KLAMATH MOUNTAINS PROVINCE WINTER STEELHEAD
Oncorhynchus mykiss irideus

Moderate Concern. Status Score = 3.3 out of 5.0. Klamath Mountain Province (KMP) winter steelhead are in a state of decline from historical numbers in the basin. These ocean-maturing fish are relatively more widespread than the stream- maturing summer-run fish, yet still face an uncertain future in the Klamath Basin due to reductions in suitable habitat.

Description: Klamath Mountains Province (KMP) winter steelhead are anadromous rainbow trout that return to select freshwater streams in the Klamath Mountains Province, from the Klamath to the Smith rivers in California. Winter steelhead are distinguishable from other steelhead by (1) time of migration (Roelofs 1983), (2) the mature state of gonads at migration (Shapovalov and Taft 1954) (3) location of spawning in mainstem rivers and tributaries and behavioral traits (Everest 1973, Roelofs 1983). More recently, the early maturing life history has been found to have a genetic basis in the Omy5 gene locus (Pearse et al. 2014). Winter steelhead are nearly identical in appearance to the more rare summer steelhead but are more likely to have spawning colors in the lower reaches of rivers (see description under Northern California coastal winter steelhead).

Taxonomic Relationships: All coastal rainbow trout of North America, including coastal steelhead, have been identified in the subspecies *Oncorhynchus mykiss irideus* (Behnke 1992). CDFW recognize distinct life history variations of steelhead in the KMP Distinct Population Segment (DPS) based upon their timing of freshwater entry, reproductive biology and spawning strategy (Busby et al. 1996, Hodge et al. 2013). These life history variations are generally called winter and summer steelhead, with a distinctive variant known as 'half-pounder' that may be derived from any steelhead of any run-timing. Genetic data support the hypothesis that winter and summer steelhead populations are somewhat distinct (Prince et al. 2015). The KMP winter steelhead are treated separately here from summer steelhead that are part of the same ESU because the two runs and they are distinctive in their behavior and reproductive biology. Observations of run timing suggest presence of fish that return during the fall months, especially in the Trinity River, though the origins of this life history require further study (W. Sinnen, CDFW, pers. comm. 2016, Figure 1). For a more thorough discussion of steelhead that return to the UKTR in the fall, see the KMP summer steelhead account.

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.

The National Marine Fisheries Service (NMFS) does not classify Klamath River basin steelhead as Distinct Population Segments based on run-timing of adults, but instead recognizes two distinct reproductive ecotypes adapted to different sets of environmental conditions. These two ecotypes are stream-maturing (summer) and ocean-maturing (winter) steelhead. Genetic analyses from samples collected between the Klamath River estuary and the confluence of the Trinity River supports these two discrete migrating populations based primarily on timing of freshwater entry and resulting early or late maturation (Papa et al. 2007), correlating with run timing. In the future, KMP winter steelhead should be recognized as a distinct DPS and managed separately from other steelhead based on differing life histories, morphology, and genetics (Hodge et al. 2013, Prince et al. 2015). See the Northern California coastal steelhead account for a full discussion.

KMP winter steelhead are more closely related to KMP summer steelhead than to winter steelhead elsewhere (Pearse et al. 2007, 2016; Prince et al. 2015). Pearse et al. (2007) analyzed genetic samples collected from 30 sites throughout the Klamath River watershed and three Trinity River sites, and found that geographically proximate populations were most similar genetically, even when taking into account the genetic contributions from Iron Gate and Trinity River hatcheries. Winter steelhead appear to contain two genetically distinct populations in the KMP (Papa et al. 2007). Steelhead sampled from the mouth of the Klamath were most similar to other nearby coastal streams (Smith River, Wilson Creek), while fish from the Shasta and Scott rivers clustered closely to steelhead from Iron Gate Hatchery, suggesting that influence of hatchery gene flow (possibly from straying) to these nearby tributaries has occurred over time (Pearse et al. 2007). In addition, these more coastal steelhead expressed limited gene flow with steelhead sampled upstream of the Trinity River confluence, suggesting some population differentiation over time.

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 fresh water. Steelhead/rainbow trout are incredibly plastic species, capable of adapting to and utilizing a wide range of habitats through different life history strategies. Unlike salmon, steelhead can spawn several times throughout their lives (iteroparity). Winter steelhead enter freshwater with fully developed gonads and spawn soon after arriving on spawning grounds. The diversity of habitats within the Klamath Basin yields, for salmonids, perhaps the greatest diversity of life history characteristics and of spatial and temporal habitat usage of any steelhead-bearing river. A total of 38 distinct steelhead life history strategies alone have been identified, including non-anadromous and anadromous forms (Coulter et al. 2013, Hodge et al. 2016). Within this portfolio of life history strategies, three primary pathways emerge: 1) a fast growing group that smolts at age one to two) a non-anadromous, intermediate growth group; and 3) a slow-maturing anadromous group that smolts at age two or three (Hodge et al. 2015). 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 the fishes' 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. Nearly three-quarters of steelhead juveniles adopt the life history strategy of their mothers, and that only about 10% of the total population became non-anadromous (Hodge et al. 2010).

Ocean-maturing steelhead enter fresh water between November and April and are generally referred to as winter steelhead. Winter steelhead spawn in mainstem reaches of rivers and tributaries that are mostly passed over by summer steelhead (Roelofs 1983). These fish enter the river as sexually mature adults and spawn shortly after reaching spawning grounds (Busby et al., 1996). After spawning is complete, many winter steelhead migrate back to sea by March or April (Hodge et al. 2015). In the Klamath drainage, 40-64% of the total spawning population are repeat spawners (Hopelain 1998), though post-spawn survival rates differ by tributary. In the Salmon River, for example, one-third of returning adult steelhead are repeat spawners, compared to about 15% in other tributaries (Hodge et al. 2015). Maximum-recorded age of steelhead in recent studies is seven years, and female fecundity has been estimated at 2,000-3,000 eggs per fish (Hodge et al. 2015).

The early life history of winter steelhead in the Klamath and Trinity River basins is fairly well understood. Fry in the Trinity River emerge in April and begin downstream emigration in May, reaching a peak in June and July (Moffett and Smith 1950). Newly emerged steelhead initially move into shallow, protected margins of streams (Moyle 2002). Juveniles aggressively defend territories (Shapovalov and Taft 1954) in or below riffles, where food production is greatest. Moffett and Smith (1950) found steelhead fry favored tributary streams with a peak in downstream movement during the early summer on the Trinity River. When higher flows and lower water temperatures returned to the mainstem during late fall and winter, downstream movement increased. This pattern is assumed to be largely intact, but could be aided by replication of a more natural flow regime below Lewiston dam. Steelhead parr showed the greatest freshwater movement towards the end of their first year and spend their second year inhabiting mainstem rivers. At the Big Bar rotary screw trap downstream of Orleans, a fairly equal proportion of young of year (34%), 1+ (37%) and 2+ (27%) steelhead were captured emigrating downstream over a three-year period (USFWS 2001). The large majority of returning steelhead (86%) in the Klamath River basin apparently spend two years in fresh water before undergoing smoltification and migrating to sea (Hopelain 1998). Average lengths for steelhead smolts entering the ocean ranges from 200 mm (Trinity River) to 270 mm (Shasta River) (Hodge et al. 2015). Klamath River basin steelhead remain mostly in the North Pacific Ocean for one to three years feeding and growing larger before returning to spawn (Hayes et al. 2016).

Half-Pounder Steelhead: In addition to the different run timings of mature steelhead, the KMP is also home a population of smaller, immature fish referred to as 'half-pounders' (Snyder 1925). Half-pounders are small, sub adult fish (25-35 cm) that despite their moniker actually tend to weigh closer to 0.4 kg (Lee 2016). They spend two to four months in the Klamath estuary or nearshore ocean environment before returning to the river in late summer and early fall (between late August and early October) to over-winter and forage in the lower and mid-Klamath river reaches (Kesner and Barnhart 1972, Lee 2016). To confuse things further, some steelhead juveniles may 'double-smolt,' which is a variant of the half-pounder strategy that allows fish to adjust their strategy before they enter the ocean: a fish may undergo smoltification in an estuary but then migrate back upstream in search of better growth and survival conditions rather than are found in the ocean. The following year, these fish smolt again at a larger size and emigrate to the sea to feed and grow before returning to spawn. In the KMP, half-pounders are most common in mainstem and some tributary habitats downstream of Seiad Valley.

The proportion of half-pounders in the total KMP steelhead population likely changes over time as conditions change. During the 1980s, the number of half-pounders in the population at Iron Gate Hatchery was high, resulting in an increase in average size at release of smolts since the 1980s. This practice may have decreased expression of half-pounder life history over time (Peterson and Hankin 2014). During the 1990s, half-pounders in spawning winter steelhead were most common from the mid-Klamath region tributaries (86-100%) when compared to the Trinity River (32-80%) or Lower Klamath River (17%); the lower Klamath fish also demonstrated the greatest first-year growth rates (Hopelain 1998). In a more recent study on this unique life history, less than 10% of these smolts matured precociously to spawn, and adult fish that exhibited the half-pounder life history earlier in life tended to be smaller and less fecund than their ocean-maturing counterparts (Hodge et al. 2014). One important tradeoff is the fact that half-pounders are much more likely to spawn repeatedly over their lifetime than are other ocean-maturing fish. Therefore, the half-pounder life history continues to be viable because the fish enjoy increased survival and spawn more frequently than larger-bodied individuals (Hodge et al. 2014). It is hypothesized that a patch of relatively cool ocean water off the Klamath/Trinidad region of California has contributed to the rise and persistence of this life history, because ocean conditions result in ample feeding habitat for only a short time. Generally, September brings a warm period such that a critical thermal migration corridor to the North Pacific feeding grounds may become closed, so some immature steelhead retreat into the rivers to spend the rest of the year in fresh water (Hayes et al. 2015). The half-pounder life strategy of steelhead in the KMP requires further study.

Habitat Requirements: The KMP encompasses a variety of habitats: from cool fog-belt redwood forests near the coast which experience the highest precipitation in the state, to extreme temperatures in the inland valleys of the Scott and Shasta rivers (Siskiyou Co., SWAP 2015). In the upper portions of KMP watersheds, alluvial valleys that historically supported freshwater marshes and grasslands have been converted to agriculture. In middle and lower reaches, KMP rivers flow through steep mountain slopes in deeply incised canyons with bedrock channels and support fairly narrow riparian habitats (SWAP 2015). While flows in rivers such as the Smith and Klamath are largely precipitation-driven, the Shasta River is spring-fed and some Northern tributaries to the Trinity River rely on snowmelt from the Trinity Alps. This diversity of habitats is the reasons for the diversity of life histories and habitat use strategies that steelhead exhibit in this area.

Habitat requirements of KMP winter steelhead are basically the same as Northern California Coastal winter steelhead (see Northern California winter steelhead account). The majority of a steelhead's life is spent at sea, though relatively little is known about that aspect of their life history, or even where they spend their time in the North Pacific, despite their wide distribution. Many age-0 California steelhead juveniles spend a year feeding in the California Current off the Klamath-Trinidad region, then move northwest to cooler waters offshore in the North Pacific. Recent trawl surveys by NOAA Fisheries indicate that most steelhead from Oregon and California populations mix once reaching salt water and move through surface waters of the Northeast Pacific feeding on pelagic organisms. Recent surveys show that steelhead feed on krill, fish, and amphipods in surface waters far offshore of British Columbia (Hayes et al. 2016). After feeding for several years in a narrow range of sea surface temperatures (apparently 8-14°C), they return to their natal rivers for spawning (Harding 2015, Hayes et al. 2016).

Winter steelhead typically enter fresh water from September through March, spawning shortly after migrating to suitable spawning areas (Busby et al. 1996). Due to their migration and spawning period coinciding with periods of high flows, winter steelhead often ascend into tributaries not accessible during low-flow periods. These include streams in medium-sized watersheds that are often not accessible early in the fall because of sediment barriers at the mouths. Spawning habitat for winter steelhead is variable in space and time, resulting in low levels of genetic differentiation among populations in the same watershed (Barnhart 1986, Papa 2007, Prince et al. 2015). Spawning peaks before March throughout the KMP. Little is known about the spawning distribution of winter steelhead throughout the KMP because high, turbid flows make observations difficult.

Juvenile habitat requirements of winter steelhead seem to be similar to those of winter steelhead throughout Northern California; they emigrate into perennial streams soon after hatching (Everest 1973). Roelofs (1983) suggested that use of small streams reduces juvenile mortality because the embryos and fry are less susceptible to predation by larger fish that cannot survive in small streams.

Distribution: The KMP winter steelhead range includes all coastal rivers and creeks throughout the Klamath and Trinity basins and streams north to the Elk River near Port Orford, Oregon. Their range encompasses the Smith River in California and the Rogue and Applegate rivers in Oregon. In the Klamath River, they historically ascended all major rivers and tributaries, and likely spawned in tributaries to Upper Klamath Lake before passage was blocked by a chain of dams on the river (Hamilton et al. 2005). Dam removal of the four lower Klamath dams (Copco 1 and 2, J.C. Boyle, and Iron Gate) is slated to begin in 2020, which will presumably restore access to over 480km of spawning and rearing habitat for steelhead. In the Trinity River, Lewiston Dam blocks upstream access (Moffett and Smith 1950).

At sea, NOAA Fisheries' Southwest Fisheries Science Center salmon trawling surveys have indicated that steelhead were most abundant off the Klamath-Trinidad coast; catch for both juvenile and adult steelhead increased with distance offshore compared to both Coho and Chinook salmon (Harding 2015). It is hypothesized that many of California and Oregon's steelhead feed offshore of the KMP region for some time before migrating northward along thermal corridors to rich feeding grounds in the North Pacific off British Columbia and Alaska, but this is far from certain (Hayes et al. 2015).

Trends in Abundance: Population data are sparse for KMP winter steelhead due to their run-timing. Turbidity, survey repeatability, funding personnel availability, safety concerns and other problems, make it nearly impossible to do monitoring using traditional weirs or spawner surveys during winter months. What information does exist comes from weirs, video cameras, or DIDSON sonar in the fall/early winter. Such information as exists, however, indicates that adult steelhead returns to the KMP have declined from historical numbers and continue to follow a general downward trajectory. Busby et al. (1994) estimated steelhead runs in the basin to average 222,000 adults during the 1960s, but it is unclear to which run these fish belonged. Based on creel and gill net harvest data (Hopelain 2001), the winter steelhead population was estimated at 10,000-30,000 adults per year in the early 1980s in the Klamath River. Returns to the Iron Gate hatchery are highly variable and have significantly declined in recent years despite increases in yearling releases (Figure 2). In general, early hatchery practices saw early-returning fish get selected for spawning over time; it is not clear what impacts this unnatural selection had on the life histories, which have been shown to have a genetic and thus heritable basis (Kendall et al. 2015, Williams et al. 2016, Pearse et al. *In review*), of returning future fish over time. However, no steelhead have been released from Iron Gate Hatchery since 2013, and the program remains in transition until restoration plans have been developed for post-dam removal and a fisheries reintroduction plan and Hatchery Genetics Management Plan have been completed (W. Sinnen, CDFW, pers. comm. 2016). CDFW also used video technology at weirs meant to count salmon and counted 180 adults in the Shasta River (CDFW 2013) and 251 adults on the Scott River (CDFG 2012) for the 2010-2011 and 2011-12 seasons, respectively. However, the cameras did not operate for the entire steelhead migration period (CDFW 2013).

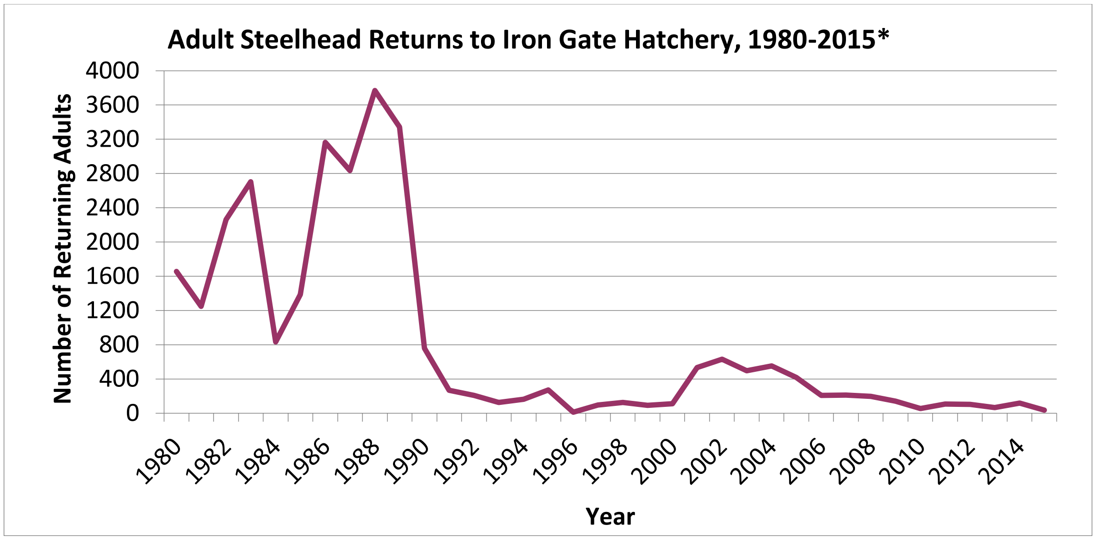

Figure 2. Adult Steelhead Returns to Iron Gate Hatchery. Data from W. Sinnen, CDFW, pers. comm. 2016. *From 1980-89, an average of 200,000 steelhead yearlings were released; from 1990-99, the average was 77,000; from 2000-09, the average increased to 90,000; from 2010-2012, the average was only 32,000. No juvenile steelhead have been released since 2013.

The average historical Trinity River steelhead run was estimated to be in the same range as that of the Klamath River, although more variable, and ranged from 7,800 to 37,000 adults during the 1980s. However, it is unclear which run-timing these totals apply to. Recent estimates of winter-run steelhead are not available due to the difficulty associated with obtaining reliable estimates. They are likely somewhat more abundant than summer-run fish in the UKTR basins (J. Nelson, CDFW, pers. comm. 2016).

In the Smith River, spawning escapement was estimated to be approximately 30,000 adult steelhead during the 1960s. More recently, DIDSON sonar counts were used to estimate 16,000 and 15,000 winter steelhead in the Smith River for the 2010-2011 and 2011-2012 seasons, respectively (Larson 2013).

Factors Affecting Status: Populations of KMP winter steelhead are large enough to support sport fisheries but appear to be in long-term decline in most rivers. The runs in the Klamath-Trinity populations are increasingly supported by hatcheries, while the Smith River remains a stronghold for wild steelhead. The general decline of winter steelhead likely has multiple causes (see Northern California coastal winter steelhead account), including: degradation of river systems by decreased flows from agricultural diversions in the inland portion of the Basin; forestry and other land use practices; inability to pass migration barriers en route to spawning grounds; and human-influenced variation in oceanic and atmospheric conditions related to climate change, especially temperatures (SWAP 2015). The main factors impacting winter steelhead include 1) dams, 2) diversions, 3) logging, 4) agriculture, 4) hatcheries, and 5) harvest.

Dams. Like many rivers in California, the Klamath and Trinity rivers have been dammed but the Smith remains undammed. Three dams that directly affect KMP steelhead in the Klamath Mountains Province are Iron Gate and upstream dams (Klamath), Dwinnell (Shasta), and Lewiston (Trinity) dams. These dams have blocked access to large portions of formerly utilized KMP steelhead habitats, especially important spawning and rearing grounds in the upper portions of both systems. They have altered the main stem by regulating flows, increasing water diversions (Lewis et al. 2004) and degrading water quality (Hamilton et al. 2011). Iron Gate Dam does not allow fish passage and for now completely blocks access to historical upstream spawning and rearing habitats. 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 and creating conditions favorable to toxic algae blooms (Hamilton et al. 2011). Juvenile steelhead are likely to persist in the main stem because of abundant food resources and the presence of natural and anthropogenic thermal refuges due to dam operations. Warm temperatures stress steelhead by altering movement, feeding, or growth patterns. Removal of Iron Gate and other upstream dams under the Klamath Basin Agreements will open up over 480 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 30 km of habitat in the upper Shasta River since its construction in 1928. The dam and multiple diversions have 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 are stressful to 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 River in the Trinity Alps and the Scott River are fed by snowmelt. Along with Trinity Dam, located just upstream, the dams have greatly reduced flows, altered the temperature regime, and disrupted the natural hydrograph of the mainstem Trinity River. In 2000, a Record of Decision was filed, which determined that 48% of Trinity River flows were to be sent downstream to support fisheries and wildlife habitat instead of being diverted at Lewiston Dam via pipe to the Sacramento River. The Trinity River Restoration Program is tasked with allocating Record of Decision flows seasonally and restoring fish habitat in the upper portion of the river. In 2003, a flow regime with lower spring and higher summer and early fall flows than were observed historically was initiated with comprehensive physical/mechanical restoration to restore the riparian corridor and fisheries of the Trinity River. Significant projects have been completed to permit greater flows, reconnect the floodplain with the river channel to improve juvenile rearing habitat, and place spawning gravel in the channel to restore spawning areas.

Diversions. Flows in many KMP streams have been reduced by domestic and agricultural diversions and pumping from adjacent wells. In the Scott and Shasta rivers, diversions may be the single greatest factor affecting steelhead numbers by reducing flows, habitat availability and quality through increases in water temperatures and nutrients from returning 'excess' water to the river (Lewis et al. 2004). Return water is warmed by its passage through ditches and fields and is often polluted with nutrients from animal waste as well. Many of the diversions in the Scott and Shasta valleys are screened to prevent loss of juvenile salmonids in the diversions, but their effectiveness has not been adequately evaluated.

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 limit 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 SONCC Coho salmon account) has increased erosion on steep hillsides, greatly increasing sediment loads in the rivers. High sediment loads fill deep pools 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. One indirect effect of habitat loss is increased vulnerability of remaining adult fish to predation, both from humans and natural predators such as otters (A. Naylor, CDFW, pers. comm. 1995). The effects of logging are especially severe in tributaries where steelhead concentrate for spawning and rearing. For example, increased sedimentation of spawning grounds leads to reduction of embryo survival and alevin emergence rates in the Shasta and South Fork Trinity rivers (Burns 1972).

Poor watershed conditions caused by logging (and mining) were exacerbated by the effects of the 1964 floods in almost all summer steelhead drainages throughout Northern California. These floods deposited enormous amounts of gravel that originated from landslides and mass wasting, especially from areas with steep slopes. The flood filled in pools, widened streambeds, and eliminated riparian vegetation that served as cover and kept streams cooler. The gravel 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 still occurs on steep slopes and recent forest fires may be contributing to soil instability through increased by road building. In addition, in many streams, improperly constructed culverts under logging roads are barriers to upstream spawning and rearing areas. 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. In the Smith River and small coastal streams, impacts of logging are less pronounced, especially where watersheds are protected, but legacy effects of past logging still limit the ability of habitat to produce steelhead.

Mining. Legacy effects of 19th century hydraulic mining still negatively affect KMP steelhead habitats in many areas. Historical mining was widespread and intensive in this region and, in combination with logging, devastated many watersheds. Legacy effects of mining may be difficult to distinguish from contemporary impacts from logging, rural development, and other land uses that require road building, vegetation removal, or other landscape alterations that contribute to destabilization of the steep slopes of the Klamath Province and increased sediment loads in rivers and streams. The upper Klamath, Salmon, Scott, and Trinity rivers bear evidence of mining impacts (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 (USFS and Salmon River Restoration Council 2002, 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, although historical impacts were almost certainly greater than they are today. A ban on suction dredge mining has been upheld in the California Supreme Court, marking a decisive victory for salmonids throughout the state (CDFW 2016).

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 such as the Salmon, Scott, and Trinity rivers are subject to frequent and intense fires (e.g., Forks, Salmon, and Corral complex fires, 2013) that are predicted to increase in frequency and intensity under climate change scenarios. Fires can increase water temperatures in 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 and the influence of recreational angling on steelhead abundance is assumed to be minimal but not known with certainty. 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 do target steelhead seasonally; however, the effects of this harvest on both wild and hatchery steelhead is largely unknown (W. Duffy, HSU, pers. comm. 2017). The impact of marine (commercial and recreational) fisheries on steelhead is poorly known. Steelhead are rarely documented in ocean fisheries (Hayes et al. 2016); however, these activities may account for some mortality.

Agriculture. Agriculture, especially irrigated pasture and alfalfa for livestock grazing in the inland portions of the Province, impacts streams throughout the Klamath and Trinity basins through both runoff and sedimentation. The Shasta and Scott valleys have been identified as two regions where improved agricultural practices and corresponding diversions and groundwater pumping could dramatically increase salmon and steelhead populations in the Klamath Basin (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, pollution from sediment, fertilizer, pesticide inputs, and 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 small headwater streams. In the neighboring Eel River and Redwood Creek watersheds, 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. 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 the Scott and Shasta valleys 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. In areas grazed by large herds or where grazing occurs for extended periods without allotment rotation or exclusion fencing, fecal matter from livestock can also impair water quality and increase nutrient loading, leading to eutrophication, as in the Smith River estuary (J. Garwood, CDFW, pers. comm. 2016). In addition, 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).

Transportation. Most KMP steelhead streams are paralleled or crossed by roads, often in many locations. Unsurfaced and unimproved roads (mining, logging, and 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.

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 hatchery production on the Trinity River has primarily relied upon native brood stock to boost production, there have been numerous documented transfers of fish from outside the respective watersheds, leading to potential hybridization and selection against natural gene flow among 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. In fact, before Iron Gate Hatchery stopped releasing winter-run steelhead juveniles in 2013, a significant percentage of returning fish were resident *O. mykiss* that never migrated to the ocean and remained in the Klamath River (Jong, 1994). It is assumed that poor location of the hatchery itself (J. Nelson, CDFW, pers. comm. 2016) and poor water quality in the mainstem Klamath River below Iron Gate Dam could have selected for resident life history over anadromous life history of Iron Gate Hatchery steelhead and contributing to their precipitous decline (USFWS 1999).

The behavioral (competition and predation) and genetic interactions of juvenile hatchery steelhead with wild steelhead on the Klamath and Trinity Rivers have not been evaluated, but are recognized as issues requiring attention, as are adult competitive interactions (CDFG 2001). 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. 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. Future investigations such as these will guide adaptation of Trinity Hatchery operations and drive completion of a Hatchery Genetics Management Plan and fisheries reintroduction after the four lower Klamath dams are removed.

In addition to these state-managed hatcheries, a small private hatchery called Rowdy Creek Hatchery operates near the mouth of Rowdy Creek (Smith River, Del Norte County). This hatchery is operated by the local Kiwanis Club and runs on donations. They raised over 100,000 yearling steelhead a year from returning wild and fin-clipped hatchery steelhead for several decades, with the last steelhead returning to be spawned in 2006 (http://www.rowdycreek.com/).

In 2005 and 2006, 564 and 2,231 steelhead adults were spawned, respectively. The impacts of this relatively small hatchery operation are likely small but unknown.

Alien species. Naman and Sharpe (2012) could not quantify predation by invasive Brown trout (*Salmo trutta*) on juvenile Chinook, Coho, or steelhead in the Klamath-Trinity Basin, but the impacts are likely non-negligible. In addition to direct predation, Brown trout compete with other native salmonids at all life stages for food, rearing and spawning habitat (NMFS 2014). A small but persistent run of American shad (*Alosa sapidissima*) also inhabit the Klamath River, and could potentially prey on juvenile steelhead (W. Duffy, HSU, pers. comm. 2017).

Factor	Rating	Explanation
Major dams	Medium	Major dams block access to habitat on the Klamath, Trinity, and Shasta rivers, reducing habitat availability and quality.
Agriculture	Medium	Agriculture and diversions in the KMP, especially for illegal 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 is widely dispersed but increasing.
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	Medium	Impacts from hardrock mines and their effluents appear to be low, but legacy impacts from hydraulic mining and dredging in portions of the Klamath, Scott, Salmon, and Trinity rivers have fundamentally changed productivity and suitability for spawning.
Transportation	Medium	Most primary streams have roads along their length and many crossings, degrading water quality and simplifying habitats.
Logging	Medium	Logging is pervasive in KMP watersheds and continues to degrade habitats; legacy effects limit steelhead production.
Fire	Medium	Wildfires are common in KMP watersheds and can result in sedimentation, exacerbating other habitat alteration stressors.
Estuary alteration	Medium	The Smith River Estuary has lost ~50% of its historical rearing habitat (Quiñones and Mulligan 2005).
Recreation	Low	Recreational impacts are low.
Harvest	Low	It is illegal to take wild steelhead, though poaching may be a limiting factor in some areas. Tribal harvest poorly understood.
Hatcheries	Medium	The Trinity River hatchery produces hundreds of thousands of steelhead a year; interactions between wild and hatchery steelhead are likely detrimental to the health of wild stocks.
Alien species	Low	Brown trout are present in the Trinity River and likely compete with and prey on other salmonids, though impacts not quantified.

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of KMP winter steelhead. Factors were rated on a five-level ordinal scale where a factor rated "critical" could push a species to extinction in 3 generations 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 unlikely as a result; and a factor rated "no" has no known negative impact to the taxon under consideration. Certainty of these judgments is moderate. See methods for explanation.

Effects of Climate Change: Streams in the Klamath Basin downstream of Iron Gate Dam are projected to be warmer and drier during the summer and fall months due to reduction in total snowpack and seasonal retention of snow as the climate continues to change (Hamlet et al. 2005, Stewart et al. 2005). Snow pack water content in the last 50 years has already significantly declined at several monitoring stations in the Klamath Basin (Van Kirk and Naman 2008), leading to lower flows and increasing water temperatures (Allan and Castillo 2007). Climate change may also alter streamflow patterns by increasing winter runoff of rain rather than snow, likely decreasing spring and summer stream flows, and increasing the occurrence of winter floods and summer droughts (Field et al. 1999). 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).

Increases in water temperatures will strongly affect the physiology and behavior of salmonids at each stage of life and their life history strategies. Changes in movement patterns are likely to be the most obvious response of individual salmonids to climate change, particularly as fish are exposed to increases in water temperature and changes in stream flow patterns (Groot and Margolis 1991). Increased temperatures will hasten developmental and growth rates, and may shift migration patterns of Klamath salmonids to earlier in the year. However, photoperiod at a given site can also influence the initiation of salmonid migrations; thus, migration initiation and timing may become decoupled from water temperature up to a point (Feder et al. 2010). Salmonids may also seek colder waters as a method of thermoregulation under warmer streamflow conditions. Salmonids use cold water pockets as thermal refuges in rivers during juvenile rearing and adult migration when water temperatures exceed 22°C (Strange 2010). In summer, juveniles use thermal refuges to avoid 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. In addition, fall water temperatures are forecast to decrease several weeks earlier than they currently do after dam removal, with important implications for habitat suitability and run-timing of salmonids (W. Duffy, HSU, pers. comm. 2017).

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 baseflows may increase juvenile mortality through stranding and changes in the timing of peak spring and base flows may reduce survival of juveniles emigrating from rivers into the ocean (Lawson et al. 2004). Increases in winter flows may decrease adult survival or reproductive success due to the higher metabolic cost of upstream migration at higher flow stages. Due to these factors, Moyle et al. (2013) rated KMP winter steelhead as highly vulnerable to extinction from to climate change, using a systematic procedure, while recognizing at present KMP are not in immediate danger.

S**tatus Score = 3.3 out of 5.0. Moderate Concern.** There is no immediate extinction risk for KMP winter steelhead. Some populations will likely decline further or even be extirpated under current management trends. KMP winter steelhead are managed by CDFW for recreational harvest, and recruits from the Trinity River Hatchery prop up populations. In 2001, NMFS found that the DPS as a whole did not warrant listing as a threatened species under the Endangered Species Act. However, Klamath Mountain Province steelhead are listed by the US Forest Service Pacific Southwest Region as a Sensitive Species, and a Species of Special Concern by CDFW (CDFW 2015).

Lack of strong protection for wild stocks, combined with climate change reducing adult holding and juvenile rearing habitat, will continue to pressure KMP winter steelhead. The absence of coordinated province-wide management actions to protect them increases the likelihood of local extirpations. The most recent genetic data indicating that summer and winter steelhead in the KMP are discrete units (Prince et al. 2015) raises the question of whether or not lumping these two runs together for management purposes should be revisited.

Metric	Score	Justification
Area occupied	4	Winter steelhead found throughout KMP watersheds; dams block access to large portion of upstream spawning and rearing habitat.
Estimated adult abundance	3	KMP winter steelhead abundance is relatively unknown, but is probably less than 50,000 fish/year including Smith River run.
Intervention dependence	3	Frequent management actions needed for habitat restoration and protection to prevent continuation of long-term decline. Klamath dam removal and restoration is likely to improve this score.
Tolerance	4	Steelhead are very adaptable and winter fish return during a time when flows are highest and temperatures lowest.
Genetic risk	3	Presumably genetically diverse; however, hybridization risk with hatchery steelhead is a considerable threat.
Climate change	3	All KMP watersheds are projected to see seasonal water temperatures and flows change.
Anthropogenic threats	3	9 Medium factors.
Average	3.3	23/7.
Certainty (1-4)	2	Data are particularly sparse for KMP winter steelhead.

Table 2. Metrics for determining the status of KMP winter steelhead, where 1 is poor value and 5 is excellent and 2-4 are intermediate values. Certainty of these judgments is moderate.

Management Recommendations: KMP winter steelhead appear to be in slow decline, although fish mainly of hatchery origin continue to support a fishery. Climate change will increase stream temperatures, reduce summer flows and otherwise change flow patterns, and will have to be taken into account for all management actions.

Klamath River actions. Wild Klamath Basin steelhead are particularly at risk; present numbers are far below estimates from even two decades ago and the Iron Gate Hatchery has not met production or escapement goals for decades. Returns of anadromous adult steelhead to the Hatchery have been so low over the last decade that release of all steelhead stopped in 2013 (M. Knechtle, CDFW, pers. comm. 2016). It is presumed that hatchery fish overwhelmingly exhibit resident life history strategies in the Klamath Basin due to prevailing environmental conditions (W. Duffy, HSU, pers. comm. 2017). Although currently-accessible Klamath tributaries (e.g., Salmon River and Clear, Dillon, and Elk creeks) provide healthy spawning and nursery areas, water quality and quantity in the mainstem may remain too seasonally poor to provide connectivity between these locations and for rearing habitat of larger juveniles. If coordinated restoration efforts are successful following dam removal on the Klamath River and flows improve in the Trinity River, it is possible to optimistic about the state of KMP steelhead populations in California in the next 15-20 years. Numbers could increase significantly once connections are re-established with Klamath River above Iron Gate and the upper Klamath Basin but there is considerable uncertainty as to how much steelhead will benefit (Hodge et al. 2015). Use of conservation hatcheries to 'jump-start' resident, ocean-maturing, and stream-maturing steelhead populations in the newly-accessible habitat should be carefully considered, recognizing that hatchery selection pressures can negatively impact genetic integrity, behavior, and over all fitness (Quinones et al. 2013). An Iron Gate Hatchery Genetic Management Plan (CDFW 2014) has been drafted for Coho salmon, which may be able to serve as a model for adapting hatchery operations benefit all salmonids, especially after removal of four Klamath dams. An alternative option would be closure of Iron Gate Hatchery for a full decade after dam removal, with monitoring for relative abundances of wild and hatchery fish, while the Trinity River hatchery continues to support the fishery (Quinones et al. 2013). This could offer scientists a chance to better understand the carrying capacity of the habitat left behind on the Klamath River after dam removal, and provide valuable data that could inform recovery of salmonids to levels deemed appropriate for the time.

A particularly promising approach to improving the status of steelhead and other Klamath salmonids is found in Blue Creek, the lowest substantial tributary to the river, has headwaters in the Siskiyou Wilderness Area. The entire lower watershed has been acquired through standard and non-standard means (e.g. carbon credits, New Market tax credits, etc.). The land will eventually pass entirely 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).

Trinity River actions. Trinity River Restoration Program actions, such as improved flows, manipulation of shallow edge habitats, and removal of barriers, will benefit steelhead populations. The California Department of Fish and Wildlife, along with partnering agencies and organizations, has implemented the Trinity Record of Decision to supply ~50% of annual inflow to the river. However, several key components have not been implemented, including:

1. Increasing naturally produced steelhead through protection of selected subbasins that protect steelhead distribution and diversity.
2. Completing management plans for each subpopulation of winter steelhead.
3. Restoring favorable instream conditions to benefit desired ecosystem function and the community of fishes, including Coho and Chinook salmon and Coastal Cutthroat trout downstream.
4. Improving hatchery operations for the Trinity River Hatchery to reducing hatchery impacts on wild steelhead populations.

Smith River actions. The Smith River remains relatively undisturbed, with major conservation activities taking place within the watershed, so it is likely to remain a stronghold for wild steelhead regardless of what happens in other watersheds. In 1990, the Smith River National Recreation Area Act provided some degree of additional protection for the important watershed. As 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. The conservation strategy of acquiring large tracts of private lands to protect important watersheds, such as Goose, Mill, and Hurdygurdy creeks is important 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, and should be replicated where possible to ensure strongholds exist for KMP winter steelhead. In 2016, the Red Flat Nickel mine proposal in the Oregon portion of the Smith River watershed was defeated by legislation, setting further precedent of protecting this National Wild and Scenic River into the future.

Research and monitoring. More research on KMP steelhead populations in California is also needed, especially to determine (1) genetic identities of each population, (2) extent of possible limiting holding and rearing 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. Managers would benefit from a better understanding of the physical and biological cues that lead to their wide variety of migration and habitat utilization patterns. Determination of survival and escapement rates for wild steelhead is essential to understanding viability and persistence of individual populations. Additional information regarding the genetics, ecology, and behavior of KMP steelhead is also needed to help inform management and conservation strategies after the four lower dams on the Klamath River are removed. For example, hooking mortality from legal catch-and-release fishing on wild winter steelhead has unknown consequences to small populations, and new information could better inform updated regulations. Although penalties for fishing violations are high, increased vigilance and enforcement are required to help maintain and recover wild steelhead populations where they remain

Across all KMP winter steelhead populations, there is a need to accurately census distribution and abundance of populations. Monitoring 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, 2015). The Coastal Salmonid Monitoring Plan seeks to integrate methods and data across

California coastal watersheds, which can help managers use the best scientific information available to them to manage the resource. More comprehensive monitoring could help adjust fishing regulations to reduce impacts on wild fish.

General actions. Improvement of juvenile steelhead rearing habitat should be a priority for all agencies, because reduction in summer rearing and carryover habitat has been repeatedly identified as a critical limiting factor for steelhead in the Klamath Mountains Province. Land management practices that reduce sedimentation, increase cover, and minimize changes to rearing habitat should be identified and implemented where practicable.

KMP winter steelhead populations would benefit from restoration actions that reduce impacts from logging, mining, and illegal and quasi-legal marijuana cultivation in the basin. Land management strategies that seek to reduce sedimentation, increase cover, and minimize other stressors that negatively affect habitat for adults are critical to recovering populations. Continued funding for upslope restoration on private lands, fencing riparian areas, and improving water conservation will be necessary at a watershed scale, with greater participation by landowners, for there to be a benefit to KMP steelhead in places like the Shasta and Scott Rivers. Removal of migration barriers in tributaries, replanting riparian areas, adding complex woody debris to stream channels, and reducing sediment reaching rivers and streams are also necessary.

Future management measures to bolster KMP steelhead should address: (1) improving water management to mimic natural hydrographs, and especially to reduce undocumented water withdrawals, (2) identifying watershed management approaches that minimize sediment delivery to streams and maintain high water quality, (3) implementing restoration of downstream reaches to favor out-migrating smolts, (4) rebuilding present wild populations through identifying and affording protection to key refuge areas, such as the Smith River, that protect genetic and life history strategy diversity, and (5) creating a basin-wide restoration program involving stakeholders, managers, and policymakers from the upper and lower Klamath Basins to allow rapid implementation of a common vision for the restored Klamath River after dam removal. These 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, 2015). The Klamath dam removal and restoration project will be the largest such restoration project ever undertaken in the Klamath Basin. This action provides an exciting opportunity to showcase cooperation and serve as a proving ground for salmonid reintroduction and management to the benefit of all stakeholders and species.

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