that is free from human intervention.
Genetic risk	2	Due to the spatial and temporal separation between summer and winter fish, the summer steelhead life history is in jeopardy of extinction in the KMP.
Climate change	1	Highly vulnerable; temperatures and flows already marginal in many areas and summer steelhead require cold water in the warmest months to survive to spawn.
Anthropogenic threats	1	2 High, 6 Medium factors.
Average	1.9	13/7.
Certainty (1-4)	3	Well-documented.

Table 3. Metrics for determining the status of the KMP summer steelhead, where 1 is a major negative factor contributing to status, 5 is a factor with no or positive effects on status, and 2-4 are intermediate values. Certainty of these judgments is moderate. See methods for explanation.

Management Recommendations: Restoration and management recommendations for all KMP steelhead is discussed at length in the KMP winter steelhead account. Conservation recommendations for summer steelhead have been developed for most populations (Jones and Ekman 1980, Roelofs 1983, McEwan and Jackson 1996), but management for the broader stream-maturing life history is not a high priority because they are not listed under state and federal endangered species acts despite their unique life history and genetics (Prince et al. 2015). Present management focuses on increased monitoring to assess population trends and limiting factors of summer steelhead. However, special management is needed in the few watersheds where summer steelhead are most abundant (New, South Fork Trinity rivers; Wooley, Dillon, Clear creeks); it should focus on reducing human impacts and improving habitats, especially keeping water temperatures down such as protecting accessibility to coldwater seeps and springs, remote canyon pools with depth and overhead cover, and decreased disturbance by humans. Recent efforts to increase flows in the cold, spring-fed Shasta River are likely to help steelhead in that tributary, but similar actions are necessary basin-wide.

Management plans for each summer steelhead population should be compiled in a formal Summer Steelhead Management Plan. This plan should address:

(1) Enforcement of fishing and land use regulations in over-summering areas, especially related to groundwater pumping, illegal diversions, marijuana cultivation, etc.
(2) Watershed management to minimize sediment and maintain healthy water quality
(3) Regulation of adult harvest during migrations
(4) Management of downstream reaches to favor out-migrating smolts
(5) Rebuilding present populations through natural and artificial means, where necessary
(6) Restoration of populations that have become extirpated
(7) Protection of adults and juveniles from predation and poaching

Across all populations, there is a need for accurate censuses to identify the factors that limit their numbers. For an accurate assessment, distribution and abundance of all populations, monitoring must expand and be well coordinated within the KMP. Strategies should incorporate approaches from the Steelhead Restoration and Management Plan for California, as well as build upon comprehensive life-cycle monitoring as addressed in the Smith River Fishery Management Plan Draft of 2015. The Coastal Salmonid Monitoring Plan seeks to integrate methods and data across California coastal watersheds, which will help managers assess and utilize the best scientific information available to them. Additional information regarding the genetics, ecology, and behavior of KMP steelhead is also needed and will help inform management and conservation strategies after the four lower dams on the Klamath River are removed.

Improvement of summer steelhead habitat, and thus habitat for half-pounder steelhead and spring-run Chinook, should become a priority for the Department of Fish and Game and other agencies, as reduction in summer carryover habitat has been repeatedly identified as a critical limiting factor. Land management practices which reduces sedimentation, increases cover, and minimizes changes to summer steelhead over-summering habitat should be strongly enforced. More research on summer steelhead populations in California is badly needed, especially to determine (1) genetic identities of each population, (2) extent of possible summer holding areas, (3) distribution of spawning areas and whether they require special protection, (4) habitat requirements of out-migrating smolts, and (5) effects of poaching, illegal marijuana cultivation, and disturbance from recreation on adults.

The highest degree of protection for KMP steelhead (and other fishes) is found in the Wild and Scenic Smith River (Del Norte Co.), which is the largest river in California without a major dam. In 1990, the Smith River National Recreation Area Act provided some degree of protection for the important watershed. In the Klamath Basin, intergovernmental cooperation among tribes, state, and federal agencies, and non-governmental organizations has played an important role in protecting steelhead habitat. Acquiring large tracts of private lands to protect important watersheds, such as Goose, Mill, and Hurdygurdy creeks is a valuable mechanism for conserving steelhead sanctuaries for holding, spawning, and rearing that benefits other salmonids as well. This has since been replicated on Blue Creek, in partnership with the Western Rivers Conservancy and the Yurok Tribe. The entire lower watershed has been acquired through standard and non-standard means (e.g. carbon credits, New Market tax credits, etc.). The land is being handed over to the Yurok Tribe for management in perpetuity as a Salmon Sanctuary. The entire project includes adjacent lands as well, so when all negotiations are completed, there will be 73 square miles of land and stream managed by the Yurok as salmon sanctuary, climate preserve, and sustainable community forest. It is important to note that this project assures that cold water from the creek will continue to flow into the Blue Pool in the river at the mouth of the creek; this pool serves as a cool-water refuge for salmon and steelhead moving up the river when temperatures are warm and flows low in fall months (Western Rivers Conservancy 2014).

Special management considerations and regulations should be afforded to KMP summer steelhead populations. Fishing in the New River and South Fork Trinity during periods when these watersheds are only occupied by summer steelhead and spring Chinook in the late fall should be banned. The potential impact of hooking mortality from legal catch-and-release fishing in the New River and South Fork Trinity during periods when these watersheds are only occupied by summer steelhead and spring Chinook in the late fall may be high and pose serious threats. Although fishing is prohibited in many areas and fines for violations are high, protection of summer steelhead populations may require special guards or streamkeepers for a number of years, as is the case in the neighboring Rogue River watershed in Oregon.

On the Trinity River, CDFW and partnering agencies and organizations have implemented the Trinity Record of Decision to supply ~50% of annual inflow to the river; historically, up to 90% was diverted. There is still important work to be done. CDFW has not yet implemented several key components that will benefit all steelhead life histories, including:

1. Increasing naturally-produced steelhead through protection of selected subbasins (e.g. Blue Creek refuge) that protect steelhead distribution and diversity.
2. Completing management plans for each subpopulation of summer steelhead.
3. Restoring favorable instream conditions to benefit desired ecosystem functions and the community of fishes, including coho and Chinook salmon and coastal cutthroat trout.
4. Reducing hatchery impacts on wild steelhead populations. An Iron Gate Hatchery Genetic Management Plan has been drafted for coho salmon, and current hatchery operations are being evaluated at the Trinity Hatchery. Adapting hatchery operations to utilize new scientific information will benefit all salmonids, especially after removal of the four Klamath dams.

As the Klamath dams are removed, habitat for spawning and rearing should be restored as quickly as possible. Literature suggests that dam removal will increase diversity of life histories and increase resiliency of the population, but this remains to be seen (Hodge et al. 2015). Hatcheries using naturally-produced resident, ocean-maturing, and stream-maturing steelhead ecotypes to repopulate the newly-accessible habitat should also be carefully considered and weighed, as hatchery selection pressures may negatively impact genetic integrity and variation in colonizing *O. mykiss* (Quinones et al. 2013).

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