U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: *Lavinia exilicauda chi*

COMMON NAME: Clear Lake Hitch

LEAD REGION: Region 10 (Legacy Region 8)

DATE INFORMATION CURRENT AS OF: July 30, 2020

STATUS/ACTION:

__X__ Species assessment - determined either we do not have sufficient information on threats or the information on the threats does not support a proposal to list the species and, therefore, it was not elevated to Candidate status

___ Listed species petitioned for uplisting for which we have made a warranted-but-precluded finding for uplisting (this is part of the annual resubmitted petition finding)

___ Candidate that received funding for a proposed listing determination; assessment not updated

___ New candidate

___ Continuing candidate

___ Listing priority number change
Former LPN: ___
New LPN: ___

___ Candidate removal: Former LPN: ___
___ A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.
___U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.
___ F – Range is no longer a U.S. territory.
___ I – Insufficient information exists on taxonomy, or biological vulnerability and threats, to support listing.
___ M – Taxon mistakenly included in past notice of review.
___ N – Taxon does not meet the Act's definition of "species."
___ X – Taxon believed to be extinct.

Date when the species first became a Candidate (as currently defined):

Petition Information:
___ Non-petitioned
__X_ Petitioned; Date petition received:
90-day substantial finding FR publication date: April 10, 2015 (80 FR 19259)
12-month warranted but precluded finding FR publication date:

PREVIOUS FEDERAL ACTIONS:

The Clear Lake hitch (hitch) (*Lavinia exilicauda chi*) (Hopkirk 1973, pp. 55–56) is a large cyprinid (freshwater minnow) that is endemic to the Clear Lake watershed in Lake County, California. Clear Lake hitch are found in Clear and Thurston Lakes, where they spend most of each year within the lakes themselves, then migrate in spring into tributary streams to spawn and then return to the lake. The U.S. Fish and Wildlife Service (Service) received a petition from the Center for Biological Diversity on September 25, 2012 (CBD 2012, entire), to list the Clear Lake hitch as threatened or endangered under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543) (Act). The Service issued a 90-day finding on April 10, 2015 (80 FR 19259), stating the petition presented substantial information that listing the Clear Lake hitch may be warranted. This conclusion was based on our review of the petition and sources cited in the petition, indicating that the petitioned action may be warranted due to: (1) the present or threatened destruction, modification, or curtailment of the species habitat or range from urban and agricultural development, dams, water diversions, migration barriers, mining activities, and grazing; (2) overutilization for commercial fishing, recreational fishing, and tribal harvest; (3) disease and predation; and (4) other natural or manmade factors affecting its continued existence, including effects from climate change, contaminants, and introduced fish. Therefore, a review of the status of the hitch was initiated to provide the scientific information from which a determination would be made. Based on the information prepared for the Clear Lake Hitch Species Status Assessment (SSA or assessment), the Service is issuing this 12-month finding for the Clear Lake hitch.

ANIMAL/PLANT GROUP AND FAMILY: Fish in the family Cyprinidae

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE:

Historically, the Clear Lake hitch occurred in several lakes and ponds found throughout the Clear Lake watershed, including: Clear Lake, Thurston Lake, Upper Blue Lake, Lower Blue Lake, and Lampson Pond. During the spring, Clear Lake hitch were also found spawning in the numerous tributaries to these larger water bodies, including: Kelsey, Scott, Middle, Adobe, Seigler Canyon, Manning, Cole, Morrison, and Schindler Creeks. All of the waterbodies listed above, with the exception of Thurston Lake, were hydrologically connected in the past and it appears that Thurston Lake and its tributary, Thurston Creek, have always been isolated from the other waterways. Local opinion is that hitch were introduced into Thurston Lake by a local resident less than 50 years ago.

CURRENT STATES/COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE:

The Clear Lake hitch is restricted to the Clear Lake watershed in Lake County, California, in the central Coast Range mountains. Currently, the hitch is thought to be extirpated from the Blue Lakes, but still occurs in Clear and Thurston Lakes. Although the Clear Lake hitch has been described as once occurring in Lampson Pond, and the location of Lampson Pond has been approximated, it is unclear whether Lampson Pond still exists since both field surveys and visual inspections of maps have failed to detect this pond (B. Ewing in litt. 2020). Therefore, since the status of Lampson Pond is unknown, the status of the Clear Lake hitch within the pond is also unknown.

LAND OWNERSHIP:

The State of California owns most of Clear Lake up to the low water line, and then between the low and high water line there is a mix of ownership. The Clear Lake tributaries are also a mix of ownership, with most of them being privately owned. Thurston Lake and Thurston Creek are entirely privately owned. Some of the spawning tributaries and nearshore habitats are owned by city, county, state, or federal agencies. Landowners that we are aware of include: Private-landowners, city agency, county agency, flood district, non-profit conservation and land trust, regional park district and State and Federal agencies. The primary landowners include, but are not limited to, the U.S. Forest Service (USFS), Bureau of Land Management (BLM), State of California, local Pomo tribes, and Lake County.

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BIOLOGICAL INFORMATION:

The Species Status Assessment for the Clear Lake hitch is a summary of the information assembled and reviewed by the Service and incorporates the best scientific and commercial information available for this species. The following sections represent a summary of the biological information provided in the SSA. For more detailed information on the species' description, taxonomy, life history, range, species needs, threats, and current and future conditions as well as detailed literature cited for all sections, please refer to the SSA (Service 2020, entire) which can be found at https://regulations.gov.

Methodology
The Clear Lake hitch Species Status Assessment draws scientific information from resources such as primary peer-reviewed literature, reports submitted to the Service and other public agencies, species occurrence information in Geographic Information Systems (GIS) databases, habitat information in GIS databases, and expert experience and observations. It is preceded by and draws upon analyses presented in other Service documents, including the 90-day finding (80

FR 19259). Finally, we coordinated closely with our partners engaged in ongoing research and conservation efforts. This assures consideration of the most current scientific and conservation status information.

Analytical Framework

The Species Status Assessment Framework (SSA framework) (Service 2016, entire) and the SSA developed for the Clear Lake hitch are intended to support an in-depth review of the species' biology and influencing factors, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability.

For the purpose of the SSA, viability is generally defined as the ability of the Clear Lake hitch to sustain itself within its natural ecosystem throughout the Clear Lake watershed up through a biologically meaningful timeframe. We chose 50 years as our biologically meaningful timeframe because the available climate models for the North Coast Region, where Clear Lake is located, show similar precipitation and temperature projections under the two different emissions scenarios (RCP 4.5 and RCP 8.5) into the mid-century (2040-2069). Beyond this period (2070-2099), both temperature and precipitation projections begin to diverge under the two emissions scenarios. Since it is unknown what emissions scenario we will be tracking in the later part of the century, and that uncertainty increases with time, we will be conservative in using the shorter 50-year timeframe. Using the SSA framework (Figure 1) (Service 2020, p. 2, Figure 1.1), we consider what the hitch needs to maintain viability by characterizing the status of the subspecies in terms of its resiliency, representation, and redundancy (Wolf *et al.* 2015, entire).

- **Resiliency** describes the ability of populations to withstand stochastic events. Measured by the size and growth rate of each population, resiliency gauges the probability that the populations comprising a species are able to withstand or bounce back from environmental or demographic stochastic events. For the Clear Lake hitch, resiliency was evaluated by assessing the hitch's demographic factors of reproduction and recruitment, and habitat elements of connectivity, water quality and quantity, and availability of wetland/tule habitat.

- **Representation** describes the ability of a species to adapt to changing environmental conditions. Measured by the breadth of genetic or environmental diversity within and among populations, representation gauges the probability that a species is capable of adapting to environmental changes. For the Clear Lake hitch, representation was evaluated by assessing the different spawning strategies they can utilize under variable environmental conditions.

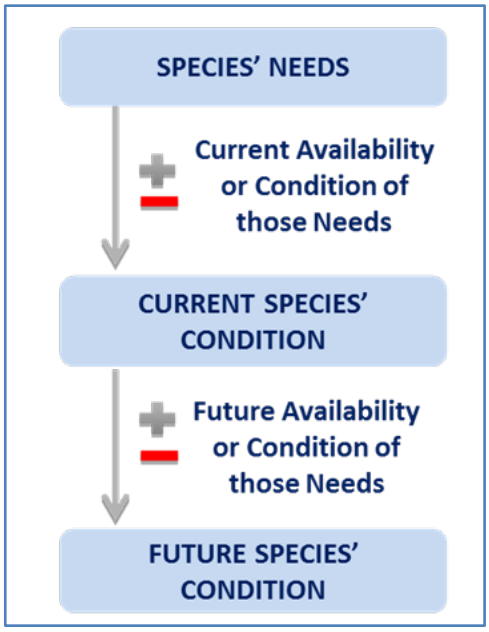

Figure 1. Species Status Assessment framework (Service 2020, p. 2, Figure 1.1)

- **Redundancy** describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resiliency, and their distribution (and connectivity), redundancy gauges the probability that the species has a margin of safety to withstand or can bounce back from catastrophic events. We evaluated redundancy of Clear Lake hitch in the context of its extant range that includes two populations, one that occupies Thurston Lake and its tributary (Thurston Creek), and one that occupies Clear Lake and its tributaries. In addition, we will also be describing how the hitch expresses within population redundancy based on types of spawning habitats (tributary, lake, or interface between the two) and the number of available tributary streams within the watershed. Although this is not entirely consistent with the SSA framework's definition of redundancy, we believe this is important to describe since a plausible catastrophic event may be prolonged drought and having different available spawning habitats may increase the ability of the Clear Lake hitch to withstand a catastrophic drought event.

To evaluate the biological status of the Clear Lake hitch both currently and into the future, we assessed a range of conditions to allow us to consider the hitch's resiliency, representation, and redundancy (together, the 3 R's). The Clear Lake hitch SSA provides a thorough assessment of the Clear Lake hitch's biology and natural history, and assesses demographic risks, influencing factors, and limiting factors in the context of determining the hitch's viability and risk of extinction.

This 12-month finding summarizes information contained in the SSA, which is a compilation of the best available scientific and commercial information and a description of the past, present, and likely future risk factors to the Clear Lake hitch. For further information about the Clear Lake watershed and the Clear Lake hitch, refer to the Clear Lake hitch Species Status Assessment (Service, 2020 entire).

Subspecies Description

Adult Clear Lake hitch have a deep and elongated body and can grow to over 350 mm standard length (SL) as measured from the tip of the mouth/snout to the end of the tail, excluding the tail fin). They have a relatively small conical head, a terminal or slightly upturned mouth, and pharyngeal teeth (teeth found in the throat area, behind the mouth and nose), which are slightly hooked with a broad surface adapted to grinding, evidence of their limnetic lifestyle. Juvenile Clear Lake hitch have a black spot at the end of the tail that extends to the head region as a gradually fading black stripe; however, as individuals age, their coloring fades and they become a brownish-yellow.

Taxonomy and Genetics

Early accounts considered the hitch inhabiting Clear Lake to be identical to the hitch found in the Sacramento River (*Lavinia exilicauda*); however, in 1973 John D. Hopkirk described the Clear Lake hitch as a distinct "lake-adapted" subspecies and found it could be differentiated by its deeper body form, larger scales and eyes, and its greater number of gill rakers. Early genetic studies suggested the more widespread species of hitch (*Lavinia exilicauda*) and the roach (*Hesperoleucus symmetricus*) are so genetically similar that they could be considered conspecifics, and further analysis found the two species showed such little genetic divergence that they could actually be considered congeners. A subsequent genetic analysis found the Clear

Lake hitch shares mitochondrial DNA haplotypes with different forms of California roach outside of the Clear Lake watershed, and their status as a subspecies was not supported. However, a later analysis using nuclear and mitochondrial DNA had differing results. The nuclear DNA analysis supported the subspecies designation for the Clear Lake hitch, but the mitochondrial DNA analysis did not. A more recent genomic analysis suggests the three currently recognized subspecies of hitch within California show strong population structuring but only weak subspecies structuring. However, since this analysis is still fairly recent and does not definitively conclude that the Clear Lake hitch is not a subspecies, and because the hitch is still currently considered a valid subspecies by the scientific community, we will continue to consider the Clear Lake hitch a subspecies in the Clear Lake Hitch SSA and for the purposes of this finding.

Habitat/Life History

For most of the year, Clear Lake hitch are only found within their lacustrine environment. However, between February and May, a portion of the overall reproductive population begin to migrate into the surrounding tributaries to spawn. Spawning activities include one to five males pursuing a gravid female to fertilize her freshly extruded eggs, which are deposited on fine to medium sized gravel within the tributary stream. Fertilized eggs develop and hatch within 7 to 10 days, fry are free-swimming after another 7 to 10 days, and young migrate to the lake at about a month old before the streams dry up. Juvenile hitch are found within the nearshore habitat of the lake where they depend on submerged aquatic vegetation for cover and prey. Juvenile hitch move from the nearshore portion of the lake into open water in early- to late-fall. There is evidence that Clear Lake hitch do not require tributary streams with gravel to spawn, but can also spawn successfully in different portions of the lake (i.e., along the shore, the mouths of tributaries, and Rodman Slough) that lack a gravel substrate.

The Clear Lake hitch grows much faster than other subspecies of hitch (i.e., Monterey hitch (*Lavinia exilicauda harengus*) and Sacramento hitch (*Lavinia exilicauda exilicauda*)) found in lacustrine environments, most likely due to Clear Lake's high productivity and high water temperatures. Females are known to grow larger than males and while males are sexually mature within their first or second year, females are sexually mature in their second or third year. Clear Lake hitch are thought to live 4 to 6 years, but it is possible some individuals can live longer. Because Clear Lake hitch females are much larger than the other subspecies of hitch within California, they are more fecund. A female Clear Lake hitch that is reproductive at age 3 and lives to age 6 could produce, on average, over 100,000 eggs in her lifetime.

Historical and Current Range/Distribution

Historically, the Clear Lake hitch occurred in several lakes and ponds found throughout the Clear Lake watershed, including: Clear Lake, Thurston Lake, Upper Blue Lake, Lower Blue Lake, and Lampson Pond. During the spring, Clear Lake hitch were also found in the numerous tributaries to these larger water bodies, including: Kelsey, Scott, Middle, Adobe, Seigler Canyon, Manning, Cole, Morrison, and Schindler Creeks. Currently, the hitch is thought to be extirpated from the Blue Lakes, but still resides in Clear and Thurston Lakes throughout the year. In the spring, reproductive adults migrate into tributary streams to spawn and then migrate back to the lakes after spawning. It is unclear whether Lampson Pond still exists (B. Ewing *in litt.* 2020); therefore, the status of the Clear Lake hitch in Lampson Pond is unknown. All of the described

waterbodies besides Thurston Lake were hydrologically connected to each other in the past and it appears that Thurston Lake and its tributary, Thurston Creek, have always been isolated from the other waterways. Local opinion is that hitch were introduced into Thurston Lake by a local resident less than 50-years ago (P. Windrem *in litt.* 2020).

Population Estimates/Status

There are no robust, statistically valid population or abundance estimates for the historical population of Clear Lake hitch. Although survey efforts have been conducted within the Clear Lake watershed, most were incidental to survey efforts that had a different purpose or were random documented observations; therefore, we do not have data on past or current population estimates for the hitch.

However, there are various recorded observations and incidental catch data from past commercial fishing operations, local tribal knowledge and observations, and other monitoring efforts, which allows a comparison of the size of the population in the past to the size of the population now. Historical accounts of the species were primarily recorded observations of the vast spawning runs that would migrate up the tributary streams in the spring and early summer and not estimates of the species' overall population size. Early accounts made claims that the Clear Lake hitch was once so abundant that during their spawning migrations they would crowd each other out to the point they would strand individuals on the shore where they would die (Rideout 1899, entire; Thompson *et al*. 2013, p. 12). A 1925 account of the species described hitch as the most abundant fish species in Clear and the Blue Lakes, and that hitch were "…so abundant that one can hardly step without stepping on several (Coleman 1930, p. 226)." Cook *et al*. (1966, p. 143–144) described the hitch as very common in Clear Lake during the early 1960s, although the authors also describe a general decline in the abundance of other stream spawning fish species (e.g., Clear Lake splittail and Sacramento pikeminnow).

There is no current population or overall abundance estimate for the Clear Lake hitch; however, more recent survey efforts conducted by the California Department of Fish and Wildlife (CDFW), local tribes, and USGS are accruing more data. Recent efforts include CDFW conducting mark and recapture surveys on a few primary tributaries to Clear Lake and visual spawning surveys on seven different tributaries to the lake. In addition to CDFW's efforts in the tributary streams, the local tribes have been also been conducting visual surveys during the spawning season. The purposes of the mark and recapture and the visual spawning surveys are to determine the number of hitch spawning in each creek, determine whether individuals are returning to the same tributary to spawn every year, and collect population data to compare to existing and future efforts. Lake or other large waterbody surveys conducted by CDFW include electrofishing efforts to identify hitch spawning in the lake, assess the population residing in the Soda Bay area of Clear Lake, and to determine whether hitch occupied two different waterbodies (Thurston Lake and Highland Springs Reservoir). Lake monitoring by USGS has been on-going to determine the status and distribution of the hitch throughout the lake, and to evaluate habitat associations.

In conjunction with the lake monitoring, USGS kept a subset of adult hitch captured to analyze strontium signatures in their otoliths (ear bones) to determine natal habitat source and to estimate the age at which those individuals left their natal habitat and entered the lake (Feyrer *et al*.

2019a, pp. 1690, 1692). Strontium signatures from water samples taken throughout the watershed indicated the watershed could be assigned to one of five unique strontium isotope groups (SIG) (see Figure 3) (Service 2020, p. 16, Figure 3.2). Otoliths were collected and analyzed from 45 hitch approximately 2-5 years old, and individuals were assigned to one of the SIG's based on the strontium signature on the portion of their otolith associated with early development, and therefore, natal habitat source. The waterbodies associated with the five SIG's include: Cole Creek, Schindler Creek (SIG 1); Kelsey Creek, Burns Valley Creek (SIG 2); Clear Lake, Adobe Creek, Scotts Creek (SIG 3); Rodman Slough (SIG 4); Middle Creek, Clover Creek, Seigler Canyon Creek (SIG 5). The use of adult otoliths for the natal habitat strontium groupings indicates those areas associated with the SIG is contributing to reproduction and recruitment (Feyrer *et al*. 2019a, pp. 1693, 1695).

Each of the five SIG's were represented in the otolith signatures, with most (58%) of the adults being assigned to SIG 3. It is likely the natal habitat associated with a majority of individuals representing SIG 3 is Adobe Creek or Clear Lake and not Scotts Creek because migration from Scotts Creek would require passage through Rodman Slough, which would be revealed during the otolith strontium analysis. A large proportion of individuals were also assigned to Rodman Slough (SIG 4), which is an unexpected natal habitat type in that it is a backwater-like area of Clear Lake. Because they are well-known, somewhat stable spawning tributaries, Cole Creek is the most likely natal habitat source for individuals from SIG 1 and Kelsey Creek is the most likely source for individuals from SIG 2. Middle, Clover, and Seigler Canyon Creeks all likely contribute to SIG5 since they all are well known spawning tributaries. Additional markers need to be developed to differentiate the individual habitats within each SIG. Furthermore, additional water samples should be collected throughout the watershed since there was evidence some habitats may not have been sampled. The otolith study suggests the Clear Lake hitch is able to spawn in a number of different habitat types and not just tributary streams with continual flow. The otolith study also suggests that the Clear Lake hitch is able to utilize the mouths of streams with little to no flow movement and areas within Clear Lake itself (Feyrer et al. 2019a, pp. 1693–1695).

Analysis Units

There are likely only two separate populations of Clear Lake hitch within the Clear Lake watershed: one is found in Clear Lake and its associated tributaries, and the other in Thurston Lake and its associated tributary. Because the primary population occurs in Clear Lake and its associated tributaries, the SSA conducted a more detailed analysis of the Clear Lake population. This was conducted by further dividing the Clear Lake watershed into Hydrologic Unit Code (HUC) 12 sub-watersheds, which better capture aquatic habitat features at a local, sub-watershed level. The HUC 12 sub-watershed units within the range of the Clear Lake hitch include (see Figure 2) (Service 2020, p. 15, Figure 3.1): West Fork Middle Creek, East Fork Middle Creek, Salt Flat Creek-Middle Creek, Lower Scotts Creek, Middle Scotts Creek, Clover Creek, Rodman Slough - Frontal Clear Lake, Manning Creek - Frontal Clear Lake, Adobe Creek, Kelsey Creek, McGaugh Slough - Frontal Clear Lake, Cole Creek, Thurston Lake, Clear Lake, Schindler Creek - Frontal Clear Lake, and Seigler Canyon - Cache Creek. HUC codes are a way of mapping and identifying all of the drainage basins in the United States in a nested arrangement from largest (Regions) to smallest (Cataloging Units). HUC 12 is a more local sub-watershed level of mapping that captures tributary systems.

Because some of the sub-watersheds do not have all of the components that the Clear Lake hitch requires to complete its life history, and because we have recent information about how different regions of the watershed have contributed to reproduction and recruitment, the two primary demographic factors limiting population growth, we further grouped some of the HUC 12 units into larger units (see Table 1) (Service 2020, p. 15, Table 3.2). This further grouping was based on otolith strontium signatures that indicated natal origins can be assigned to one of five strontium isotope groups (SIG) throughout the watershed (Feyrer et al. 2019a, entire). The use of adult otoliths for the natal habitat strontium groupings indicates those areas associated with the SIG are contributing to reproduction and recruitment. The HUC 12 units in each SIG are shown in Figure 3 (Service, 2020, p.16, Figure 3.2).

In the Clear Lake Hitch SSA, the analysis units used to analyze the overall condition of the Clear Lake population are the five SIG's. Since the entire Thurston Lake watershed is completely within the Thurston Lake HUC 12, just that sub-watershed unit is used to analyze the Thurston Lake population. It should be noted that just because the Clear Lake population is first analyzed at an analysis unit level before determining the overall condition of the population, the individuals that may occur within each analysis unit at any point in time are actually interbreeding with individuals from other analysis units and should not be considered separate, discrete populations ~~in a genetic or population biology sense~~.

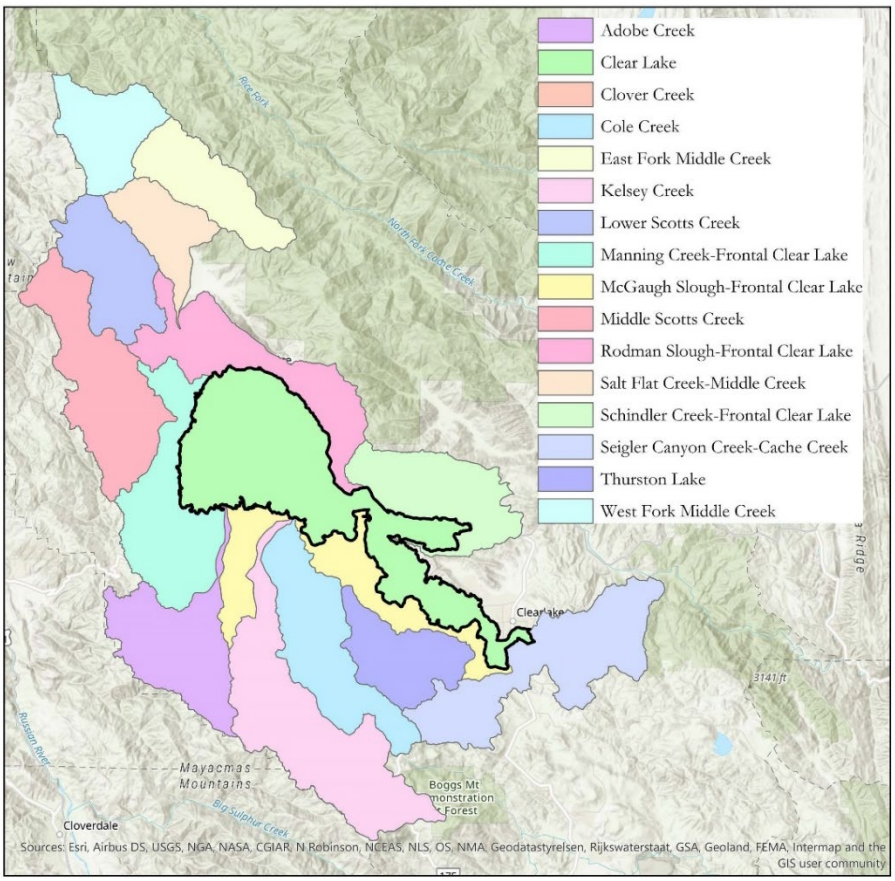

Figure 2. Clear Lake hitch HUC 12/analysis units. Clear Lake is outlined in bold (Service 2020, p. 16, Figure 3.1)

Table 1. Clear Lake hitch HUC 12 sub-watersheds within each SIG unit (Service, 2020, p. 15, Table 3.2).

SIG #	HUC 12 UNIT
1	Cole Creek, Schindler Creek - Frontal Clear Lake, McGaugh Slough - Frontal Clear Lake
2	Kelsey Creek
3	Adobe Creek, Lower Scotts Creek, Middle Scotts Creek, Manning Creek - Frontal Clear Lake
4	Rodman Slough - Frontal Clear Lake
5	Clover Creek, West Fork Middle Creek, East Fork Middle Creek, Salt Flat Creek-Middle Creek, Seigler Canyon - Cache Creek

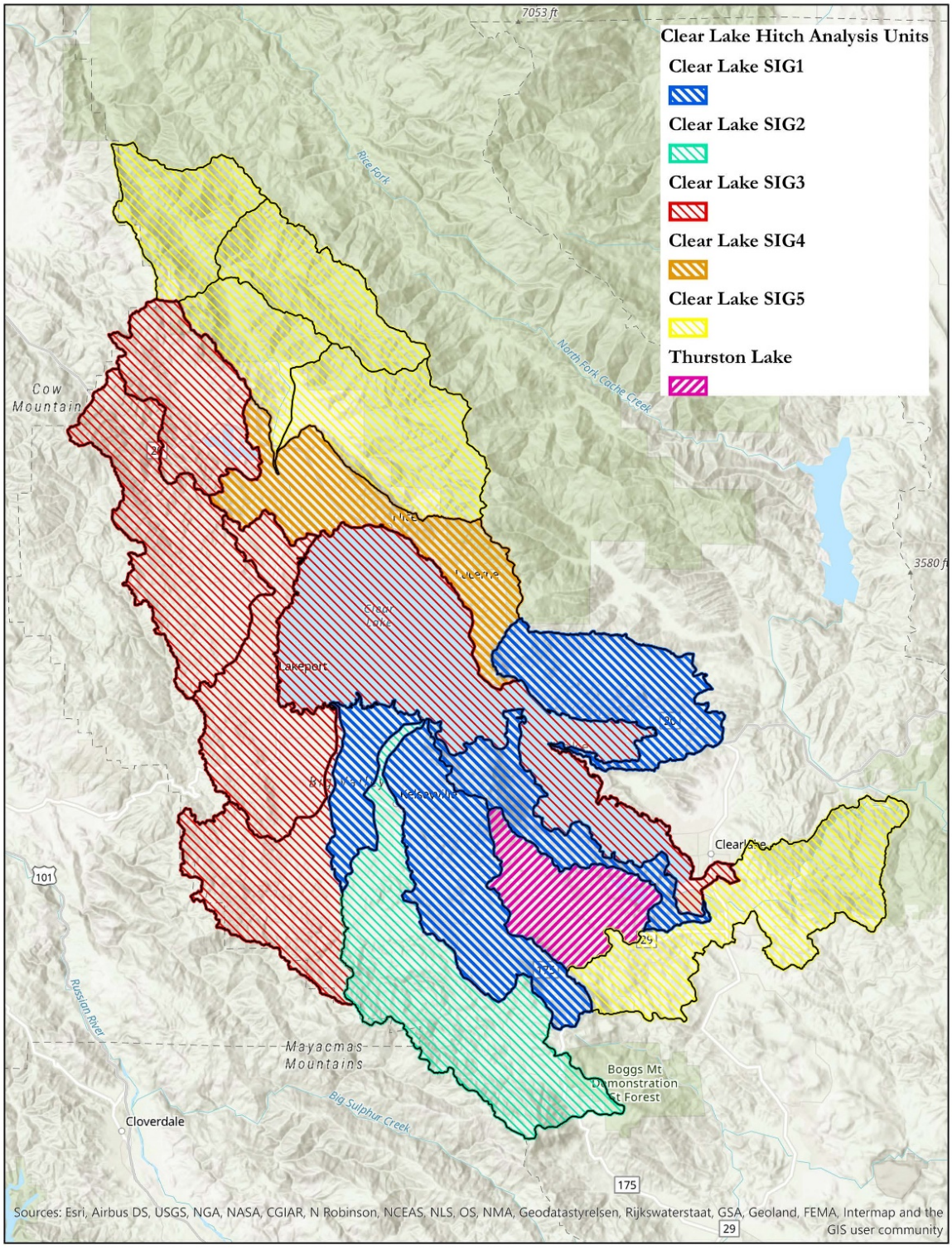

Figure 3. Clear Lake hitch analysis units: SIG1-SIG5 are associated with the Clear Lake population and the Thurston Lake HUC 12 sub-watershed is associated with the Thurston Lake (Service 2020, p. 16, Figure 3.2)

Population Resiliency, Representation and Redundancy Methodology

Population Resiliency

For the Clear Lake hitch to maintain viability, the habitat that supports each of the two populations, or some portion thereof, must be of sufficient quality to support reproduction and growth. Environmental stochastic events that have the potential to affect the Clear Lake hitch include severe storms, drought, contaminant exposure, and the modification of habitat via natural (i.e., fire, drought, etc.) and anthropogenic means. A number of factors influence the resiliency of a population, including reproduction, recruitment, and survival at both the adult and juvenile life stages. Influencing those factors is the quality and connectivity of Clear Lake hitch habitat, which determines how well the spawning areas allow for successful reproduction, whether the nearshore nursery areas allow for young-of-year survival and subsequent recruitment or whether individuals can move between tributary spawning habitats and the lake. These demographic factors and habitat elements are discussed below and are shown in the Clear Lake hitch SSA Figure 3.3 (Service 2020, p.17). A summary of demographic factors and habitat elements that were ultimately eliminated from the analysis, and the reasons for why they were eliminated, are shown in the Clear Lake hitch SSA in Table 3.3 (Service 2020, p-21).

Representation

Maintaining representation in the form of genetic or ecological diversity is important to maintain the Clear Lake hitch's capacity to adapt to future environmental changes. Genetic studies within the subspecies have not been conducted; however, as discussed above, recent genetic analyses have indicated strong population structuring between the three forms of hitch that are currently referred to as subspecies (Baumsteiger et al. 2019, p. 407). Even though there are two separate populations of Clear Lake hitch, they occur within the same watershed and occupy the same ecological niche. For the Clear Lake hitch, representation is best measured by assessing the different available spawning strategies under varying environmental conditions.

Redundancy

The Clear Lake hitch has redundancy by having two isolated populations, one that occupies Thurston Lake and its tributary, and one that occupies Clear Lake and its tributaries. Although redundancy gauges the probability that a species has a margin of safety to withstand or bounce back from a catastrophic event, due to the hitch's narrow range it may not actually express much redundancy. Depending on the scale of a catastrophic event happening within the watershed, it is possible a catastrophe could impact the entire watershed, and therefore, both populations and all tributary streams. Realistic catastrophic events that could potentially impact the Clear Lake hitch include earthquakes, volcanic activity, fires, drought, and flooding.

Because drought events are likely to occur in the future due to climate change, some of which will likely be considered severe we also describe within population redundancy that could potentially increase the ability of that population to withstand a prolonged, severe drought event. The Clear Lake hitch expresses within population redundancy in the type of natal habitat used for reproduction (tributary, lake, or interface between the two) and the number of available tributary streams within the watershed. As the number of tributaries available increases and/or the types of habitat used for reproduction increases within a population, the more redundancy that population will exhibit.

Summary of Population Needs

This section provides a summary of Clear Lake hitch population needs at all life stages (see Table 2) (Service 2020, p. 24, Table 3.4). Needs are described in terms of demographic factors and the habitat elements that are required to provide those factors.

The demographic factors required for Clear Lake hitch population resiliency include:

- **Reproduction/Recruitment:** Sustained water flow within the tributaries and accessibility to spawning habitats increase reproductive success and the possibility for future recruitment. Availability of wetland/tule habitat surrounding the lake increase early life stage survival, and therefore, recruitment. The accessibility and/or availability of spawning and rearing habitats reflect environmental conditions, anthropogenic uses (i.e., water use, development, etc.), and the presence of passage barriers, both natural and anthropogenic.

- **Survival:** To compensate for years when reproductive success and recruitment are low, adult Clear Lake hitch need to maintain a fairly high survival rate. A high survival rate allows the hitch to maintain a viable population in an area where environmental conditions do not always allow for successful reproduction and recruitment. The most important factors acting on the hitch are influencing survival at the early life stages. The lack of consistent flow and presence of barriers within the tributaries, the loss of tule habitat along the shores of Clear Lake, and the effect of competition and predation while in the nearshore habitat all have a negative impact on juvenile survival. Due to the lack of information regarding survival at any life stage, this factor will not be carried forward for our analysis.

The habitat elements required to provide for the demographic factors described above include:

- **Connectivity:** Hydrological connectivity within the watershed is required for adult upstream spawning migrations and for the young to migrate downstream to the lake. In addition to having enough water within the tributaries to allow for up- and down-stream migrations, the streams must also be free of barriers that prevent hitch passage.

- **Tributary Water Quality:** Hitch require clean, minimally contaminated tributary water. Water temperatures need to be within a specific range to initiate spawning activity (14-18°C) and egg hatching (15-22°C for multiple days). Tributaries with suitable water quality parameters allow for successful reproduction and early life stage survival. Because this habitat need is not likely a factor limiting population growth, it will not be carried forward for our analysis.

- **Tributary Water Quantity:** For successful reproduction and recruitment, the Clear Lake hitch requires tributary streams maintain consistent flow throughout the spawning season. Reproducing adults need adequate water flow to access suitable spawning habitat upstream, and their early life stages need consistent flow to avoid desiccation and to allow young to migrate downstream to the lake.

- **Spawning Gravel:** To maintain their position within their natal tributary stream while developing, fertilized Clear Lake hitch eggs require clean fine to medium sized gravel. When freshly extruded eggs are fertilized, they sink to the stream bottom and become wedged in the gravel interstices, increasing egg survival. Eggs that are fertilized during shoreline spawning may also require gravel to maintain position while developing; however, observations of successful spawning along shorelines only containing mud suggest gravel may not be required in some situations or areas. This factor will not be carried forward for our analysis because it is not likely a factor limiting population growth and there is evidence the hitch may not require gravel for successful spawning

- **Instream/Streamside Vegetation:** Instream and streamside vegetation increase survival for early life stages of Clear Lake hitch by acting as cover from predators, providing instream temperature regulation, and by providing aquatic invertebrate prey. Because the hitch can spawn without any vegetative cover, their prey items do not necessarily have to originate at that specific spawning site, and there is no evidence this habitat element is limiting population growth, this factor will not be carried forward for our analysis.

- **Wetland/Tule Habitat:** Juvenile Clear Lake hitch continue to develop and grow in the nearshore habitat of the lake until they transition to adults. The juveniles rely on tules and/or other submerged vegetation for cover from predators and that same vegetation provides invertebrate prey. Having adequate vegetative cover in the littoral zone increases juvenile hitch survival and the likelihood that juveniles will be able to contribute to recruitment.

- **Lake Water Quality:** Both juvenile and adult Clear Lake hitch require clean water. Hypoxic conditions, sediment and nutrient inputs, algae blooms, and contaminants all influence lake water quality and can negatively impact both juvenile and adult survival. Maintaining water temperatures above 15˚C is also required for juvenile survival.

- **Adult Prey Items:** Adult hitch reside in the open water of the lake and feed on zooplankton, adult midges, and other invertebrates found in this habitat. Having an adequate adult prey base contributes to adult survival and provides resources for reproduction. This factor will not be carried forward for our analysis because adult prey is not likely a factor limiting population growth.

Table 2 Clear Lake hitch population needs by life stage. The last column categorizes what demographic need the habitat element fulfills: reproduction/recruitment (R) (Service 2020, p. 24, Table 3.4)

Scale	Life Stage	Needs	Reproduction/ Recruitment
Population	Eggs/Embryo/Larvae	Clean, minimally contaminated tributary water	R
	All	Maintenance of water flow within tributary streams for survival and to migrate up and down tributaries	R
	Eggs/Embryo	Riffles with clean, fine to medium gravel substrate	R
	Larvae	Instream or streamside vegetation for cover and prey	R
	Juveniles	Emergent vegetation in littoral zone for cover and prey	R
	Juveniles/Adults	Well oxygenated and minimally contaminated lake water for adult and juvenile survival	
	Adults	Food supply to support adults in open water habitat	R

Summary of Biological Information

The Clear Lake hitch is a subspecies of fish in the freshwater minnow family Cyprinidae and is restricted to the Clear Lake watershed in Lake County, California. Clear Lake is located approximately 100 miles north of San Francisco in the Coast Ranges and experiences hot, dry summers and cool, wet winters, with most precipitation occurring from November to March. The lake is fed by numerous tributaries, most of which are ephemeral and low gradient as they drain into the lake.

Historically, the Clear Lake hitch occurred in several lakes and ponds found throughout the Clear Lake watershed, including: Clear Lake, Thurston Lake, Upper Blue Lake, Lower Blue Lake, and Lampson Pond. During the spring, Clear Lake hitch were also found spawning in the numerous tributaries to these larger water bodies, including: Kelsey, Scott, Middle, Adobe, Seigler Canyon, Manning, Cole, Morrison, and Schindler Creeks. Currently, the hitch is thought to be extirpated from the Blue Lakes, but still resides in Clear and Thurston Lakes throughout the year. In the spring, reproductive adults migrate into tributary streams to spawn. All of the described waterbodies with the exception of Thurston Lake were hydrologically connected to each other in the past and it appears that Thurston Lake and its tributary, Thurston Creek, have always been isolated from the other waterways (B. Ewing *in litt.* 2020; P. Windrem *in litt.* 2020). Although survey efforts have been conducted within the Clear Lake watershed, most were incidental to survey efforts that had a different purpose or were random documented observations; therefore, we do not have data on past or current population estimates for the hitch.

The Clear Lake hitch needs for its life stages clean minimally contaminated tributary water, maintenance of water flow within tributary stream for survival and to migrate up and down tributaries, riffles with clean, fine to medium gravel substrate, instream or streamside vegetation for cover and prey, emergent vegetation in littoral zone for cover and prey, well oxygenated and

minimally contaminated lake water for adult and juvenile survival, and a food supply to support adults in open water habitat.

THREATS:

We define "threat" as any action or condition that is known to or is reasonably likely to negatively affect individuals of a species. This includes those actions or conditions that have a direct impact on individuals, as well as those that affect individuals through alteration of their habitat or required resources. The mere identification of "threats" is not sufficient to compel a finding that listing is warranted. Describing the negative effects of the action or condition (i.e., "threats") in light of the exposure, timing, and scale at the individual, population, and species levels provides a clear basis upon which to make our determination. In determining whether a species meets the definition of an "endangered species" or a "threatened species," we consider the factors under section 4(a)(1) (16 U.S.C. 1533) and assess the cumulative effect that the threats identified within the factors—as ameliorated or exacerbated by any existing regulatory mechanisms or conservation efforts—will have on the species now and in the foreseeable future.

Habitat Loss, Degradation, and Modification

Beginning in the mid-1800s when Euro-Americans first started to settle in the area, the Clear Lake watershed began to undergo numerous changes. Various forms of past mining activities, agricultural and urban development, increased fire activity, past deforestation, and historical overgrazing practices have all contributed to the degradation of the Clear Lake watershed, causing toxic cyanobacteria blooms and periodic fish kills in the lake. The degradation of tributary streams has changed their hydrology, reducing the amount of water retained in the streams over the Clear Lake hitch's spawning season. This loss of flow earlier in the season and the presence of numerous passage barriers in the tributary streams have greatly reduced reproduction and early life stage survival (egg, larvae). The conversion of wetland habitats surrounding the lake not only negatively impacted Clear Lake's water quality, but it also reduced the amount of rearing habitat for any juvenile hitch that are able to migrate to the lake from their natal stream. This loss of rearing habitat also reduces early life stage survival (juvenile), further reducing the likelihood of recruitment. The degradation of Clear Lake's water quality impacts adult hitch survival, especially when poor lake conditions result in large fish kills.

Tributaries

The reduction in stream spawning fish, including the Clear Lake hitch, seen in Clear Lake during the late 1940s was attributed to the modifications of the lake's tributaries, which the species relies on for spawning and early rearing (Murphy 1951, p. 480). It is estimated that historically, the tributaries to Clear Lake ran until at least September; however, currently only Kelsey Creek is known to retain water into September and most streams are now drying in early summer or late spring (Murphy 1951, p. 480; B. Ewing *in litt.* 2020). A combination of activities have contributed, and are continuing to contribute, to the reduction in tributary flow during the hitch's spawning season. Increased fire activity and legacy effects from instream gravel removal and deforestation have likely increased the rate of runoff within the tributary streams during the winter. Those same factors, possibly in conjunction with both in-creek and groundwater pumping for urban and agricultural uses, have greatly reduced the amount of flow that actually makes it to the lake during the summer (Murphy 1951, p. 480).

Loss of Consistent Tributary Flow

Gravel mining activities in the Clear Lake watershed first began in the latter half of the 19th century and occurred in most of the spawning tributaries to Clear Lake (Suchanek *et al*. 2003, pp. 1253-1254, 10; Thompson *et al*. 2013, p. 19). Gravel mining originally occurred as scattered operations throughout the watershed until the early- to mid-20th century when operations became centralized within the creeks (County of Lake 1992, p. 48; Richerson *et al*. 1994, p. III-19). This period coincides with improved automobile technology and increased pressure to build more reliable roads (County of Lake 1992, p.48). As the human population within the county grew in the 1960s and 70s, new houses and associated roads needed to be constructed to accommodate the new residents. Since the instream gravel was available as a convenient source of material, gravel was extracted from the tributaries and was used as building material for both homes and roads (County of Lake 1992, p. 48; Richerson *et al*. 1994, p. VIII-150). Until the 1981 partial moratorium on instream gravel extraction, approximately 1 million metric tons of instream gravel was extracted from the watershed (Richerson *et al*. 1994, pp. III-19–III-20; CDFW 2014, p. 29). Although the amount of gravel mining within the Clear Lake tributaries has been reduced, mining and extraction are still known to occur in Scotts and Alley Creeks (B. Ewing *in litt.* 2020). In addition, since gravel accumulation within the stream channel can also act as a passage barrier, approximately 5,000 cubic yards of gravel is removed annually from Scotts Creek (Murphy 1948b, p. 106; Richerson *et al*. 2008, p. A260; CDFW 2014, p. 29).

Past gravel mining in tributary streams not only removed spawning substrate that the species uses for reproduction and egg development, but it also lowered streambeds and destabilized channels, causing increased erosion, incision, and channelization. In addition, large swaths of riparian vegetation were removed from along the streams to allow access for gravel extraction, further exacerbating the issues with erosion. The flushing of eroded material not only negatively impacted tributary streams by increasing the amount of suspended sediments and silt within the creek, ultimately increasing turbidity in some streams to zero visibility, but it also negatively impacted the lake ecosystem when those sediments eventually were transported into the lake (see Section 4.1.2) (CDFG 1955, entire; Richerson *et al*. 1994, p. III-19, VIII-2; Suchanek *et al*. 2003, p. 1254; CDFW 2014, pp. 29, 45). Flood control projects in the watershed have also contributed to increased nutrient and sediment transport in the watershed by channelizing and armoring tributary streams with rip-rap and by reclaiming large portions of wetland habitat that once surrounded the lake (CDFW 2014, p. 29). There are almost 14 miles of levee structures that are maintained by the U.S. Army Corps of Engineers (Corps) on Scotts, Middle, Clover, and Alley Creeks (Corps 2012, p. 3).

Fire has always occurred naturally in the Clear Lake watershed; however, with Euro-American settlement in the middle of the 19th century, widespread intentional burning occurred throughout the watershed to clear brush or promote grass growth for livestock grazing (Suchanek *et al*. 2003, pp. 1243–1245, 1246–1247). Numerous fires have occurred in the Clear Lake area in the recent past, with several large 10,000+ acre fires occurring directly in the watershed (Suchanek *et al*. 2003, pp. 1244, 1248, Figure 121.4 and Table 121.2). The 2017 and 2018 fire seasons in California were some of the worst on record and it is likely fire activity will continue to increase within the Clear Lake watershed (CalFire 2019a, entire). The 2018 Mendocino Fire Complex, a portion of which occurred in Lake County, was the largest fire on record in California (CalFire

2019b, entire). Past fire suppression practices within the state of California have reduced the occurrence of fire, but due to the accompanying fuel accumulation, these practices have made fires more devastating when they do occur (Suchanek *et al*. 2003, p. 1247). Fire activity within the watershed results in increased erosion and bank incision, which channelizes the stream. This channelization can decrease the amount of time water is retained within the tributary channel (Murphy 1948b, p. 106; County of Lake 1992, p. 13).

Deforestation within the watershed began in the mid-19th century and was primarily conducted for agricultural uses. Forests were cleared to plant orchards and vineyards, and trees were removed for timber harvest, which was then sold as fuel to nearby mining operations or as lumber. Commercial timber harvest operations continued in the watershed into the middle of the 20th century. Large-scale forest removal within the Clear Lake watershed increased the amount of erosion occurring in the tributary streams, contributing to bank incision within the tributaries and increased sediment and nutrient transport into the lake (Suchanek *et al*. 2003, pp. 1247–1248). Increased erosion and bank cutting further decrease the amount of time water is retained within the tributaries.

Livestock grazing, primarily cattle and sheep, began in the Clear Lake watershed in the mid-1800s and still continues today. Although overgrazing no longer appears to be occurring in the Clear Lake watershed, overgrazing was an issue until the mid-20th century. The number of sheep grazing in the watershed peaked in the 1870s and again in the 1930s, but has declined to a fairly low number since that time (Suchanek *et al*. 2003, p. 1257). Past overgrazing in the watershed has resulted in the loss of stream-side vegetation, which decreased soil stability and increased the rate of runoff within the creeks, effectively reducing the amount of time water is retained within the channel (Murphy 1948b, p. 106; Suchanek *et al*. 2003, p. 1257). Although the amount of grazing pressure has decreased in the watershed, the impacts of past practices are still contributing to the issues seen in the watershed today.

Although a majority of instream gravel removal and all large-scale deforestation no longer occur in the watershed, the rate of runoff within the tributary streams is not likely to decrease into the future unless restoration actions are implemented. Likewise, fire activity will likely continue to increase within the Clear Lake watershed as the incidence of drought increases and intensifies due to climate change. In addition, some of the available literature attributes the early season draw down of the tributaries to water extraction in the upstream reaches of the spawning streams (Suchanek *et al*. 2003, p. 1256).

Water extraction continues throughout the watershed today. Both surface and ground water is being diverted from Clear Lake tributaries for agricultural purposes and domestic use (CDFW 2014, p. 27), with about 60% of the water supply coming from groundwater sources in an average year (County of Lake 2014). These diversions are legal extractions conducted under riparian and water rights associated with land ownership. Surface water is diverted via intake pumps and groundwater is extracted via the installation of shallow wells near the tributary channel where they capture underflow (CDFW 2014, p. 27). In 2013 and 2014, water rights users in Kelsey Creek used 85 and 134.5 million gallons of water, respectively, and 31.4 million gallons in each of those years from Adobe Creek. In addition, from 2008 to 2014, 18 private water wells were permitted for installation along the two creeks. Although this amount of water

withdrawal is legally permissible, it is unknown what effects this amount of water extraction is having on the hydrology of these tributary streams and the Clear Lake hitch (Big Valley 2015, p. 4). A 2016 memorandum from Lake County's Water Resources Department summarized groundwater conditions throughout the Clear Lake watershed for that year. Although the previous three years were considered drought years, the county determined groundwater levels during the spring of 2016 were close to normal. Groundwater levels and their deviation from normal during the spring of 2016 varied throughout the watershed (County of Lake 2016, entire).

Water extractions are often cited as one of the primary reasons for the reduction in the Clear Lake hitch's population; however, although stream gauges are installed in some of the tributary streams, no studies have been conducted on the effects water extraction is having on Clear Lake tributaries or the Clear Lake hitch. The California Department of Fish and Wildlife (CDFW) compared stream flow conditions at the USGS gauge on Kelsey Creek (USGS Station 11449500) and catch data from the early 1990s. Both 1990 and 1991 were considered dry water years with below average tributary flow during the spring; however, the highest number of hitch were captured during seining efforts during those years. Flow conditions improved to average or above average the following three years, but the number of fish captured declined (CDFW 2014, p. 27).

Agricultural production in the Clear Lake area was first initiated during early Euro-American settlement in the mid-1800s. Early crops included apples, almonds, grapes, nectarines, peaches, pears, plums, and prunes, many of which are still grown today (Suchanek et al. 2003, p. 1256; USDA 2019). The conversion of land for vineyard establishment has recently increased. From 1989 to 1999, the acreage of grapes grown in the watershed almost tripled from around 2,500 acres to over 7,000 acres. During the initial establishment period the potential for sediment and nutrients entering the aquatic ecosystem increases, which can result in negative impacts to both the tributary streams and the lake. However, measures can be implemented to reduce this risk (Suchanek et al. 2003, p. 1257).

In 2008 over 8,370 acres of grapes, 2,226 acres of pears, and 2,800 acres of walnuts were grown in Lake County (Lake County undated, p. 3). In comparison, in 2017 over 9,500 acres in Lake County were dedicated to grape production, over 2,000 acres were in pear production, and 3,750 acres were in walnut production (Lake County 2018, pp. 2–4). The acreage of fruit, nut, field, seed, and vegetable crops in Lake County only slightly increased from 2008 to 2017, with just over 107,100 acres in 2008 compared to 108,226 acres in 2017 (Lake County undated, pp. 3, 6, 7; Lake County 2018, pp. 4, 7, 8). Agricultural development is found throughout the watershed; however, it is most concentrated in the southwestern portion of the watershed, primarily near Kelsey and Adobe Creeks (see Figures 4.2a–e; USDA 2019). The presence of agricultural production in the watershed has an impact on the amount water flowing in the tributaries to Clear Lake.

There have been numerous recent efforts to save hitch that become stranded in pools within the tributaries when the tributary streams began to rapidly dry up. In March 2014, 197 individuals were rescued from two pools within Adobe Creek and the surviving fish were released into Kelsey Creek (Ewing 2014a, entire). A few months later in June 2014, over 1,400 hitch were rescued from Cooper Creek and 389 hitch were rescued from Adobe Creek when the flow within

those creeks began to rapidly drop. The surviving individuals from both rescues were released into Rodman Slough and the Konocti Vista Casino boat ramp, respectively (Ewing 2014e, pp. 3, 6). Unfortunately, during visual spawning surveys that same year, approximately 300 adult hitch were found dead in a portion of Adobe Creek that had dried (Ewing 2014c, p. 7).

During the spring of 2018, numerous young of year were stranded in a pool within Cole Creek when the water flow began to rapidly drop during the spring of 2018. The creek no longer had continuous flow into the lake and the small pool the fish were stranded in would have eventually dried, killing all of the 3,100+ young fish. Fortunately, members of Robinson Rancheria and CDFW were able to rescue the fish and transport them for release at Clear Lake State Park.

Regulatory mechanisms and management actions that are or could potentially provide some protection or benefit to tributary streams include: California Environmental Quality Act (CEQA) - any stream altering projects will be required to complete CEQA, which will direct all local and State agencies to avoid or minimize environmental damage, where feasible; US Forest Service (USFS) sensitive species designation – any USFS project within the Clear Lake hitch's range will avoid or minimize impacts to the hitch. The USFS will also have to complete an analysis under the National Environmental Policy Act (NEPA); Lake County's Aggregate Resources Management Plan – completely eliminated instream gravel mining in certain creeks and limits current mining activities to certain areas; Clear Lake Integrated Watershed Management Plan – has documented the historical and current conditions of the watershed (and specific tributary streams) and detail specific implementation actions that will enhance and/or protect the watershed; and the Sustainable Groundwater Management Act (SGMA) – once implemented, will reduce or halt any overdraft from occurring and will bring groundwater basins into balance (i.e., water inputs are in balance with the amount of water extracted from the basin). Reducing overdraft from groundwater pumping in the Big Valley groundwater basin could improve flow conditions in Thompson Creek, Adobe Creek, Kelsey Creek, and Cole Creek. None of the regulatory mechanisms or management actions fully ameliorate habitat loss, degradation, and modification within the watershed, primarily because much of the degradation occurred in the past, although the effects are still occurring today.

The loss of consistent tributary flow during the spawning season is seen throughout the Clear Lake hitch's range. This influence is affecting the hitch at the individual, population, and subspecies level and is likely to continue into the future. The loss of consistent tributary flow has and will continue to reduce population resiliency by reducing reproductive success, early life stage survival, and the likelihood of recruitment. This reduction in resiliency results in a reduction to the hitch's overall representation and redundancy.

Passage Barriers

The lack of adequate tributary flow can act as a barrier to migrating fish, reducing the amount of available spawning habitat and leaving young stranded before they can migrate to the lake. However, even when flow conditions allow for migration, most of the tributaries in the watershed contain physical barriers that prevent hitch passage, reducing the amount of spawning and rearing habitat available. The installation of dams, diversions, roadways, and crossings have had a negative impact on migrating hitch by eliminating access to portions of stream with suitable spawning habitat or impeding passage during certain years until specific flow conditions

(i.e., high flow) are met (Suchanek *et al*. 2003, p. 1254; CDFW 2014, pp. 45, 69–70; see Figure 4.3). Using a variety of data sources, CDFW estimated that over 92% of the historical 180 stream miles of spawning habitat is currently blocked or has reduced access due to the presence of barriers (CDFW 2014, pp. 24-25). In addition, since the presence of a barrier on a spawning stream reduces the amount of available spawning habitat, reproducing adults have to compete for available spawning substrate. Fertilized eggs have been known to accumulate just below a barrier to the point that they will die due to oxygen deprivation (Robinson Rancheria 2015, p. 1).

Numerous dam structures can be found throughout the Clear Lake watershed, including dams on Kelsey, Adobe, Highland Springs, and Manning Creeks. These dams were installed in the mid- to late 20th century and were installed primarily for irrigation and recreation (Suchanek et al. 2003, p. 1248). In addition, during the spring of 2016 CDFW identified potential barriers on Lyon's Creek, Scott's Creek, Seigler Canyon Creek, Clover Creek, and Kelsey Creek (Ewing 2016a, entire). An unusual barrier in the watershed is the diversion of flow from Alley Creek into Clover Creek. This diversion has reduced the probability of hitch accessing that tributary for spawning, although in some circumstances they are still able to use the Clover Creek channel bypass to access Alley Creek. However, sometimes the diversion becomes filled in with sand and silt, in which case it can be a barrier (CDFW 2014, p. 69).

CDFW has begun to address some of the barriers in the spawning tributaries. On Kelsey Creek, there are two fish ladders that were constructed to allow fish passage over the Kelsey Creek Detention Structure. Although local county water resources staff had seen the species use the west ladder, the species did not seem to be using the east ladder. So in late September 2017, CDFW staff reconstructed the fish ladder to allow for hitch passage. The reconstruction included installing holding pools for the fish to rest as they move upstream and breaks in the ladder to help slow the rate of water flow (Ewing 2017c, entire). In addition to the Kelsey Creek fish ladder enhancement, CDFW, in conjunction with the California Department of Transportation (CalTrans) also installed a fish ladder on Cole Creek at the Highway 29 culvert in 2017 to allow for hitch passage. At this location the culvert's foundation was acting as a barrier and the installation of the fish ladder will allow the hitch to move upstream of the culvert in future years (Ewing 2017d, entire).

The presence of passage barriers are seen throughout the Clear Lake hitch's range; however, most physical barriers are concentrated to the west and northwest portions of the watershed. This influence is affecting the hitch at the individual, population, and subspecies level and is likely to continue into the future. The presence of barriers has and will continue to reduce population resiliency by reducing reproduction and early life stage survival. This reduction in resiliency results in a reduction to the hitch's overall representation and redundancy. There are currently no regulatory mechanisms or management actions that fully ameliorate the presence passage barriers.

Juvenile hitch require nearshore habitat containing tules or other emergent vegetation for cover from predators and for their prey base. Starting in the mid-19th century and continuing through the mid-20th century, large tracts of wetland nearshore habitat was converted for agricultural production and urban development (Suchanek *et al*. 2003, pp. 1256, 1257; CDFW 2014, p. 21). However, with the loss of surrounding wetland habitats Clear Lake lost its natural filter. Over

time, increasing amounts of sediment and nutrients from the degraded tributary streams were transported directly into the lake, and nutrient inputs from surrounding urban and agricultural development ended up in the lake. This increase in nutrients and sediments entering Clear Lake degraded its water quality, resulting in increased cyanobacteria blooms and potentially periodic fish kills. Moreover, contaminants from historical mercury mining along the lake's shore and the use of various pesticides in and around the lake have also contributed to the degradation of water quality within the lake.

Wetland/Tule Habitat Loss

Prior to early Euro-American settlement, large wetland/marsh complexes surrounded Clear Lake (CDFW 2014, p. 21). The conversion of these large wetland complexes was largely driven by the desire for agricultural production and urban development (Suchanek *et al*. 2003, pp. 1256, 1257; CDFW 2014, p. 21). Large wetland complexes in the Tule and Robinson Lake areas were reclaimed for agriculture by the late 19th century and within 60 years two other wetland reclamation projects, primarily for agriculture conversion, were completed in the Middle Creek and Rodman Slough areas (Suchanek et al. 2003, p. 1255). The area that is now the town of Clear Lake Oaks was once a large marsh that was described as a "tule bog" (DWR 1975, p. 31). It has been estimated that there were at least 9,000 acres of marsh habitat surrounding the lake prior to early Euro-American settlement in the mid-19th century and by 1977 the amount of marsh had declined to just under 1,500 acres; a loss of almost 85% of Clear Lake's nearshore wetland/tule habitat and the acreage of wetlands has not increased much since the 70's estimate was performed (Week 1982, p. 16; Suchanek et al. 2003, p. 1241). In the Clear Lake hitch SSA, Figure 4.4 shows the concentration of development within the Clear Lake hitch's range and Figure 4.5 shows the remaining wetland habitats surrounding the lake (Service 2020, pp. 36-37).

Most of the agricultural production and urban development that occurs surrounds the lake and the lower reaches of the tributary streams. The population within Lake County has increased from just over 2,200 people in 1850 to approximately 55,000 by 2000. In just a 20-year timeframe, from 1966 to 1986, Lake County's population more than tripled (Suchanek et al. 2003, p. 1239; Thompson et al. 2013, p.18). However, more current census information has seen a -0.4% decrease in the Lake County population in the last 10 years or so, from over 64,660 people in 2010 to almost 64,400 people in 2018 (U.S. Census Bureau website: https://www.census.gov/quickfacts/fact/table/lakecountycalifornia/PST045218). As a secondary consequence of urban development directly abutting the lake, emergent vegetation was removed to install not only lakeside homes, but also various lake structures such as the estimated 600+ docks and boat ramps that line the shore (Week 1982, p. 20; CDFW 2014, p. 37). The installation of these structures removed the nearshore habitat that juvenile hitch require for rearing and protection from predatory fish (CDFW 2014, p. 37).

Guidance for future development within Lake County can be found in the Lake County General Plan, which was developed in 2008 and provides guidance through 2028. The county plans to implement "smart growth" by aiming to direct growth within existing developed areas and by discouraging urban sprawl (Lake County 2008, pp. 3-15–3-18, 3-51–3-55). Limiting future urban growth to already developed areas will reduce or eliminate future habitat loss due to urban development; however, an increased population in the county will likely increase the need for water, which will have different negative effects to the watershed (i.e., decreased tributary flow,

decreased lake water quality).

Regulatory mechanisms and management actions that are currently or could potentially provide some protection or benefit to wetland/tule habitats surrounding Clear Lake include: the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project – if this project is constructed in the future, it could potentially increase the amount of wetland/tule habitat surrounding the lake and improve the condition of currently degraded wetland habitat. Construction of this project would greatly benefit juvenile hitch by providing increased cover from predators and competitors, and increased prey abundance; and the Clear Lake Shoreline Ordinance – this county ordinance has prohibited the destruction of tules on residential properties along the shoreline around Clear Lake and requires full mitigation for any tule habitat that is destroyed. This ordinance benefits the Clear Lake hitch by providing a consistent amount of tule habitat for juveniles. None of the regulatory mechanisms or management actions fully ameliorate wetland habitat loss, primarily because the loss occurred in the past and the county ordinance only maintains the amount of existing tule habitat.

The existing loss of wetland/tule habitat is affecting the hitch at the individual, population, and subspecies level, and is likely to continue into the future. The loss of wetland/tule habitat has reduced the amount of habitat available to juvenile hitch, increasing intra-species competition for available cover and prey items. In addition, the introduction of non-native fish species that also utilize this habitat type further increases competition for the limited available resources. The loss of wetland/tule habitat has and will continue to reduce population resiliency by reducing juvenile survival and the likelihood of recruitment. This reduction in resiliency results in a reduction to the hitch's overall representation and redundancy.

The combination of wetland habitat loss and drought can result in increased predation pressure and competition. Past habitat loss has left only a small proportion of wetland habitat surrounding Clear Lake and drought conditions can reduce the amount of emergent vegetation growth within those remaining wetland habitats. This reduction in emergent vegetative growth reduces the amount of cover the hitch has available to hide from predators, increasing predation pressure. It can also increase competition as more fish concentrate into this limited habitat type.

Cyanobacteria "Blue-Green Algae" Blooms

With the loss of the extensive tule expanses within the lake's nearshore habitat, there has been an increase in the amount of sedimentation and nutrients entering the lake (Prine *et al*. 1975, p. 21). Wetlands act as a filter for sediments and nutrients transported from the tributaries into the lake and the loss of these large wetland complexes directly surrounding the lake has had negative consequences to Clear Lake's water quality (Richerson *et al*. 1994, pp. III-1, V-1, VIII-1; Suchanek *et al*. 2003, p. 1255). One of the issues in Clear Lake are the cyanobacteria "blue-green algae" blooms that periodically occur. Early accounts suggest the algae blooms may have occurred historically, but the increased incidence of these blooms currently are likely indirectly caused by wetland loss (Stone 1876, p. 381; Suchanek *et al*. 2003, p. 1255; Richerson *et al*. 1994).

Blue-green algae blooms are the result of phosphorus input from sewage discharge and erosion. Within the Clear Lake watershed, phosphorus input from sewer discharge is low and the primary

input is from tributary erosion (Richerson *et al*. 1994, pp. III-9, III-11). Phosphorus is found naturally in underlying sediments within the Clear Lake watershed (Richerson *et al*. 1994, p. V-99) and the degradation of tributary streams have exposed those sediments, allowing for transport into the lake during rain events. Furthermore, increased temperatures due to climate change will likely increase the incidence of blue-green algae blooms in Clear Lake (Grantham 2018, pp. 37–38). Blue-green algae blooms can be toxic to fish (Gorham 1960, p. 242; Prine *et al*. 1975, p. 23; Richerson *et al*. 1994, p. III-9); however, it is unknown what impact they have on the Clear Lake hitch. There are currently no regulatory mechanisms or management actions addressing blue-green algae blooms.

Degraded Water Quality

Historical accounts of fish kills were recorded as early as 1873, when large numbers of dead blackfish, perch, and roach were observed in the lake and along the lake's shoreline during the summer (Stone 1876, p. 381). Large fish kills were documented in the Clear Lake Oaks area and within Cache Creek during the late summer of 1932, and again within the lake during the summer of 1933 (Murphy 1951, p. 453). The most recent large fish kill was documented in 2017 (USGS 2018, p. 9). There have been many different theories regarding the source of these fish kills, including over-exertion from spawning, high temperatures, pollutants, algae blooms, disease, low dissolved oxygen, increased alkalinity from volcanic activity in the Clear Lake area, or a combination of heavy algae blooms causing an oxygen depletion (Ingram and Prescott 1954, p. 84; Murphy 1951, p. 448; Cook *et al*. 1966, p. 152). Whatever the ultimate cause, a hypoxic zone frequently develops in the summer at the bottom of the lake (Cook *et al*. 1966, p. 152; Hopkirk 1973, p. 4; Feyrer *et al*. 2019b, p. 6). Lake monitoring during the summer of 2017 and 2018 found both juvenile and adult hitch were abundant in areas where dissolved oxygen levels are suitable (Feyrer *et al*. 2019b, p. 6), so it is likely the hitch actively avoid hypoxic areas. Fish kills have been observed in the absence of algae blooms and these have been attributed to surface water temperature changes (Macedo 1991, p. 5). Due to the wind action that frequently occurs at Clear Lake and the lake's relatively shallow depth, the lake is mixed numerous times throughout the year (Thompson *et al*. 2013, p. 9).

Regulatory mechanisms and management actions that are or could potentially prevent fish kills due to decreased lake water quality include: the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project – if this project is constructed in the future, it will improve degraded water quality by reducing the amount of sediment and nutrients entering Clear Lake, potentially reducing the incidence of large fish kills; and the Aggregate Resources Management Plan – this plan has reduced, and will continue to limit, the amount of instream gravel mining activities being conducted throughout the watershed. Limiting gravel mining has reduced the rate of erosion in the tributary streams and the amount of sediment entering Clear Lake. In addition, Lake County, the California Department of Transportation, USFS, and the Bureau of Land Management have undertaken various actions to prevent or reduce nutrients and contaminants from entering Clear Lake. There are no regulatory mechanisms or management actions that are fully ameliorating lake water quality degradation.

Declines in Clear Lake water quality are affecting the hitch at the individual level, and depending on the extent of the fish kill, it could be affecting the Clear Lake hitch at the population level as well (Clear Lake population). This influence is likely to continue into the future. The impacts of

reduced lake water quality and the occurrence of periodic fish kills reduce both juvenile and adult survival, reducing overall resiliency, representation, and redundancy.

Overutilization for Commercial, Recreational, or Educational Purposes

Commercial fishing operations are not currently occurring on Clear Lake. However, Clear Lake is known for its recreational fishery, with largemouth bass (*Micropterus salmoides*) being the dominate fish species caught. During a Clear Lake angler survey in 1988, centrarchids (sunfish family) dominated the catch with largemouth bass comprising 67% of reported catch, bluegill 15%, and crappie 6% (Macedo 1991, pp. 1, 8, Figure 3). Hitch comprised 2% of the reported catch and all of the hitch caught were in the southern portion of the lake (Macedo 1991, pp. 8, 10, 11, Figures 3–5). Centrarchids also dominated the catch in 1969; however, crappie (56%) and bluegill (23%) were the dominate species caught and no hitch catch was reported (Macedo 1991, p. 8, Figure 3). Because Clear Lake is known for its excellent bass fishing, there are numerous bass fishing contests or tournaments that occur regularly on the lake. Fishing contest permits for Clear Lake must be approved by CDFW and for the period between August 14, 2019, and December 5, 2020, there are currently 66 fishing contests that have been approved and 2 are pending (CDFW 2019). Since the majority of fishing contests and recreational anglers are targeting bass, it is likely only a negligible amount of hitch are incidentally caught (CDFW 2014, pp. 37-38).

Recreational fishing affect the hitch at the individual level and it is likely only a negligible amount of hitch are actually caught. In addition, because the hitch is listed as threated under the California Endangered Species Act (CESA), anglers are prohibited from taking the hitch unless authorized by a permit. Although CESA may not completely ameliorate the loss of individuals due to overutilization for recreational purposes, the loss is considered negligible since any fishing efforts are not targeting the Clear Lake hitch.

Tribal Harvest/Cultural Use

The Clear Lake area is one of the earliest known sites to be occupied by Native Americans, approximately 10,000 years ago (Richerson *et al*. 2008, p. A259). The local Pomo tribes historically relied on the large spawning runs of hitch during the spring for subsistence, drying and storing them to eat throughout the year. The hitch was such an important diet staple that the local tribes went to war over access to the abundant resource (Barrett 1908, p. 14; Kniffen 1939, p. 362, 370; Scotts Valley 2013 *in* CDFW 2014, p. 34). The local tribes collected hitch in the tributary streams by constructing a series of willow-made dams in the creek after the adults completed their upstream migration to spawn. Hitch would collect above the dams as they made their migration back to the lake and the Pomo would capture the hitch using woven baskets (Kniffen 1939, p. 363).

It is unknown how many hitch were historically collected for tribal harvest; however, early tribal accounts suggest the hitch spawned in large numbers (Scotts Valley 2013 *in* CDFW 2014, p. 34). Tribes continued to harvest hitch until the mid-1980s when the spawning runs began to decline (Big Valley Environmental Protection Agency 2013 *in* CDFW 2014, p. 26). State regulations allowed capture of hitch on tributary streams by hand or dip-net until the species was designated a candidate for state listing under CESA (CDFW 2014, p. 26). Prior to the state listing of the hitch and while it was still considered a candidate for listing, CDFW issued a Memoranda of

Understanding to three tribes for collection of hitch for scientific and educational purposes (Kratville, D. pers. comm., October 7, 2013, unreferenced *in* CDFW 2014, p. 26). Because large spawning runs continued to be maintained annually, historical harvest for tribal subsistence did not appear to have a substantial population-level effect on the species. Because tribes no longer harvest large quantities of hitch from their limited spawning runs, tribal harvest only affects the hitch at an individual level. There are currently no regulatory mechanisms or management actions that fully ameliorate individual loss due to tribal harvest; however, tribal harvest of hitch is currently covered under a Memorandum of Understanding (MOU) and any future tribal harvest or take will continue to require authorization from CDFW since the hitch is listed as threated under CESA.

Disease

Outbreaks of koi herpes virus and fish fungi (*Saprolegnia* spp.) have been documented in various fish species found in Clear Lake, but these diseases do not appear to negatively impact the Clear Lake hitch. Parasites, such as anchor worms (*Lernaea* spp.), do infect the Clear Lake hitch and there have been numerous documented observations of individuals with attached anchor worm parasites or of individuals containing lesions, which are evidence of previous anchor worm attachment (Big Valley 2015, p. 3). Anchor worms are a parasitic crustacean (copepod) that infect freshwater fish (Steckler and Yanong 2012, p. 1). Although a low level anchor worm infection may not necessarily cause adverse symptoms to the fish other than being irritating, a heavy infection of anchor worms can cause inflammation at the attachment site that can later become infected by a bacteria or fungus, which can eventually result in death. Fish can also die if a large number of anchor worms attach to the gills. Fish that are chronically infected with anchor worms will have lower fitness (Steckler and Yanong 2012, p. 2). Heavy anchor worm infections have not been reported for Clear Lake hitch (CDFW 2014, p. 36).

In addition to anchor worm infections, there have been three instances of Clear Lake hitch having facial deformities often referred to as “pug nose.” Two were captured by the United States Geological Survey (USGS) while conducting monitoring surveys in the lake and one was captured by a local tribal member during a fish rescue on one of the tributary creeks. The two individuals caught during the lake monitoring studies were both under-weight compared to other hitch their length and one of them in particular looked unhealthy (Feyrer 2018; Clear Lake Hitch Conservation Strategy Meeting Notes 2019, p. 2). This deformity has been seen in other fish species, but it is unknown what causes it and what effect, if any, it has on the individual (Franks 1995, entire; Schmitt and Orth 2015, entire). However, because it is a deformity of the mouth area, it likely reduces feeding efficiency and results in an overall lower fitness for those individual fish.

The effects of parasites and deformities will continue to act on the hitch into the future. There are no accounts of disease, parasites, or deformities causing mass mortality or extreme detrimental effects to the hitch, and therefore, this influence only affects the hitch at an individual level. There are no regulatory mechanisms or management actions that address parasites and/or deformities.

Predation and Competition

Twenty-five different species of non-native fish have been introduced into Clear Lake for

recreational or biological control purposes, and although not all of them have become established, about 20 species are still found in the lake today (Thompson *et al*. 2013, pp. 12–17, Table 1). Even early accounts in the late 1800s document the presence of non-native fish in Clear Lake. The first recorded introduction is from 1873 when Livingston Stone introduced lake whitefish (Coregonus clupeaformis) into Clear Lake; however, this attempt proved to be unsuccessful (Stone 1876, p. 377–378; Murphy 1951, p. 450). The introduction of carp is believed to be accidental when a resident of the Clear Lake area installed a carp pond in 1880 on the north shore of the lake. When the pond flooded the next winter, some of the carp were able to reach Clear Lake and become established (Murphy 1951, p. 449). White catfish (Ameiurus catus) and brown bullhead (Ameiurus nebulosus) were also introduced around 1880, although the specifics regarding their introduction are unknown (Murphy 1951, p. 450). Northern largemouth bass (M. s. salmoides) were first stocked in Clear Lake for a recreational fishing in 1888, and by 1910 the lake was known for its excellent bass fishing (Murphy 1951, p. 450, 451, 452, Table 6). By 1894, the brown bullhead, white catfish, carp, and largemouth bass were documented as inhabiting Clear Lake (Jordan and Gilbert 1895, p. 140). Smallmouth bass were introduced in 1895 and although considered unsuccessful, they have been documented in the lake since (Murphy 1951, p. 451; Thompson et al. 2013, p. 16). The California Fish Commission introduced golden shiners (Notemigonus crysoleucas) into Clear Lake in 1896 as forage for planted sport fish, and the bluegill, black crappie, and possibly the green sunfish were all introduced between 1909 and 1910, likely for recreational fishing (Murphy 1951, p. 450; Dill and Cordone 1997, p. 53; Thompson et al. 2013, p. 17). The initial introduction of golden shiners proved to be unsuccessful and subsequent plantings were documented as successful (Thompson et al. 2013, p. 15, Table 1). However, few golden shiners have been seen in more recent electrofishing surveys (B. Ewing in litt. 2020).

Western mosquitofish were introduced to the lake in 1925 to help control the gnat and mosquito populations (Murphy 1951, p. 451; Thompson et al. 2013, p. 17). The fathead minnow and redear sunfish were introduced in the 1950s as a forage fish and sport fish, respectively (Cook et al. 1966, p. 156; Dill and Cordone 1997, p. 56; Thompson et al. 2013, p. 16, Table 1). The local vector control district introduced the Mississippi silverside (Menidia audens) to Clear Lake and the Blue Lakes in 1967 to help control outbreaks of the Clear Lake gnat population (Geary 1978, pp. 1; Cook and Moore 1970, p. 70; Prine et al. 1975, p. 26, 28). By 1969, the Mississippi silverside was considered established within Clear Lake and Lower Blue Lake, but not within Upper Blue Lake (Cook and Moore 1970, p. 72). The California Department of Fish and Wildlife introduced Florida largemouth bass (M. s. floridanus) into Clear Lake in 1969, 1970, and 1971 under the assumption that this subspecies would grow larger than the northern subspecies, thereby improving the bass fishery (Moyle and Holzhauser 1978, p. 574). Threadfin shad were illegally introduced into Clear Lake in the 1980s to provide forage for sport fish (Bairrington 2000, p. 23). During the 2017 lake monitoring surveys conducted by USGS, threadfin shad comprised the largest proportion of catch (USGS 2018, p. 12). It is unknown when pumpkinseed were introduced and white crappie were likely introduced during the early 1900s (Bairrington 2000, p. 12; Thompson et al. 2013, p. 16, Table 1). Pumpkin seed may no longer be established in Clear Lake (B. Ewing in litt 2020)

The introduction of the many non-native fish to Clear Lake have had effects on the native fish fauna and the habitat found in Clear Lake. All of the native fish populations within Clear Lake

have undergone declines and at least three species that historically occurred in the lake (Pacific lamprey, thicktail chub, and Clear Lake splittail) are now considered extirpated (Thompson *et al*. 2013, p. 12). Thompson *et al*. (2013) also includes hardhead as a species that historically occurred in the lake and is now considered extirpated; however, it is unclear whether hardhead ever actually occurred in Clear Lake or were actually misidentified Sacramento pikeminnow (*Ptychocheilus grandis*) or Sacramento blackfish (Thompson *et al*. 2013, pp. 10, 12, 29; P. Moyle *in litt.* 2020). Although the loss of these species can most likely be attributed to habitat modifications throughout the watershed or a combination of different factors, the introduction of non-native fish species led to the extirpation of the Sacramento perch population within Clear Lake (Murphy 1948a, pp. 99, 100; Murphy 1951, p. 475; Cook *et al*. 1966, pp. 155, 157–158; Thompson *et al*. 2013, p. 38; CDFW 2014, p. 34; P. Moyle *in litt.* 2020).

All of the piscivorous fish species in Clear Lake are potential predators of Clear Lake hitch and there have been accounts of hitch in the digestive tracts of both largemouth bass and channel catfish (Macedo 1994, p. 5; Moyle *et al.* 1995, pp. 154 –155; Moyle *et al.* 2014, p. 10). Anecdotal reports suggest Clear Lake hitch are a main prey-item for largemouth bass. Observations of bass chasing hitch have been published on a well-known online fishing website (Bassmaster), bass anglers are known to use lures that look like the Clear Lake hitch, and when reeling-in their fishing line, anglers are known to mimic hitch movements to specifically target largemouth bass in the lake (Macedo 1994, p. 5; Shangle 2010, p. 5; P. Windrem *in litt.* 2020; T. Smythe *in litt.* 2020). A local fishing guide has stated the gut contents of trophy size bass caught in Clear Lake almost always include hitch and the record sized bass caught in Clear Lake (17.52 lbs.) had a large hitch in its digestive tract (Knight 2009, p. 2; P. Windrem *in litt.* 2020; T. Smythe *in litt.* 2020). In addition, bass anglers are known to position themselves at the mouths of streams during the spawning season to take advantage of congregating bass that feed on the schooling hitch prior to their upstream migration (T. Smythe *in litt.* 2020).

In conjunction with a recent assessment of the Clear Lake fishery, a proportion of the black bass and catfish species that were captured had their gut contents analyzed to determine what fish species they were consuming in the lake (Ewing *et al*. 2016, p. 4). Surveys were conducted by electro-fishing the shoreline of the lake and the largemouth bass was the most common species collected (Ewing *et al*. 2016, pp. 50–51). Gut analysis revealed inland silversides were the most commonly identified fish species eaten by largemouth bass; however, the largest proportion of items removed from the gut were unidentifiable fish or fish parts (Ewing *et al*. 2016, p. 52). The main gut contents in the channel catfish stomachs analyzed were aquatic invertebrates and the most common fish species were inland silversides (Ewing *et al*. 2016, p. 53). No hitch were identified in any of the gut contents analyzed; however, it is possible the unidentifiable fish parts were from hitch (Ewing *et al*. 2016, pp. 52–53).

In addition to preying on hitch when they grow to larger sizes, smaller largemouth bass are also known to feed on insects and zooplankton, directly competing with both juvenile and adult hitch for food resources (Moyle and Holzhauser 1978, pp. 577–578, 581). Threadfin shad and silversides are also known to compete with the hitch since they also depend on the same aquatic prey base (Anderson *et al*. 1986, entire; Bairrington 2000, p. 33; CDFW 2014, p. 35). During years when silverside or shad abundance is especially high, they could deplete prey resources that the hitch depends on. A comparison of hitch trend data and abundances of silversides and

threadfin shad suggests there may be a correlation between their abundances (CDFW 2014, p. 35); however, more detailed studies need to be completed. Silversides are also known to prey on larval fish, so it is likely some predation of hitch larvae by silversides is occurring in Clear Lake (Bennett and Moyle 1996, pp. 526, 529; Moyle *et al*. 2014, p. 9-10).

Besides the numerous piscivorous fish species that occur within Clear Lake, the Clear Lake hitch is also susceptible to predation from various bird and mammal species, especially during spawning migrations when they are more exposed. These species may include, but are not limited to, common merganser (*Mergus merganser*), hooded merganser (*Lophodytes cucullatus*), red-breasted merganser (*Mergus serrator*), pied-billed grebe (*Podilymbus podiceps*), horned grebe (*Podiceps auritus*), eared grebe (*Podiceps nigricollis*), western grebe (*Aechmophorus occidentalis*), Clark's grebe (*Aechmophorus clarkii*), white pelican (*Pelecanus erythrorhynchos*), double-crested cormorant (*Phalacrocorax auritus*), great blue heron (*Ardea herodias*), great egret (*Ardea alba*), snowy egret (*Egretta thula*), green heron (*Butorides virescens*), black-crowned night-heron (*Nycticorax*), osprey (*Pandion haliaetus*), bald eagle (*Haliaeetus leucocephalus*), river otter (*Lontra canadensis*), raccoon (*Procyon lotor*), striped skunk (*Mephitis*) and possibly black bear (*Ursus americanus*) (R. Macedo and S. Hill, pers. comm. 2009 *in* Moyle *et al*. 2014, p. 3; CDFW 2014, p. 9; Big Valley 2015, p. 6; eBird 2019).

Predation and competition will continue to affect the Clear Lake hitch at the individual, population, and subspecies level into the future throughout its range. Predation and competition pressure within Clear Lake impacts the hitch by reducing survival and recruitment, which reduces resiliency by decreasing the size of the overall population. Predation pressure within the tributaries to Clear Lake impacts the hitch by reducing survival, reproduction, and recruitment, which further reduces resiliency by decreasing the size of the spawning population in any given year and by reducing the overall population altogether. This loss of resiliency reduces the hitch's overall representation and redundancy since it results in fewer individuals spawning in each of the tributary streams and natal habitat types. There are currently no regulatory mechanisms that address predation or competition.

The combination of wetland habitat loss and drought can result in increased predation pressure and competition. Past habitat loss have left only a small proportion of wetland habitat surrounding Clear Lake and drought conditions can reduce the amount of emergent vegetation growth within those remaining wetland habitats. This reduction in emergent vegetative growth reduces the amount of cover the hitch uses to hide from predators, increasing predation pressure. It can also increase competition as more fish concentrate into this limited habitat type.

Drought

Drought conditions within the Clear Lake watershed can have detrimental effects on the Clear Lake hitch by reducing the amount of flow within the tributary streams over the spawning season, reducing water quality in the lake, and possibly reducing emergent vegetation growth in the lake. Murphy (1948b) describes the almost complete lack of spawning runs in 1946 and 1947 due to the lack of water flow in the tributaries (Murphy 1948b, p. 105). However, the hitch's ability to spawn along the lake shore provides an alternative to tributary spawning for at least a small proportion of the population. In addition, the hitch's long lifespan is likely an adaptation to natural drought conditions in California, which can last for years.

Annual average air temperatures in California have increased by 1.5°F since the beginning of the 20th century (Bales 2013, p. 2). This coincides with increased aridity or drought conditions recorded within California since the early 1900s (Cook *et al*. 2004, p. 1016). This increase in aridity can impact the Clear Lake hitch by reducing the amount of time water is retained within the tributary streams and wetland habitats, which the hitch requires for spawning and rearing. Increases in aridity also reduce wetland/emergent vegetation growth, which the hitch requires for rearing and for cover from predators. All of these factors can impact the reproductive success and recruitment of the hitch and could potentially reduce survival if flows drop too drastically in the tributary streams and/or within their wetland habitats, or if they are subject to increased predation due to a reduction in cover.

The reduction of flow in the tributary streams during the spawning season can completely eliminate or greatly reduce the likelihood for successful reproduction and/or recruitment, and due to the Clear Lake hitch's very narrow range, the effects of drought will impact the entire subspecies. The ability to spawn along the shore provides for some redundancy within each population, but it is unknown whether shore spawning would be able to support a viable population over the long-term. Having a longer life span is likely an adaptation to variable environmental conditions; however, prolonged droughts can have devastating effects on the overall population, especially in conjunction with other factors that are currently acting on the hitch. There are currently no regulatory mechanisms that address drought.

The Clear Lake hitch evolved in Lake County, California, which has always had a highly variable climate with natural periodic droughts. However, the degradation and loss of water retention within their spawning streams and the loss of large stretches of suitable spawning habitat due to various instream barriers has likely reduced reproductive success and recruitment. During drought conditions this can completely or almost completely eliminate all stream based spawning in a given year. If drought conditions persist over multiple years, stream based reproduction can also be reduced or eliminated for multiple years. Furthermore, climate change projections suggest the Clear Lake area will see more varied precipitation and higher temperatures during the spring, which could result in even less water flow being retained within the tributary streams during the hitch's spawning season (Pierce *et al*. 2013, pp. 842, 844, 848–850, Figure 1). Although the hitch has the ability to spawn within the lake, it is unknown whether that method of reproduction would be able to sustain a viable population of hitch in Clear Lake.

Pesticides and Other Contaminants

A variety of pesticides have been applied to the lake in order to control insect or plant outbreaks and numerous contaminants have entered the watershed, primarily due to mining activity, but also from other anthropogenic uses. Clear Lake has been listed as an impaired water waterbody by the California State Water Resources Control Board (SWRCB) under Section 303(d) of the California Clean Water Act, due to both mercury contamination and increased nutrient input from sedimentation (SWRCB 2012; SWRCB 2019).

Pesticides

Previously, Clear Lake gnat outbreaks occurred regularly in Clear Lake and were considered a nuisance to residents near the lake. In order to control these outbreaks, the county applied

various pesticides to the lake to control the gnat at different life stages. Over 120,000 lbs. of the larvicide DDD (dichloro-diphenyl-dichloroethane) was applied to the lake on three different occasions in 1949, 1954, and 1957, and its biological accumulation up the food chain resulted in elevated concentrations of DDD in fish tissues and the mortality of numerous western grebes (*Aechmophorus occidentalis*) within the lake (Goldman and Wetzel 1963, pp. 284–285; Cairns and Parfitt 1980, p. 504; Suchanek *et al*. 2003, pp. 1249–1250). Although the highest levels of DDD concentrations were seen in piscivorous fish species, fish species at lower trophic levels like the Clear Lake hitch also had concentrations of the larvicide in their tissues (Cook 1965, pp. 44, 46). Conversely, later analysis of the lake bottom revealed concentrations of 0.05 to 1.0 ppm (parts per million) within the first 5 inches of sediment; some researchers indicated that bottom feeding fish species would be most impacted by their greater exposure to high levels of DDD. This was further supported by the high levels of DDD or its metabolic products found in carp tissues decades after the larvicide applications (Cairns and Parfitt 1980, pp. 504, 509). Even after almost 20 years post-application, concentrations of DDD or its metabolic breakdown products continued to be seen in various fish species tissues, including the hitch (Cairns and Parfitt 1980, pp. 505–506). It is possible that agricultural pesticide application, specifically the use of DDT, which can break down to produce DDD, has contributed to the elevated levels seen in fish tissue years after the final application of the larvicide to the lake (Cook 1965, p. 44; Cairns and Parfitt 1980, p. 504).

The application of DDD not only had a direct impact on the hitch through contamination, but it also likely impacted the hitch by targeting, and greatly reducing, one of their main prey items. An estimation of the gnat population in Clear Lake and other nearby lakes after DDD application revealed the gnat population was 99-100% eliminated, although the effectiveness of subsequent DDD applications to Clear Lake declined (Lindquist and Roth 1949, pp. 5, 10, 13; Hunt and Bischoff 1960 *in* Suchanek *et al*. 2003, p. 1249). The application of DDD not only eliminated or greatly reduced gnat populations; it was also known to reduce another prey item of juvenile Clear Lake hitch, chironomid larvae. However, chironomid larvae populations were able to recover faster than gnat populations post-DDD treatment (Lindquist and Roth 1949, p. 13). Due to the rebounding gnat population in Clear Lake after treatment with DDD and because subsequent DDD applications were losing effectiveness, other pesticides such as malathion and Methyl parathion were used to target the gnat population (Cook 1965, p. 44; Suchanek *et al*. 2003, p. 1250).

In addition to the insecticides used to control the Clear Lake gnat population, the aquatic herbicides Komeen™ (copper sulfate) and SONAR™ (fluridone) have also been applied in the lake to control *Hydrilla verticillata*, a highly invasive submerged aquatic weed (Suchanek *et al*. 2003, p. 1250, 31; CDFW 2014, p. 32). Two herbicides were used to target different parts of the plant, Komeen targets Hydrilla vegetative growth while SONAR treats the tubers (Suchanek et al. 2003, p. 1250). Komeen is not known to directly kill fish; however, it is known to affect various aquatic invertebrates within the treatment areas and, therefore, may indirectly impact fish, including the hitch through a reduction in prey base (Bairrington 2000, p. 63). SONAR is considered less toxic than Komeen, but because it is a systemic herbicide that is slowly absorbed in the vascular system, it also impacts similar non-target vegetation such as tules and other submerged vegetation (Bairrington 2000, pp. 64–65; CDFW 2014, p. 32). Because juvenile Clear Lake hitch require tule habitat for cover, the use of Komeen can indirectly impact the hitch

(CDFW 2014, p. 32).

Other pesticides are also used throughout the watershed on private homeowner and agricultural lands. Pesticide use on private land does not legally have to be reported, so it is unknown what chemicals are being applied and in what amounts (Suchanek *et al*. 2003, pp. 1250–1251). The reported application of pesticides on agricultural lands has increased from 2008 to 2017. In 2008, over 589,500 lbs. of different forms of chemicals used as pesticides were applied in Lake County (CALPIP 2019). In 2017, the poundage increased to almost 759,000 lbs. (CALPIP 2019). However, it is unknown what effect terrestrial pesticides are having on the aquatic environment or if they are being transported through tributary streams into the lake (Suchanek *et al*. 2003, p. 1252). Furthermore, it is unknown what effect they could be having on the Clear Lake hitch.

Mercury

In addition to the gravel mining operations throughout the watershed, there were some small-scale commercial mining operations in 1864 and 1865 in the Clear Lake area that mined both borax and sulfur (Suchanek *et al*. 2003, p. 1253). Large-scale commercial sulfur extraction along the eastern shore of Clear Lake began in 1865 when the Sulphur Bank Mercury Mine was established. The sulfur mining operation switched over to mercury mining in 1873 after mercury sulfide deposits were found beneath their sulfur source. Early extraction methods were not as destructive; however, in 1927 the mine began to implement open-pit mining at a large-scale level and would bulldoze any waste products into the lake itself (Richerson *et al*. 2008, p. A259). The company continued to mine sporadically throughout the 1950s until the Sulphur Bank Mercury Mine was officially closed in 1957, although waste continued to contaminate the lake well into the 1990s (Suchanek *et al*. 2008, p. A153).

Sediment cores taken throughout Clear Lake provided some insight into when and why mercury concentration began to increase within the lake. Sedimentation rates began to increase from about 1 mm/year to an average of 8.6 mm/year beginning in 1927 (Richerson *et al*. 2008, p. A257). Calculated sedimentation rates were 13.3–20.4 mm/year from 1927 to 1954, and then decreased to 2.2–4.3 mm/year from 1954 to 2000 (Richerson *et al*. 2008, pp. A267–269). In addition to increased levels of sedimentation post-1927, there was also a significant increase in the concentration of mercury, methylmercury, dry matter, phosphorus, and an isotope of nitrogen (^{15}N) found within the sediment horizon after 1927, and the concentrations of nitrogen, sulfur, carbon, and water content decrease within the post-1927 horizon. The dramatic changes in the sediment cores seen post-1927 were likely from the implementation of open-pit mining using heavy equipment to extract ore deposits (Richerson *et al*. 2008, pp. A257, A268–270). The highest concentrations of mercury were found in the Oaks Arm of the lake, which is where the Sulphur Bank Mercury Mine is located; however, elevated mercury levels were also found lake-wide (Richerson *et al*. 2008, p. A271). The use of heavy ground moving equipment associated with the open-pit mining also likely contributed to the algal blooms seen in the lake by excavating and disturbing large swaths of sediments, which increased nutrient runoff (Richerson *et al*. 2008, p. A260).

Mercury and other mining-associated contaminants have entered the lake via erosion of waste piles, purposeful dumping/bulldozing of mine waste, atmospheric deposition, and subsurface drainage (Richerson *et al*. 2008, p. A275). Since 1992, the EPA has implemented numerous

remediation projects to address the continued mercury contamination originating from the Sulphur Bank Mercury Mine. The remediation projects include the removal of waste rock piles that continued to erode and discharge mercury, removal of contaminated soil from residential areas, installation of diversions to prevent contaminated water and sediments from entering Clear Lake, closure of three abandoned geo-thermal wells, the capping of mine waste used to build an old road, and the installation of two test sediment covers to contain mercury contaminated sediment within Clear Lake (Richerson *et al*. 2008, pp. A265, A275; EPA 2019).

The Sulphur Bank Mercury Mine became an EPA Superfund Site in 1990 due to the elevated mercury levels found in Clear Lake's larger piscivorous fish (Curtis 1977, p. 1; Suchanek *et al*. 2003, p. 1253; Thompson *et al*. 2013, p. 19). Elevated levels of mercury in fish can significantly impair reproductive success; however, effects can vary based on a multitude of factors, including species and life stage, and there are no specific studies for Clear Lake hitch (Crump and Trudeau 2008, pp. 902, 904; CDFW 2014, p. 32–33). Mercury concentrations found in hitch caught in Clear Lake from the 1980s and 1990s averaged 0.19 mg/kg, while the larger piscivorous fish such as adult largemouth bass averaged .54 mg/kg (CEPA 2002, pp. *ii*, 9; CDFW 2014, p. 33). The Regional Water Quality Control Board, Central Valley Region, proposed a target of 0.13 mg/kg for fish in trophic level 3, which includes the Clear Lake hitch (CEPA 2002, p. *ii*). Consumption advisories for fish removed from Clear Lake were first issued in the 1980s and the California Office of Environmental Health Hazard Assessment continues to provide advisories for Clear Lake fish and invertebrates (Thompson *et al*. 2013, p. 19; OEHHA 2018).

Regulatory mechanisms and management actions that are or could potentially prevent effects to the Clear Lake hitch due to pesticide and mercury contamination in Clear Lake include the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project, which if constructed in the future will improve degraded water quality by filtering some of the contaminants that enter Clear Lake from the tributary streams. In addition, Lake County, the California Department of Transportation, USFS, and the Bureau of Land Management have undertaken various actions to prevent or reduce and contaminants from entering Clear Lake. There are currently no regulatory mechanisms or management actions that are fully ameliorating habitat degradation due to contamination from pesticides or other sources.

The effects of mercury contamination, and possibly pesticide use, will continue to act on the hitch into the future; however, it is unknown what effects pesticide and mercury contamination are having on the Clear Lake hitch and there are no accounts of either causing mass mortality or extreme detrimental effects to the subspecies.

Climate Change

The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements (IPCC 2013a, p. 1450). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, whether the change is due to natural variability or human activity (IPCC 2013a, p. 1450).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has been faster since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (for these and other examples, see Solomon *et al*. 2007, pp. 35–54, 82–85; IPCC 2013b, pp. 3–29; IPCC 2014, pp. 1–32). Results of scientific analyses presented by IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate, and is "very likely" (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (Solomon *et al*. 2007, pp. 21–35; IPCC 2013b, pp. 11–12 and Figures SPM.4 and SPM.5).

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of greenhouse gas emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (e.g., Meehl *et al*. 2007, entire; Ganguly *et al*. 2009, pp. 11555, 15558; Prinn *et al*. 2011, pp. 527, 529). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increased global warming through the end of this century, even for the projections based on scenarios that assume that greenhouse gas emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of greenhouse gas emissions (Meehl *et al*. 2007, pp. 760–764 and 797–811; Ganguly *et al*. 2009, pp. 15555–15558; Prinn *et al*. 2011, pp. 527, 529; IPCC 2013b, pp. 19–23). See IPCC 2013b (entire), for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation.

Global climate projections are informative, and, in some cases, the only scientific information available for us to use. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (IPCC 2013b, pp. 15–16). Therefore, we use "down-scaled" projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used in the analyses of a given species (see Glick *et al*. 2011, pp. 58–61, for a discussion of downscaling).

Hayhoe *et al*. (2004) produced down-scaled climate change models for California using climate data from the period from 1961–1990 to predict future temperatures and precipitation for the period 2070–2099. They used two different climate models to run two scenarios, one which assumed that greenhouse gas concentrations would increase substantially (SRES A1Fi), and one which assumed that concentrations would stabilize by the end of the century (SRES B1). Their projections indicate an increase in both winter and summer temperatures along the northern portion of the state, although the temperature increase is more pronounced to the east (Hayhoe *et al*. 2004, pp. 12423–12424, Figure 1). Three of their projections also indicate a decrease in winter precipitation concentrated along the north coast, although one projected a small increase

in precipitation by 2099 (Hayhoe *et al*. 2004, pp. 12424–12425, Supplemental Figure 11).

Pierce *et al*. (2013) used different methods to produce down-scaled climate change models for California, using climate data from the period of 1985 to 1994, and predicted future temperature and precipitation changes for the future period of 2060 to 2069. The models were run under one emissions scenario (SRES A2) and the results suggest that by the 2060s, average temperatures within the range of the Clear Lake hitch could increase 2.2°C, with average spring temperatures rising about 1.9°C and average summer temperatures rising 2.9°C (Pierce *et al*. 2013, pp. 841, 842, 844, Figure 1). The average annual change in precipitation within the range of the hitch is projected to be zero; however, there are projected seasonal changes with wetter conditions in the winter and drier conditions throughout the rest of the year (Pierce *et al*. 2013, pp. 848–850). Precipitation projections also suggest there will be increased chances of flooding due to an increase in the 3-day maximum precipitation rate, especially in the northern portion of the state within the range of the Clear Lake hitch. It should be recognized that under all of the model projections, the projected seasonal changes are relatively small when compared to the state's natural variability (Pierce *et al*. 2013, p. 855).

Downscaled climate projections were also completed for several regions throughout California for California's Fourth Climate Change Assessment, including the North Coast Region where Lake County is located (Grantham 2018, entire). Ten global climate models were used for the regional assessments and each model considered two different emissions scenarios, one in which greenhouse gas emissions continue to increase into the next century (RCP 8.5, similar to SRES A2) and one in which greenhouse gas emissions stabilize by mid-century and then decline to levels seen in the 1990s by the end of the century (RCP 4.5) (Grantham 2018, p. 15). Under both emissions scenarios, annually averaged maximum temperatures in Lake County are expected to increase. Under RCP 8.5, annually averaged maximum temperatures are projected to increase by almost 3°C (4-5°F) by mid-century (period between 2040 and 2069) and about 4°C (7-8°F) by the end of the century (period between 2070 and 2099). Under emissions scenario RCP 4.5, annually averaged maximum temperatures are projected to increase by about 2°C (3-4°F) by mid-century and 3°C (4-5°F) by the end of the century (Grantham 2018, pp. 17–18, Figure 2.4).

In addition to temperature projections, the downscaled models for California's Fourth Climate Change Assessment also assessed future changes in precipitation, both the amount and the timing. The precipitation changes projected by the models were much more complex than the predicted temperature changes, mostly because the predicted changes are within the range of historical variation (Pierce *et al*. 2018, p. 20; Grantham 2018, p. 19). There is also less difference between the two different emissions scenarios than was seen for the temperature predictions (Pierce *et al*. 2018, p. 20). The downscaled models for the North Coast Region predict the amount of annual precipitation within that area is within the range of historical variation, although with a slightly increasing trend. Within Lake County in particular, annual precipitation projections under both emissions scenarios show a similar, 4-8% increase in annual precipitation by mid-century. However, late century projections suggest a 6-10% increase in annual precipitation for RCP 4.5, while RCP 8.5 suggests an increase of 10-16% (Grantham 2018, p. 19, Figure 2.7).

This increase in precipitation will mostly occur during the winter months, with either no change

or a decrease in precipitation during the spring (Pierce *et al*. 2018, pp. 23–24, Figures 13 and 14). Specifically, under RCP 4.5 the average precipitation change is projected to increase 8-16% during the winter during both the mid-century and late century time periods, but is projected to decrease 4-8% during the spring over the mid-century time period. Under RCP 4.5, there is a 0-4% predicted change in precipitation during the spring months for the late century time period. Under RCP 8.5, winter precipitation is projected to increase 8-12% during the mid-century time period and 20% or more into the late century. Spring precipitation under RCP 8.5 is projected to increase 0-4% mid-century and decrease 0-4% late century (Pierce *et al*. 2018, pp. 22-24). In general, the winter months (December–February) are projected to be wetter and the spring months (March–May) are projected to be drier. The increase in precipitation in the winter is also likely to be compressed into a shorter wet season in the winter, which will result in earlier drying in the spring (Grantham 2018, pp. 6, 19–20). Likewise, streamflow will likely increase during the wet season but decrease in the dry season, with the greatest increase in flow during the month of January and the greatest decrease in flow during the month of May (Grantham 2018, p. 23). In addition, the number of drought years are projected to increase under both scenarios, but under RCP 8.5 it almost triples into the end of the century (Pierce *et al*. 2018, pp. 27–28).

Because the Clear Lake hitch has such a narrow geographic range, any changes in climate will likely be uniform across the range. Projected climate change effects are likely to impact the amount of water retained within tributary streams and wetland habitats, potentially reducing reproduction and recruitment by eliminating or greatly reducing spawning within certain tributary streams and reducing the amount of rearing habitat available. In addition, these effects may also impact the growth of riparian and emergent vegetation, further reducing reproductive success and recruitment, and potentially increasing predation pressure during early life stages. Although the increase in precipitation during the winter will increase tributary inundation, the degraded tributary streams are unlikely to retain the extra flow into the spring when it would benefit spawning runs. In addition, the increase in winter flows may exacerbate the transport of sediments and nutrients into Clear Lake. The ability to spawn in the lake provides an alternative to stream reproduction during the spawning season, but it is unknown whether this reproductive strategy can maintain a viable population of hitch in Clear Lake over the long-term. Having a longer life span is likely an adaptation to variable environmental conditions within the Clear Lake area; however, prolonged drought conditions can greatly impact the overall population, especially in conjunction with other factors that are currently acting on the hitch. Moyle *et al*. (2013) conducted an assessment to determine the Clear Lake hitch's vulnerability to the effects of climate change. They determined that the hitch was "critically vulnerable" to the effects of climate change (specifically, the change in spring hydrograph) and that the hitch "…is extremely likely to be driven to extinction by year 2100 without conservation measures (Moyle *et al*. 2013, pp. 3, 7, Table S1)."

Regulatory mechanisms and management actions that are or could potentially provide some protection from the effects of climate change include the Clean Air Act and the California Global Warming Solutions Act. Both address climate change by reducing greenhouse gas emissions within the United States and California, respectively. There are no regulatory mechanisms or management actions that fully address the effects of the climate change. For more information on the Clean Air Act and the California Global Warming Solutions Act, see Regulatory Mechanisms and Management Actions below.

The effects of climate change will continue to impact the Clear Lake hitch at the individual, population, and subspecies level into the future by exacerbating the negative influencing factors described above, especially drought. The loss and/or reduction of suitable spawning streams throughout the hitch's range and the declining quality of riparian and rearing habitat will likely reduce reproductive success, recruitment, and survival. The reduction in tributary streams available to the hitch for spawning will further decrease its overall representation and redundancy.

Climate change projections suggest the Clear Lake area will see more varied precipitation and higher temperatures during the spring, which could result in even less water flow being retained within the tributary streams during the hitch's spawning season (Pierce *et al*. 2013, pp. 842, 844, 848–850, Figure 1). Although the hitch has the ability to spawn within the lake, it is unknown whether that method of reproduction would be able to sustain a viable population of hitch in Clear Lake.

Summary of Threats

Our analysis of the past, current, and future threats influencing viability revealed there are six primary threats affecting the current and future viability of the Clear Lake hitch. These risks to viability are primarily related to habitat changes, both negative and positive:

1. The loss of spawning habitat due to past watershed modifications that have blocked access to or altered the flow regime of tributary streams;
2. The loss of wetland/tule habitat that juveniles require for rearing;
3. The effects from poor lake water quality;
4. The effects of increased competition and predation from a combination of introduced fish species and habitat loss;
5. Drought, which further reduces tributary flow; and
6. The implementation of regulatory mechanisms (i.e., CESA, Lake County's Clear Lake Shoreline Ordinance, and SGMA) and management actions (i.e., Lake County's Aggregate Resources Management Plan, Middle Creek Flood Damage Reduction and Ecosystem Restoration Project, and other miscellaneous restoration actions occurring throughout the watershed).

Furthermore, the negative influencing threats, especially drought, are all likely to be exacerbated by the effects of climate change Although we did assess the use or take of Clear Lake hitch for tribal harvest or recreational bycatch, we will not be carrying this threat forward into the future analysis because these risks do not appear to be occurring at a level that affects the entire population. The six influences listed above, will be carried forward in our assessment of the current condition of the Clear Lake hitch. To assess the possible future condition of the Clear lake hitch, we use those same six influences for our analysis but we also include the continuing and increasing effects of climate change.

Cumulative Effects of Combined Threats Influencing Viability

When evaluating the impacts of threats on a species, we do so by examining the effect of all the threats combined. It is the cumulative sum of all the threats, in light of the cumulative sum of any and all ameliorating measures, that determines the species overall status. The discussion of the potential for one threat to "influence" how another threat acts on the species can be found under the "Threats" discussion above and the ameliorating measures can be found below in the Existing Regulatory Mechanisms, Management Actions and Conservation Measures Planned or Implemented Section below and in the Clear Lake Hitch SSA (Service 2020, pp. 51-55).

EXISTING REGULATORY MECHANISMS, MANAGEMENT ACTIONS AND CONSERVATION MEASURES PLANNED OR IMPLEMENTED:

California Endangered Species Act (CESA)

On August 6, 2014, the California Fish and Game Commission determined the Clear Lake hitch warranted listing as a threatened species under the California Endangered Species Act (CESA). Fish and Game Code § 2067 states a "(t)hreatened species" means a native species or subspecies of bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by this chapter. As a threatened species under CESA, the take of individuals is prohibited unless the take is authorized by a permit. CESA regulations only apply to the take of individuals and not habitat. It should be noted that the state's definition of take is not the same as the Service's definition of take under the Federal ESA.

California Environmental Quality Act (CEQA)

California Environmental Quality Act of 1970 (CEQA) does not regulate land use, but requires all local and State agencies to avoid or minimize environmental damage, where feasible, during the course of proposed projects. CEQA provides protection for species that are state- or federally-listed as endangered, threatened, or rare. CEQA may be required for watershed restoration work and any restoration work that requires a Lake and Streambed Alteration Agreement, a.k.a. 1600 Agreement, (Section 1600 of Fish and Game Code), is also required to comply with CEQA.

National Environmental Policy Act (NEPA)

The National Environmental Policy Act of 1970 (NEPA) (42 U.S.C. 4371 et seq.) requires that all activities undertaken, authorized, or funded by Federal agencies be analyzed for potential impacts to the human environment prior to implementation. However, NEPA does not require adverse impacts be fully mitigated, and some impacts could still occur. Additionally, NEPA is only required for projects with a Federal nexus, and, therefore, actions that do not require a Federal permit or that occur on private land are not required to comply with this law.

United States Forest Service (USFS)

The Clear Lake hitch has been designated a United States Forest Service (USFS) sensitive species. Species identified as sensitive by the USFS are species in which population viability is a concern, as evidenced by significant current or predicted downward trends in population

numbers or density, and/or significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution. The designation of sensitive species will ensure the Forest Service is: assisting States, including California, in achieving their goals for conservation of endemic species; as part of the NEPA process, review programs and activities, through a biological evaluation, to determine their potential effect on sensitive species; avoid or minimize impacts to species whose viability has been identified as a concern; if impacts cannot be avoided, analyze the significance of potential adverse effects on the population or its habitat within the area of concern and on the species as a whole; establish management objectives in cooperation with the States when projects on National Forest System lands may have a significant effect on sensitive species population numbers or distributions; and establish objectives for Federal candidate species, in cooperation with the Service or National Marine Fisheries Service, and the States.

Clean Air Act

The Clean Air Act of 1970 (42 U.S.C. 7401 et seq.) provides the platform for the Environmental Protection Agency (EPA) to develop and enforce regulations to protect the general public from exposure to airborne contaminants known to be hazardous to human health. In 2007, the Supreme Court held that gases such as carbon dioxide fit within the Clean Air Act's definition of "air pollutant," and thus that EPA has the authority to regulate the emissions of such gases from new motor vehicles (Massachusetts *et al*. v. EPA, 549 U.S. 497, 532 (2007)).

California Global Warming Solutions Act

The state of California passed Assembly Bill 32 (AB 32), the California Global Warming Solutions Act of 2006, to reduce the amount of greenhouse gas emissions within the state to 1990 levels by 2020. AB 32 requires the California Air Resources Board to adopt regulations for reporting and verifying statewide greenhouse gas emissions and for monitoring and enforcing compliance with the program.

Clear Lake Integrated Watershed Management Plan (CLIWMP)

The local resource conservation districts developed the Clear Lake Integrated Watershed Management Plan (CLIWMP) to document the historical and current conditions of the Clear Lake watershed and any management actions that have or are currently being implemented. Opportunities to enhance and/or protect the watershed are then identified using that background information. The CLIWMP is a watershed management program that describes specific implementation actions needed to create an environmentally and economically healthy watershed, both for the benefit of the existing local community and for future generations (County of Lake *et al*. 2010a, entire). In addition to the CLIWMP, the local conservation districts also developed watershed assessments for Scotts, Middle, and Kelsey Creeks. The purpose of those assessments are similar to the CLIWMP, to document the historical and current conditions of those watersheds and any management actions implemented. The assessments will aid in educating watershed users and landowners on the condition of that particular watershed, the management and restoration actions that need to be implemented to improve conditions, and how the conditions of those particular watersheds impact the condition of Clear Lake (County of Lake *et al*. 2010b, entire; County of Lake *et al*. 2010c, entire; County of Lake *et al*. 2010d, entire).

Aggregate Resources Management Plan

Lake County developed an Aggregate Resources Management Plan (County of Lake 1992, entire) to address concerns about the impacts of gravel mining on the watershed. The plan describes the policies regarding mining in specific areas, identifies areas deemed as suitable for future mining projects, and informs the public about mining in Lake County. The plan calls for a moratorium on mining in certain creeks and limits mining activities to certain areas (County of Lake 1992, pp. 83–86). The regulation of gravel mining in the county has reduced the rate of erosion in the tributary streams and increased the amount of riparian habitat along the stream channels. Although in-stream sources of gravel are no longer the primary source of aggregate in Lake County since gravel is now acquired from other sources, illegal gravel mining or extraction has been known to occur in the watershed without enforcement (CEPA 2008, pp. 8, 89; B. Ewing *in litt.* 2020).

Middle Creek Flood Damage Reduction and Ecosystem Restoration Project

The Middle Creek Flood Damage Reduction and Ecosystem Restoration Project (Middle Creek Project) is both a flood risk reduction project for urban and agricultural areas along the northern end of Clear Lake and an ecosystem restoration project that will improve degraded wetland habitat and water quality in Clear Lake. The Middle Creek Project area was once approximately 1,400 acres of wetland habitat that was lost in the early 1900s through the construction of levees and conversion to agricultural use. Because these levees are no longer functional and there is an urgent need to restore surrounding wetland habitats to improve the lake and the watershed, Lake County requested the Corps' assistance to evaluate the project in 1995. The Middle Creek Project consists of acquiring reclaimed land, breaching existing levees to flood historical wetland and floodplain areas, and reconnecting Scotts and Middle Creeks. Final NEPA and CEQA review was completed in 2003 and 2004 respectively, and the Middle Creek Project was authorized by the Water Resources Development Act in 2007. Federal funding for the Middle Creek Project has not yet been appropriated to start project design; however, funding for land acquisition has been acquired (Corps 2012, pp. 1–2).

The Middle Creek Project will benefit the Clear Lake watershed by reducing the amount of sediment and nutrients entering Clear Lake, improving overall water quality. It will also increase the existing amount of wetland habitat within the Clear Lake watershed by approximately 79 percent (Corps 2012, p. 3). If the Middle Creek Project were to be implemented it would benefit adult hitch by improving the water quality of Clear Lake, which would likely reduce the incidence of large fish kills. The Middle Creek Project would also greatly benefit juvenile hitch by increasing the amount of wetland habitat surrounding the lake, providing increased cover from predators and competitors, and increased prey abundance.

Clear Lake Shoreline Ordinance

The destruction of woody species and tules on residential properties along the shoreline around Clear Lake is prohibited under Section 23-15 of the Clear Lake Shoreline Ordinance. These types of vegetation can be managed via mowing, pruning, or trimming, but those activities cannot result in the death of the plant. In addition, there is a no-net-loss program for commercial, resort, or public properties that requires mitigation for any areas of vegetation cleared by providing replacement plantings, although this ordinance is not always enforced (County of Lake *et al*. 2010a, pp. ES-16, 3-10; CDFW 2014, p. 42; B. Ewing *in litt.* 2020). These ordinances benefit the Clear Lake hitch by providing a consistent amount of tule habitat for juveniles.

Clear Lake Hitch Conservation Strategy

A group including local tribes, local government, state agencies, and federal agencies have been working on the development of a conservation strategy for the hitch. The strategy will document the past and current status of the hitch, will describe the negative influences that have resulted in the hitch's current status, and will identify the actions that will address those negative influences in order to maintain a viable population of Clear Lake hitch throughout its range. This strategy will benefit the hitch by helping to inform the public on how they can help the hitch and to direct funds to implement actions or projects that will specifically benefit the hitch.

Sustainable Groundwater Management Act (SGMA)

The Sustainable Groundwater Management Act (SGMA) is a California state law which provides a framework for sustainable groundwater management in California. Based on California Water Code Section 10933(B), ground water basins throughout the state have been classified into four categories of prioritization (high, medium, low, very low). Phase 1 of the categorization process was finalized in January 2019 and 458 basins were prioritized during that phase. Fifty-seven basins have been categorized under Phase 2; however, their prioritization has not yet been finalized (DWR 2019a, pp. 2, A-1). The law will require water agencies and governments of high and medium priority basins to halt overdraft and bring groundwater basins into balance. Several groundwater basins in the Clear Lake watershed have been prioritized during the Phase 1 prioritization. The Big Valley basin to the southwest of Clear Lake received a medium prioritization, whereas the other eight basins in the watershed were given a low priority (Scotts Valley, Upper Lake Valley, Middle Creek, Long Valley, High Valley, Clear Lake Cache Formation, Burns Valley, and Lower Lake Valley). The medium and high priority basins will be managed by a group of local agencies, referred to as Groundwater Sustainability Agencies, and they will be tasked with reaching sustainability in their basin within 20 years of implementing their Groundwater Sustainability Plans. Groundwater Sustainability Agencies have been formed for the Big Valley and Scotts Valley basins; however, a Groundwater Sustainability Plan has not yet been developed for the Big Valley basin (DWR 2019b; DWR 2019c; DWR 2019d). Reducing overdraft from groundwater pumping in the Big Valley basin could improve flow conditions in Thompson Creek, Adobe Creek, Kelsey Creek, and Cole Creek.

Miscellaneous

Lake County, the California Department of Transportation, US Forest Service, and the Bureau of Land Management have undertaken various actions to prevent or reduce nutrients and contaminants from entering Clear Lake (West Lake Resource Conservation District, undated; CDFW 2014, p. 41). These actions include the Eightmile Valley Sediment Reduction and Habitat Enhancement Project, which the Bureau of Land Management and Scotts Valley Band of Pomo Indians have recently received a grant for (CDFW 2014, p. 41). CDFW has two Conceptual Area Protection Plans (CAPP) that cover different portions of the Clear Lake watershed. A CAPP allows different organizations and agencies to apply for land acquisition funding through the Wildlife Conservation Board. Both plans focus on the protection of wetland and riparian habitats, which would benefit the Clear Lake hitch during early life stages (CDFW 2014, p. 42).

CURRENT CONDITION AND CURRENT CONDITION OF THE 3R'S:

In the SSA, we analyzed the hitch's current condition by determining the condition of each of the demographic factors and habitat elements carried forward in the SSA in light of the past and current influences to Clear Lake hitch viability that were defined in the Threats section. The past and current influencing factors that have resulted in the hitch's current condition include the loss of spawning habitat due to past watershed modifications that have blocked access to or altered the flow regime of tributary streams, the loss of wetland/tule habitat that juveniles require for rearing, the effects of poor lake water quality, the effects of increased competition from a combination of introduced fish species and habitat loss, drought reducing tributary flow, and the implementation of regulatory mechanisms and restoration actions. We describe the hitch's current condition by characterizing its status in terms of resiliency, representation, and redundancy (3 Rs).

The various past and current negative influencing threats discussed above have reduced the current abundance of hitch compared to historical accounts. This decline in abundance is primarily due to reductions in reproductive success, recruitment, and survival, most likely caused by the loss of consistent tributary flow, the loss of wetland/tule habitat surrounding the lake, reductions in lake water quality, effects due to introduced fish species, and the effects of drought conditions. Table 3 describes those influencing factors we carried forward for the current condition analysis (Service 2020, p. 62, Table 5.3). These will be used, in addition to implemented management actions, to assess the current condition of each Clear Lake population and the viability of the hitch overall. The current resiliency of each population will help describe the level of redundancy and representation the Clear Lake hitch currently expresses. However, neither redundancy nor representation could ever be considered at a high level due to the hitch's narrow range and low variability of habitat characteristics across the hitch's geographical range.

Table 3 Influences used to determine the current and future condition of the Clear Lake hitch (Service 2020, p, 62, Table 5.3)

Negative Factor Influencing Viability	**Cause(s)**	**Past, Current, and/or Future Factor**	**Effect(s) to the Clear Lake Hitch**	**Potential Regulatory Mechanism or Management Action**
The loss of spawning habitat - altered tributary flow regime	Instream gravel mining	Past activity, currently having effects on the watershed and will continue in the future	Reduced reproduction, early life stage survival, and likelihood of recruitment	CEQA; Lake County's Aggregate Resources Management Plan
	Deforestation	Past activity, currently having effects on the watershed and will continue in the future	Reduced reproduction, early life stage survival, and likelihood of recruitment	CEQA; NEPA; US Forest Service (USFS) sensitive species designation
	Grazing practices	Past activity, currently having effects on the watershed and will continue in the future	Reduced reproduction, early life stage survival, and likelihood of recruitment	There are currently no regulatory mechanisms that address grazing practices
	Existing flood control project infrastructure	Past installation, currently having effects on the watershed and will continue in the future	Reduced reproduction, early life stage survival, and likelihood of recruitment	CEQA; NEPA
	Fire activity; increased incidence due to climate change	Past, Current, and Future	Reduced reproduction, early life stage survival, and likelihood of recruitment	Clean Air Act; California Global Warming Solutions Act
	Water utilization for agricultural and urban uses	Past, Current, and Future	Reduced reproduction, early life stage survival, and likelihood of recruitment	SGMA
The loss of spawning habitat - blocked access	Lack of adequate tributary flow	Past, Current, and Future	Reduced reproduction and early life stage survival	SGMA; Misc. restoration actions
	Physical barriers (dams, diversions, roadways, and crossings)	Past, Current, and Future	Reduced reproduction	Barrier removal and/or fish ladder installation by CDFW and CalTrans

Negative Factor Influencing Viability	Cause(s)	Past, Current, and/or Future Factor	Effect(s) to the Clear Lake Hitch	Potential Regulatory Mechanism or Management Action
The loss of wetland/tule habitat	Conversion to agricultural production and urban development	Past activity, currently having effects on the watershed and will continue in the future	Reduced early life stage survival and likelihood of recruitment	Clear Lake Shoreline Ordinance; Middle Creek Flood Damage Reduction and Ecosystem Restoration Project
Reductions in lake water quality	Loss of wetland/tule habitat surrounding the lake	Past activity, currently having effects on the watershed and will continue in the future	Reduced survival	Clear Lake Shoreline Ordinance; Middle Creek Flood Damage Reduction and Ecosystem Restoration Project
	Mercury contamination	Past activity (mercury mining), currently having effects on the watershed and will continue in the future	Reduced survival	Aggregate Resources Management Plan; Middle Creek Flood Damage Reduction and Ecosystem Restoration Project; Misc. restoration actions
	Increased sediment and nutrient input	Past, Current, and Future	Reduced survival	Aggregate Resources Management Plan; Middle Creek Flood Damage Reduction and Ecosystem Restoration Project; Misc. restoration actions
	Cyanobacteria blooms	Past, Current, and Future	Reduced survival	Aggregate Resources Management Plan; Middle Creek Flood Damage Reduction and Ecosystem Restoration Project; Misc. restoration actions
Increased predation and competition pressure due to the establishment of non-native fish species	Introduction of non-native fish species	Past activity (introduction), currently having effects on the hitch and will continue in the future	Reduced survival, reproduction, and likelihood of recruitment	There are currently no regulatory mechanisms that address predation and competition.
Drought conditions	Environmental setting; increased incidence due to climate change	Past, Current, and Future	Reduced reproduction and recruitment	There are currently no regulatory mechanisms that address drought.

Summary of Methods for Current Condition Analysis

There are two populations of Clear Lake hitch, one occupying Clear Lake and its tributaries, and the other Thurston Lake and its tributary. In order to analyze the Clear Lake population in more detail, we broke the populations down into HUC 12 sub-watersheds. There are 16 HUC 12 sub-watersheds found throughout the range of the Clear Lake hitch, each of which occupy different areas within the watershed that contribute to the various hitch needs during their different life history stages. We further grouped some of the HUC 12 units based on an analysis of strontium signatures throughout the watershed, which indicate the contribution of different natal habitats to the population in Clear Lake. Because the entire Thurston Lake population occurs entirely within the Thurston Lake HUC 12 unit, it will be not be lumped into a SIG and resiliency of that HUC 12 will be used as the analysis unit for that entire population. The Clear Lake population occupies numerous HUC 12 units, each of which are associated with one of the five SIG's (see Figure 3 and Table 1) (Service 2020, pp. 15-16, Figure 3.2 and Table 3.2). Each of the demographic factors and habitat elements carried forward in the SSA will be analyzed using the methods/assumptions described below and shown in Tables 4 and 5 (Service 2020, pp. 69-70, Tables 5.4a and 5.4b).

Reproduction: Observational data collected by the Chi Counsel for Clear Lake Hitch (CCCLH) and CDFW will be used to analyze reproduction. Specifically, the consistency of spawning observations in those primary natal habitat associated with each SIG, except for SIG 4, will be used to categorize condition. The following are the primary natal habitats for each SIG, minus SIG 4: Cole Creek (SIG 1); Kelsey Creek (SIG 2); Clear Lake and Adobe Creek (SIG 3); Middle Creek, Clover Creek, and Seigler Canyon Creek (SIG 5). SIG 4, Rodman Slough is not typically included in observational surveys, and therefore, the recruitment category level assigned to SIG 4 will also be used for reproduction (moderate, see below).

Recruitment: The recruitment analysis for the Clear Lake hitch will have two components: the presence of wetland habitat and the results from the otolith analysis. Since the otolith analysis confirmed some level of recruitment for each of the SIG's, this component of the analysis will be weighted double. Overall scores are determined by adding the two components. Because we know the remaining amount of wetland habitat surrounding the lake has declined compared to the historical condition, we are assuming for this analysis that this component cannot be in a high condition. Therefore, we will be defining a moderate condition for the wetland habitat component as having remnant habitat within the SIG and a low condition as having very little remnant habitat within the SIG (see Table 5) (Service 2020, p. 70, Table 5.4b). Figure 5.2 in the Clear Lake hitch SSA shows the existing wetland habitat within each SIG (Service 2020, p-65).

Although only one year of the otolith analysis was conducted, we will be using the proportion of individuals assigned to each SIG to categorize the otolith component of recruitment. We recognize that if all portions of the lake were equally contributing to recruitment, which may have been the case historically, the proportion of individuals representing each SIG would be equal (20%). However, because of the loss of wetland habitat surrounding the lake, we are assuming that each SIG can no longer support an equal amount of recruitment. Therefore, this component of the analysis is really just a comparison of what portion of the lake is currently contributing to recruitment. For the otolith component, we define a high condition as those SIG's that are contributing 20% or more to recruitment, moderate as less than 20% but more that 10%,

and low condition as less than 10%. Of the hitch analyzed for the otolith analysis, 57% came from SIG 3, 18% came from both SIG's 2 and 4, and 2% and 5% from SIG's 1 and 5, respectively.

Connectivity: Connectivity will be analyzed by considering the presence and concentrations of passage barriers within a SIG (see Figure 4) (Service 2020, p. 68, Figure 5.3). Larger concentrations of potential passage barriers will be considered a low condition (SIG's 2, 3, and 5), whereas SIG's with no or few barriers are considered high condition (SIG's 1 and 4). There will not be an initial moderate category for this factor; however, depending on future projections, passage barriers within a SIG could improve or deteriorate from a high or low current condition to a future moderate condition.

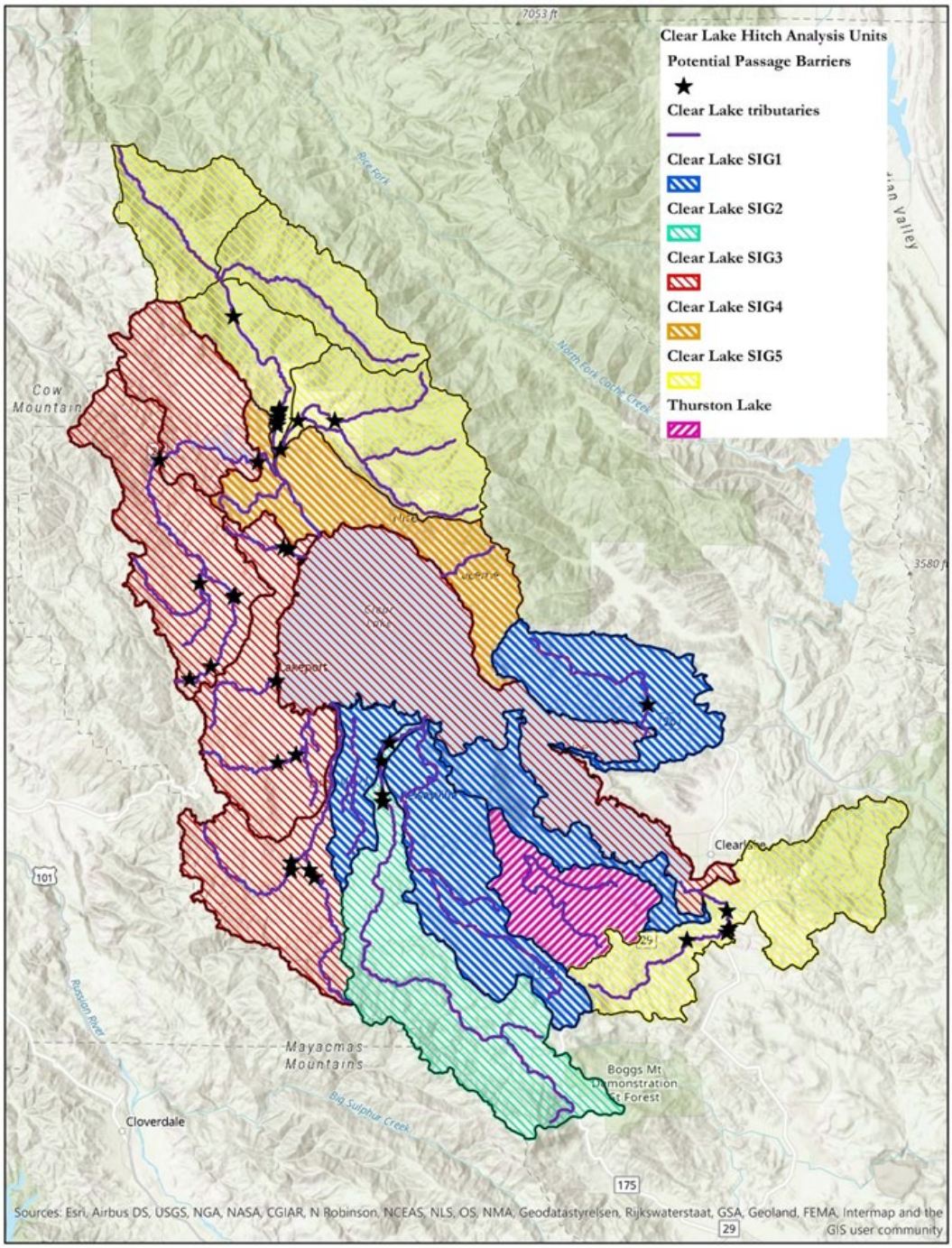

Figure 4 Passage barriers within each analysis unit (Service 2020, p. 68, Figure 5.3)

Tributary Water Quantity: The amount of water within a primary natal habitat stream is likely influenced by the presence of surrounding urban development and agricultural production (Service 2020, pp. 30-32 and p. 26, Figures 4.2a–e and 4.4). The greatest concentration of agricultural production is within SIG 1, with lower levels of production in each of the other analysis units. The greatest concentration of urban development is within SIG's 2 and 3, and there is an intermediate amount in SIG's 1, 4, and 5. Therefore, for the purposes of this analysis,

SIG's 1, 2, and 3 are considered a low condition due to the high concentration of water users, and SIG's 4 and 5 are a moderate condition since water reliance is not as intense. Coincidentally, SIG's 1, 2, and 3 happen to fall within the Big Valley groundwater basin, which has been given a medium priority under SGMA due to overdraft.

Wetland/Tule Habitat: Remaining wetland/tule habitat is found either within each SIG or, as in the case for SIG 5, is found in the SIG between SIG 5 and the lake. Because the amount of wetland/tule habitat has been greatly reduced from past conditions and the presence of non-native fish within this habitat type has increased both predation pressure and competition, we consider wetland/tule habitat to be at a low condition for all analysis units. It is assumed that the loss of rearing habitat (both physical loss and the introduction of non-native fish that exclude the hitch via predation or competition) is one of the primary factors limiting population growth.

Lake Water Quality: The current water quality condition for Clear Lake is considered moderate. Although the lake has been degraded and in some years conditions should be considered low, it is not thought to have a population level effect on the hitch every year and therefore, is typically at a moderate condition.

Table 4 (Service 2020, p. 69, Table 5.4a) Demographic factors and habitat elements used to create condition categories in Table 6 (Service 2020, p. 72, Table 5.5a) below

	Demographic Factors		**Tributary Habitat Elements**		**Lake Habitat Elements**	
Condition Category	**Reproduction**	**Recruitment (see Table 5 or 5.4b)**	**Connectivity**	**Tributary Water Quantity**	**Wetland/ Tule Habitat**	**Lake Water Quality**
High	Reproduction documented each year	Overall recruitment total from recruitment analysis is high	Free passage under all flow conditions; no/few barriers	Water is retained within the tributaries throughout the spawning season	Extensive wetland habitat is available for rearing	Lake water is well oxygenated and minimally contaminated
Moderate	Reproduction documented frequently, but not each year	Overall recruitment total from recruitment analysis is moderate	--	Water is retained within the tributaries throughout a large portion of the spawning season	Some wetland habitat is available for rearing	Lake water is oxygenated most of the time, hypoxic conditions do occur periodically. Some contaminants are present, but not at lethal levels
Low	Reproduction documented infrequently	Overall recruitment total from recruitment analysis is low	Free passage only under specific flow conditions; many or large concentration of barriers	Water is retained within the tributaries throughout just a small portion of the spawning season	Limited wetland habitat is available for rearing	Lake water is not well oxygenated and hypoxic conditions occur frequently. Contaminants are present, sometimes at lethal levels
Ø	No reproduction	No recruitment	No passage under any flow conditions	Water is not retained within the tributaries during any portion of the spawning season	No wetland habitat is available for rearing	Lake water quality is uninhabitable

Table 5 Recruitment analysis used to create recruitment condition category in Table 4 (Service 2020, p. 69-70, Table 5.4a and Table 5.4b). The otolith analysis is weighted double when calculating the overall condition

Condition Category	Recruitment – Wetland Habitat	Recruitment – Otolith Analysis (2X)
High	--	Otolith analysis shows SIG is a primary contributor to population recruitment (>20%).
Moderate	Remnant wetland habitat occurs within the SIG	Otolith analysis shows SIG contributes to population recruitment, but is not the primary source (<20% and >10%).
Low	Very little remnant habitat occurs within the SIG	Otolith analysis shows SIG has very little contribution to population recruitment (<10%)
Ø	No wetland habitat within the SIG	No recruitment, no individuals assigned to SIG

Determining Overall Analysis Unit Condition

The overall condition for each analysis unit is calculated by summing the condition of each of the demographic factors and habitat elements within that unit. A high condition for any demographic factor or habitat element (factor/element) is worth a score of 3, moderate is worth 2, and a low condition is worth 1. Because there are six factors/elements to analyze, an analysis unit that has all factors/elements in a high condition would have a total score of 18. Likewise, an analysis unit with all six factors/elements in moderate condition would have a total of 12 and one with all factors/elements in low condition would have a total of 6. We took the difference between the lowest and highest possible overall condition scores (6 and 18) and divided this into three equal intervals representing the breadth of possible scores. A score of 9 or less means the analysis unit is in overall low condition, a score of 15 or greater means the unit is in overall high condition, and scores between 10 and 14 mean the unit is in overall moderate condition.

Determining Population Condition

The overall condition of a particular factor/element for the entire Clear Lake population is calculated by summing the condition of that particular factor for each analysis unit, which was determined using the evaluation described above. Similar to the analysis unit evaluation, conditions of high, moderate, and low are scored as 3, 2, and 1, respectively. However, unlike the analysis unit evaluation, there are only five SIG's that are being evaluated, therefore, a factor/element in high condition for each of the analysis units would have a total score of 15. Likewise, a factor/element with all five SIG's in moderate condition would have a total of 10 and one with all SIG's in low condition would have a total of 5. We took the difference between the lowest and highest possible overall condition scores (5 and 15) and divided this into three intervals representing the breadth of possible scores. A score of 8 or less means the factor/element is in overall low condition, a score of 13 or greater means the factor/element is in overall high condition, and scores between 9 and 12 mean the factor/element is in overall moderate condition.

The overall condition of the Clear Lake population is determined by using the same scoring process that was used to determine the condition of each analysis unit, which is described above. All six factors/elements have a score ranging from 1 to 3 based on the condition of that factor/element (high condition = 3, moderate condition = 2, and low condition = 1). The condition of all factors/elements are summed to give an overall population score between 6 and 18. A score of 9 or less means the population is in overall low condition, a score of 15 or greater means the population is in overall high condition, and scores between 10 and 14 mean the population is in overall moderate condition. An overall high condition for a population is an indicator of high probability of population persistence. Populations in high condition have accessible tributaries available throughout the spawning season, have different natal habitats available for reproduction, individuals that are reproducing successfully and populations that are actively recruiting, and the amount and quality of spawning and rearing habitat is sufficient to allow for varying population densities. An overall moderate condition is an indicator that probability of persistence for that population may be compromised by the lack and/or degradation of one or more need, and a low overall condition indicates low probability of population persistence due to the lack and/or degradation of multiple needs.

Current Population Resiliency

When we refer to or discuss "condition" were using that as a surrogate for resiliency because we do not have data on population growth rate or size. The results of our analysis indicate an overall population condition. When populations are in high conditions, they are expected to have high resiliency. Populations in moderate condition are expected to have a moderate resiliency and populations in low condition are expected to have a low resiliency.

The Clear Lake hitch currently has two populations throughout its range, one occupying Clear Lake and its tributaries, and the other Thurston Lake and its tributary. Thurston Lake and Thurston Creek are both within the same HUC 12 unit, which is its own analysis unit and is considered to be at a high condition due to the robust population that currently resides there. The Clear Lake population occupies numerous HUC 12 units, which have been further grouped into one of five SIG's based on natal origin strontium signatures

Using the descriptions summarized above and Tables 4 and 5, and as seen in Table 6, the current condition of wetland/tule habitat within the Clear Lake population is at a low condition in each of the five units (Service 2020, p. 4-6, Tables 5.4a, 5.4b and 5.5a). Similarly, the current condition of lake water quality is at a moderate condition for all five SIG units. For reproduction, SIG's 2 and 3 are currently at a high condition because they have had consistent spawning observations each survey year. Reproduction for SIG's 1 and 5 are currently at a moderate condition due to somewhat frequent, but still inconsistent, annual spawning observations (Service 2020, pp. 58-59, Tables 5.1 and 5.2). The portion of the watershed associated with SIG 4 is not typically included in observational surveys, so the current condition of recruitment for SIG 4, moderate, is also being used for reproduction. As explained above, the current recruitment condition for SIG 3 is high, moderate for SIG's 2 and 4, and low for SIG's 1 and 5. For connectivity, SIG's 1 and 4 are currently at a high condition, and SIG's 2, 3, and 5 are at a low condition. The current condition for tributary water quantity is low for SIG's 1, 2, and 3, and moderate for SIG's 4 and 5. Currently, the Clear Lake population has four analysis units at a moderate condition (SIG's 1–4), and one unit at a low condition (SIG 5), for an overall Clear

Lake population condition of moderate. The Thurston Lake population is currently in high condition (see Table 8) (Service 2020, p. 72, Table 5.6).

Table 6 Current condition for each of the Clear Lake population analysis units and the overall current condition of the Clear Lake population (Service 2020, p. 72, Table 5.5a). See Table 4 for a description of condition categories (Service 2020, p. 69, Table 5.4a). See Table 7 for the detailed current recruitment condition analysis (Service 2020, p. 72, Table 5.5b).

Clear Lake Population Analysis Unit (AU)	Demographic Factors		Habitat Elements				Current Condition
	Reproduction	Recruitment (see Table 5.5b)	Connectivity	Tributary Water Quantity	Wetland/ Tule Habitat	Lake Water Quality	
Cole Creek (SIG1)	Moderate	Low	High	Low	Low	Moderate	Moderate
Kelsey Creek (SIG2)	High	Moderate	Low	Low	Low	Moderate	Moderate
Clear Lake, Adobe Creek (SIG3)	High	High	Low	Low	Low	Moderate	Moderate
Rodman Slough (SIG4)	Moderate	Moderate	High	Moderate	Low	Moderate	Moderate
Middle Creek, Clover Creek, Seigler Canyon Creek (SIG5)	Moderate	Low	Low	Moderate	Low	Moderate	Low
Overall Condition	Moderate	Moderate	Moderate	Low	Low	Moderate	Moderate

Table 7 Current recruitment condition analysis for the Clear Lake population of CLH (Service 2020, p. 72, Table 5.5b) Lake hitch. See Table 5 for a description of the recruitment condition categories (Service 2020, p.

Clear Lake Population Analysis Unit (AU)	Demographic Factor - Recruitment		Overall Current Recruitment Condition
	Wetland Habitat	Otolith Analysis	
Cole Creek (SIG1)	Moderate	Low	Low
Kelsey Creek (SIG2)	Low	Moderate	Moderate
Clear Lake, Adobe Creek (SIG3)	Moderate	High	High
Rodman Slough (SIG4)	Moderate	Moderate	Moderate
Middle Creek, Clover Creek, Seigler Canyon Creek (SIG5)	Low	Low	Low

Table 8 Current resiliency for each of the Clear Lake hitch populations (Service 2020, p. 72, Table 5.6).

Population	Demographic Factors		Habitat Elements				Current Condition
	Reproduction	Recruitment	Connectivity	Tributary Water Quantity	Wetland/ Tule Habitat	Lake Water Quality	
Thurston Lake	--	--	--	--	--	--	High
Clear Lake	Moderate	Moderate	Moderate	Low	Low	Moderate	Moderate

Current Species Representation

The Clear Lake hitch currently has a low level of representation. Although the hitch currently has different spawning strategies they can utilize under variable environmental conditions, the hitch

occupies a very narrow range with similar habitat characteristics.

Current Species Redundancy

The Clear Lake hitch currently has a moderate level of redundancy. Although the hitch currently has two separate populations (Thurston Lake and Clear Lake) it is possible a catastrophic event could still impact the entire range of the species. The hitch also expresses some within population redundancy by being able to utilize different habitats for reproduction and through the number of available tributary streams within the Clear Lake population.

Summary of Current Condition

We used the best available information to determine the current condition of the Clear Lake hitch. Our goal was to describe the viability of the hitch in a manner that will address the needs of the hitch in terms of resiliency, representation, and redundancy. When considering the current condition of the Clear Lake hitch, we considered the following factors influencing the hitch:

1. The loss spawning habitat due to past watershed modifications that have blocked access to or altered the flow regime of tributary streams. The lack of consistent tributary flow seen in the Clear Lake watershed is due to the effects of past instream gravel mining, deforestation, and grazing practices, existing flood control project infrastructure, fire activity, and water utilization for agricultural and urban uses. Passage barriers in the watershed include the lack of adequate tributary flow and physical barriers such as dams, diversions, roadways, and crossings;

2. The conversion and loss of wetland/tule habitat for agricultural production and urban development;

3. Reductions in lake water quality due to the loss of wetland/tule habitat surrounding the lake, contamination from past mercury mining along the lake's shore and pesticide use for agricultural and urban uses, the input of sediment and nutrients from degraded tributary streams, and nutrient inputs from surrounding urban and agricultural development. Increased nutrient and sediment inputs have contributed to periodic cyanobacteria blooms, which further reduce water quality;

4. The past introduction and establishment of non-native fish species;

5. Drought conditions within the Clear Lake watershed further reducing tributary flow during the spawning season; and

6. The implementation of current regulatory mechanisms (i.e., CESA, Lake County's Clear Lake Shoreline Ordinance) and management actions (i.e., Lake County's Aggregate Resources Management Plan, other miscellaneous restoration actions occurring throughout the watershed).

The various past and current negative influencing factors detailed above either singly or in combination have significantly reduced the current abundance of hitch, primarily due to reductions in reproductive success, recruitment, and survival. These influences were used, in addition to

implemented management actions, to assess the current condition of the Clear Lake hitch in terms of the 3 Rs. Currently, the Clear Lake hitch has one population at a high resiliency (Thurston Lake) and one at a moderate resiliency (Clear Lake). The Clear Lake hitch currently has a low level of representation; however, the hitch has never had a high level of representation due to its very narrow range with similar habitat characteristics. The Clear Lake hitch is currently at a moderate level of redundancy. Both the Thurston and Clear Lake populations are currently extant, and each likely expresses within population redundancy in spawning habitat types and/or the number of available tributary streams.

FUTURE CONDITION AND FUTURE CONDITON OF THE 3R'S:

The SSA analyzes the hitch's future condition by considering how those past and current threats will continue to act on the hitch into the future, and how those threats will impact the future condition of the Clear Lake hitch's needs (i.e., demographic factors and habitat elements). In addition, the SSA applies our future projections to the concepts of resiliency, representation, and redundancy to describe the future viability of the Clear Lake hitch.

The different combinations of influencing factors, both negative and positive (i.e., regulatory mechanisms and management actions), that will continue to act on the hitch into the future could result in varying changes to each of the Clear Lake hitch populations throughout its range. A reduction or increase in the number of available natal habitat types and tributary streams or impacts to lake water quality can reduce or increase that population's resiliency. Any reduction or increase in resiliency will further reduce or increase the level of redundancy and representation the Clear Lake hitch expresses. However, neither redundancy nor representation should ever be considered at a high level because of the hitch's narrow range and low variability of habitat characteristics across the species' geographical range. As a consequence of those influencing factors acting on the hitch and the hitch's current condition, the future viability of the Clear Lake hitch now primarily depends on ensuring successful reproduction and recruitment to maintain or increase overall population abundance. This can be accomplished by preventing further destruction of natal and rearing habitats, maintaining or improving the water quality within Clear Lake, and potentially, the restoration of tributary streams so they can retain water throughout the spawning season.

The influencing factors we carried forward for the future condition analysis (Table 3) will be used (Service 2020, p.62, Table 5.3), in addition to implemented management actions, to assess the possible future condition of Clear Lake hitch under three different scenarios. The future resiliency of each population will help describe the level of redundancy and representation the hitch will express in the future, under that specific scenario. However, neither redundancy nor representation could ever be considered at a high level under any scenario due to the hitch's narrow range and the low variability of habitat characteristics across the hitch's geographical range.

Summary of Methods for Future Condition Analysis

Because we have significant uncertainty regarding if, when, where, and/or to what extent agricultural production, urban development, restoration actions, or climate effects may occur, we have forecast the possible viability of the Clear Lake hitch in terms of resiliency, representation,

and redundancy under three plausible future scenarios. We chose to forecast the future scenarios for Clear Lake hitch viability over the next 50 years because it is within the range of the available climate change model projections for the North Coast Region, where Clear Lake is located (Grantham 2018; Pierce et al. 2018). These projections are given over two different time periods, one out 50 years (2040-2069) and one out to the end of the century (2070-2099). We chose the shorter timeframe because the two emissions scenarios used in the climate models, RCP 4.5 and RCP 8.5, have similar precipitation and temperature projections into the mid-century (2040-2069). Beyond this time period, both temperature and precipitation projections begin to diverge. Because we are uncertain what emissions trajectory we will follow into the future, and that uncertainty increases with time, we are being conservative and are using the shorter time period for this analysis. Because the rate of urban development has slowed in the last decade, we do not anticipate a significant amount of urban growth into the future. The timeframe for the current Lake County General Plan is 20 years and only projects growth out to 2028; however, we still do not expect growth to increase much after 2028. Although the amount of agricultural development increased substantially leading up to the 21st century, over the last 10 years or so the acreage of fruit, nut, field, seed, and vegetable crops in Lake County only slightly increased. Therefore, we do not anticipate a substantial increase in the amount of agricultural production into the future and do not have a specific timeframe to project the rate of agricultural production into the future. It should be noted that the presence of agricultural production in the watershed will continue to result in sediment and nutrients entering the lake into the future.

Scenario 1 evaluates the condition of the Clear Lake hitch if there is a similar or slight increase in the amount of being water extracted from the watershed and the number of restoration actions being performed throughout the watershed from what exists today. It also takes into account climate change and what effects it may have on those influencing factors already acting on the hitch. The other scenarios will evaluate the response of the hitch to different changes in each of those influencing factors. For each scenario we describe the factors influencing viability that would occur in each analysis unit and population, and the hitch's response. Since the entire Thurston Lake population is completely within the Thurston Lake HUC 12, we will continue to evaluate that population using just the one analysis unit when analyzing future scenarios.

We examine the resiliency, representation, and redundancy of the Clear Lake hitch under each of these three plausible scenarios. The resiliency of a Clear Lake hitch population depends on future environmental conditions and the availability of spawning and rearing habitat within that population. We expect each population to experience changes to these aspects of their habitat in different ways under the different scenarios. We projected the expected future resiliency of each population based on the events that may occur under each scenario and then projected an overall condition for the subspecies. For these projections, populations in high condition are expected to have high resiliency at that time period; i.e., there are multiple tributaries available throughout the spawning season and the different natal habitats are present and can be used for reproduction, individuals within a population are reproducing successfully and actively recruiting, and the amount and quality of spawning and rearing habitat is sufficient to allow for varying population densities.

Populations in high condition are expected to persist into the future and have the ability to withstand stochastic events that may occur. Populations in moderate condition are less resilient

than those in high condition, but are expected to persist 50 years into the future. Populations in moderate condition may contain fewer natal and spawning habitats, and therefore, will contribute less to reproduction and recruitment than those populations in high condition. Finally, those populations in low condition have low resiliency and may not be able to withstand stochastic events. As a result, populations in low condition are less likely to persist into the future; however, a population in a low condition does not automatically mean the population cannot support any reproduction or recruitment, it just means those demographic factors are greatly reduced.

Scenario 1

Under Scenario 1, those factors that are having an influence on each of the Clear Lake hitch populations continue at current rates, or slightly increase. The effects of climate change, specifically increased aridity, are already occurring throughout the watershed, although the effects of increased aridity are not apparent every year. Future drought conditions are projected to increase in both the number of years drought conditions persist and the intensity of drought. Due to the increased incidence of aridity, and because future climate projections show the timing of precipitation will change, some years the number of spawning tributaries available to the hitch over the spawning season will decrease. Increased fire and flooding incidence will increase the amount of erosion occurring in the tributary streams, decreasing lake water quality. As conditions worsen in the tributary streams, the hitch will have to increasingly rely on spawning in the lake or the mouths of streams. Because the Clear Lake hitch is a state listed species, direct take will continue to be limited. Due to Lake County's shoreline ordinance, existing wetland/tule habitats surrounding the lake will continue to persist. Under Scenario 1, restoration projects (contaminant remediation, tributary function, barrier removal) continue to be implemented at a small scale throughout the watershed. Scenario 1 assumes the benefits of the Middle Creek Project have not been fully met (i.e., has not yet been fully constructed; see Regulatory Mechanisms and Management Actions for a full description of benefits associated with the Middle Creek Project). A detailed analysis of each Clear Lake population analysis unit is shown in Tables 9 and 10 (Service 2020, pp. 78-79, Tables 6.1a and 6.1b). The future condition of each Clear Lake hitch population under Scenario 1 is shown in Table 11 (Service 2020, p. 79, Table 6.2).

Resiliency

Thurston Lake Population

Thurston Lake – Under Scenario 1, the resiliency of the Thurston Lake population will decline from high to a moderate level due to effects from climate change. Climate change will impact this population by reducing the availability of spawning habitats in some years and by reducing lake water quality. The one tributary stream to the lake, Thurston Creek, may not have continual flow to accommodate spawning every year.

Clear Lake Population

SIG 1 (Cole Creek) – In Scenario 1, SIG 1 experiences an increase in aridity during some years due to climate change. The increase in aridity would result in reduced spawning tributary availability during that year and a slight potential reduction in natal habitat variety. Since this analysis unit is within the Big Valley groundwater basin, the implementation of sustainable groundwater use through SGMA may increase the amount of water retained within the tributary

creeks, reducing the effects of arid conditions during some years due to climate change. Under this scenario, SIG 1 would maintain a moderate resiliency.

SIG 2 (Kelsey Creek) – This analysis unit will also experience an increase in aridity during some years due to climate change. Similar to SIG 1, the increase in aridity would result in a potential reduction in natal habitat variety and reduced spawning tributary availability during those years. Because SIG 2 is in the Big Valley groundwater basin, implementation of SGMA may increase the amount of water retained within the tributary creeks, reducing the effects of climate change. Under Scenario 1, this analysis unit would maintain a moderate resiliency.

SIG 3 (Adobe Creek and Clear Lake) – SIG 3, which includes both Adobe Creek and Clear Lake, will also experience an increase in aridity during some years due to climate change under Scenario 1. Similar to SIG's 1 and 2, the increase in aridity would reduce spawning tributary availability, especially since this SIG will likely continue to have a high concentration of passage barriers. During drought years, there will likely be a reduction in the number of natal habitats the hitch can utilize since the tributary streams may not be fully available. Because Adobe Creek is in the Big Valley groundwater basin, implementation of SGMA may increase the amount of water retained within the tributary creeks, reducing the effects of climate change. This analysis unit would maintain a moderate resiliency under Scenario 1.

SIG 4 (Rodman Slough) – This analysis unit will also experience an increase in aridity during some years due to climate change, which would reduce spawning tributary availability during those years. However, because a large portion of spawning habitat within this unit is contained within the lake, impacts due to climate change will be less than the other SIG's. Under Scenario 1, SIG 4 would maintain a moderate resiliency.

SIG 5 (Middle, Clover, and Seigler Canyon Creeks) – Similar to SIG's 1 and 2, SIG 5 will experience increased aridity during some years due to climate change under Scenario 1. Also comparable to those SIG's, the effects of climate change will reduce tributary availability over the spawning season and natal habitat variety. Unlike SIG's 1 and 2, SIG 5 is not included in the Big Valley groundwater basin and any benefits from SGMA will not apply to this analysis unit; however, overdraft is not projected to be as much of an issue in this unit. Therefore, SIG 5 would maintain a low resiliency under Scenario 1.

Table 9 Future condition for each of the Clear Lake population analysis units and the overall future condition of the Clear Lake hitch under Scenario 1 (Service 2020, p. 78, Table 6.1a). See Table 10 for the detailed future recruitment analysis under Scenario 1(Service 2020, p. 79, Table 6.1b).

Clear Lake Population Analysis Unit (AU)	Demographic Factors		Habitat Elements				Future Condition
	Reproduction	Recruitment (see Table 10 or 6.1b)	Connectivity	Tributary Water Quantity	Wetland/ Tule Habitat	Lake Water Quality	
Cole Creek (SIG1)	Moderate	Low	High	Low	Low	Moderate	Moderate
Kelsey Creek (SIG2)	High	Moderate	Low	Low	Low	Moderate	Moderate
Clear Lake, Adobe Creek (SIG3)	High	High	Low	Low	Low	Moderate	Moderate
Rodman Slough (SIG4)	Moderate	Moderate	High	Moderate	Low	Moderate	Moderate
Middle Creek, Clover Creek, Seigler Canyon Creek (SIG5)	Moderate	Low	Low	Moderate	Low	Moderate	Low
Overall Condition	Moderate	Moderate	Moderate	Low	Low	Moderate	Moderate

Table 10, Future recruitment condition analysis for the Clear Lake population of Clear Lake hitch under Scenario 1 (Service 2020, p. 79, Table 6.1b).

Clear Lake Population Analysis Unit (AU)	Demographic Factor - Recruitment		Overall Future Recruitment Condition
	Wetland Habitat	Otolith Analysis	
Cole Creek (SIG1)	Moderate	Low	Low
Kelsey Creek (SIG2)	Low	Moderate	Moderate
Clear Lake, Adobe Creek (SIG3)	Moderate	High	High
Rodman Slough (SIG4)	Moderate	Moderate	Moderate
Middle Creek, Clover Creek, Seigler Canyon Creek (SIG5)	Low	Low	Low

Overall Clear Lake Population – Under Scenario 1, the Clear Lake population maintains a moderate level of resiliency. The effects of climate change, specifically increased aridity, may reduce or eliminate stream based spawning in some years; however, future climate change projections do not predict increased aridity every year and the hitch will still have the ability to spawn in other lake based habitats when drought conditions do occur. In addition, small-scale restoration projects throughout the watershed will increase the amount of available spawning habitat available to the hitch when conditions do allow for stream based spawning.

Table 11 Future resiliency for each of the Clear Lake hitch populations under Scenario 1 (Service 2020, Table 6.2).

Population	Demographic Factors		Habitat Elements				Future Condition
	Reproduction	Recruitment	Connectivity	Tributary Water Quantity	Wetland/ Tule Habitat	Lake Water Quality	
Thurston Lake	--	--	--	--	--	--	Moderate
Clear Lake	Moderate	Moderate	Moderate	Low	Low	Moderate	Moderate

Scenario 1 projects the condition of each Clear Lake hitch analysis unit if the current risks continue on the same, or a very similar, trajectory they are on now. Overall, four of the five Clear Lake population analysis units would be at a moderate condition and one would be at a low condition. The Thurston Lake analysis unit, and population overall, would be at a moderate condition

Over the next 50 years, this scenario is most likely to occur since we expect climate change to continue (thereby increasing the likelihood of aridity) and the amount of water use within the watershed will only slightly increase due to urban development and agricultural production. We also expect groundwater resources will slightly improve in the Big Valley groundwater basin due to the implementation of SGMA, and we expect small scale restoration projects to continue throughout the watershed.

Representation

The Clear Lake hitch currently has a low level of representation and that is unlikely to change under Scenario 1. Under this scenario, the hitch will continue to have different spawning strategies to utilize under different environmental conditions.

Redundancy

Under Scenario 1, the Clear Lake hitch will likely continue to maintain its current moderate level of redundancy, as both populations are expected to be maintained and the variety of habitats that can currently be utilized for reproduction will continue to be available to each hitch population. However, because the resiliency of the Thurston Lake population is expected to decrease due to an increased incidence of drought, redundancy will decrease slightly.

Scenario 2

Scenario 2 is a best-case scenario for the Clear Lake hitch, where all of the analysis units within the Clear Lake population either retain or improve their current condition due to restoration and enhancement activities throughout the watershed. Similar to Scenario 1, those factors that are currently having a negative influence on each of the Clear Lake hitch populations continue at current rates, or slightly increase. Under this scenario, the effects of climate change affect the

entire watershed, although they may not occur annually. Drought conditions are projected to increase and some years the number of spawning tributaries available to the hitch over the spawning season will decrease. Erosion within the tributary streams will continue to be an issue due to increased incidence of fire and flooding, and as a consequence the water quality in the lake will decrease. However, restoration actions will also increase throughout the watershed, including the construction of the Middle Creek Project. The restoration of tributary streams will improve water retention throughout the spawning season, the removal of passage barriers will increase the amount of tributary habitat the hitch can use for spawning, and construction of the Middle Creek Project will increase the amount of available rearing habitat, improving that habitat element for the Clear Lake population from low to moderate condition. These activities will all increase reproductive success and increase the likelihood of recruitment within Clear Lake. The restoration of tributary streams and the creation of wetland habitats surrounding the lake from the Middle Creek Project will improve the water quality of Clear Lake, but not enough to increase it from a moderate to a high condition because mercury contamination and nutrient input are not likely to cease. Like Scenario 1, the direct take of hitch will continue to be limited by CESA, and the existing wetland/tule habitats surrounding the lake will continue to persist due to county ordinances. A detailed analysis of each Clear Lake population analysis unit is shown in Tables 12 and 13 (Service 2020, pp. 81-82, Tables 6.3a and 6.3b). The future condition of each Clear Lake hitch population under Scenario 2 is shown in Table 14 (Service 2020, p. 82, Table 6.4).

Resiliency

Thurston Lake Population

Thurston Lake – Like Scenario 1, the resiliency of the Thurston Lake population will decline to a moderate level due to effects from climate change under Scenario 2. Climate change will impact this population by reducing the availability of spawning habitats in some years. The one tributary stream to the lake, Thurston Creek, may not have continual flow to accommodate spawning every year and the water quality within the lake will likely decrease. Even though restoration projects are occurring throughout the watershed under this scenario, those efforts are not directed to the Thurston Lake sub-watershed.

Clear Lake Population

SIG 1 (Cole Creek) – In Scenario 2, SIG 1 experiences an increase in aridity during some years due to climate change. The increase in aridity could reduce tributary availability and natal habitat variety; however, due to restoration actions within the watershed, the tributary creeks will be able to retain water until later in the season, and miles of additional tributary habitat will become available with the removal of passage barriers. Those factors, along with the increase of wetland habitat for rearing, will increase reproductive success and recruitment within SIG 1 under Scenario 2. Although the condition of most demographic factors and habitat elements increase under this scenario, resiliency would be maintained at a moderate level.

SIG 2 (Kelsey Creek) – Analysis unit SIG 2 experiences an increase in aridity during some years due to climate change. Similar to SIG 1, the increase in aridity would reduce natal habitat variety and tributary availability, but restoration actions throughout the watershed would help in countering those negative effects and would improve stream function. The removal of passage

barriers within this unit increases the amount of tributary habitat available to the hitch for spawning. Under Scenario 2, the resiliency of SIG 2 will be maintained at moderate.

SIG 3 (Adobe Creek and Clear Lake) – The resiliency of the SIG 3 analysis unit will be maintained at a moderate level under Scenario 2. Even though the effects of climate change are still projected to occur, the restoration of spawning and rearing habitat will improve the tributary water quantity and wetland/tule habitat elements, and the removal of passage barriers will increase connectivity.

SIG 4 (Rodman Slough) – Conditions in SIG 4 under Scenario 2 will primarily stay the same, except for an increase of wetland/tule habitat due to restoration projects, which will increase recruitment. Although tributary restoration improved water quantity conditions in SIG's 1–3 under this scenario, this unit is already currently at a moderate condition and effects from climate change make it unlikely for any high condition to occur within the watershed. Under Scenario 2, SIG 4 would maintain a moderate resiliency.

SIG 5 (Middle, Clover, and Seigler Canyon Creeks) – Under Scenario 1 the Middle Creek Project is constructed and this analysis unit will receive the bulk of the benefit from it, primarily through an increase in habitat that supports successful reproduction and population recruitment. Like all of the analysis units in this scenario, climate change will effect SIG 5 through increased incidence of drought, but restoration actions will help counter those effects. The resiliency of SIG 5 will increase to a moderate condition under Scenario 2.

Table 12 Future condition for each of the Clear Lake population analysis units and the overall future condition of the Clear Lake hitch under Scenario 2 (Service 2020, p. 81, Table 6.3a). See Table 13 for the detailed future recruitment analysis under Scenario 2 (Service 2020, p. 82, Table 6.3b).

Clear Lake Population Analysis Unit (AU)	Demographic Factors		Habitat Elements				Future Condition
	Reproduction	Recruitment (see Table 13 or 6.3b)	Connectivity	Tributary Water Quantity	Wetland/ Tule Habitat	Lake Water Quality	
Cole Creek (SIG1)	High	Moderate	High	Moderate	Moderate	Moderate	Moderate
Kelsey Creek (SIG2)	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Clear Lake, Adobe Creek (SIG3)	High	High	Moderate	Moderate	Moderate	Moderate	Moderate
Rodman Slough (SIG4)	Moderate	High	High	Moderate	Moderate	Moderate	Moderate
Middle Creek, Clover Creek, Seigler Canyon Creek (SIG5)	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Overall Condition	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Table 13 Future recruitment condition analysis for the Clear Lake population of Clear Lake hitch under Scenario 2 (Service 2020, p. 82, Table 6.3b).

Clear Lake Population Analysis Unit (AU)	Demographic Factor - Recruitment		Overall Future Recruitment Condition
	Wetland Habitat	Otolith Analysis	
Cole Creek (SIG1)	High	Moderate	Moderate
Kelsey Creek (SIG2)	Low	Moderate	Moderate
Clear Lake, Adobe Creek (SIG3)	High	High	High
Rodman Slough (SIG4)	High	High	High
Middle Creek, Clover Creek, Seigler Canyon Creek (SIG5)	High	Moderate	Moderate

Overall Clear Lake Population – Under Scenario 2, the Clear Lake population maintains a moderate level of resiliency, although a majority of factors/elements increase in condition due to the implementation of restoration efforts throughout the watershed. The effects of climate change, specifically increased aridity, may reduce or eliminate stream based spawning in some years; however, future climate change projections do not predict increased aridity every year and the hitch will still have the ability to spawn in other lake based habitats when drought conditions do occur.

Table 14 Future resiliency for each of the Clear Lake hitch populations under Scenario 2 (Service 2020, p. 82, Table 6.4)

Population	Demographic Factors		Habitat Elements				Future Condition
	Reproduction	Recruitment	Connectivity	Tributary Water Quantity	Wetland/ Tule Habitat	Lake Water Quality	
Thurston Lake	--	--	--	--	--	--	Moderate
Clear Lake	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Scenario 2 provides an idea of the Clear Lake hitch's best possible condition over the next 50 years. This scenario presumes all of the analysis units within the Clear Lake population are able to maintain or improve their current condition. Because most restoration activities are likely to be concentrated on tributaries to Clear Lake and the lake itself, and climate change impacts will be felt throughout the watershed, the resiliency of Thurston Lake will decrease from high to moderate. Under Scenario 2, all five analysis units within the Clear Lake population would be at a moderate condition.

Although Scenarios 1 and 2 both project an overall moderate condition for the Clear Lake population, most of the demographic and habitat conditions increase under Scenario 2. This suggests the Clear Lake population is more resilient under Scenario 2 compared to Scenario 1, and the population would be more likely to maintain this moderate level of resiliency into the future.

Over the next 50 years, this scenario is not the most likely to occur because large scale

restoration projects like the Middle Creek Project and numerous small scale restoration projects spread throughout the watershed will require a lot of money and coordination. It is possible a small subset of restoration projects could occur over the next 50 years, potentially even the Middle Creek Project; however, the wide scale restoration of the entire watershed as described in this scenario is not likely to be completed within the 50-year timeframe.

Representation

Under Scenario 2, the Clear Lake hitch will continue to have a low level of representation. Although conditions will improve throughout portions of the watershed, the hitch will still be restricted to the same watershed, will continue to occupy the same ecological niche, and will continue to have the current spawning strategies available in the future. Therefore, the level of representation will not change under this scenario.

Redundancy

The Clear Lake hitch will likely continue to maintain its current moderate level of redundancy under Scenario 2, even with improved conditions throughout most of the watershed. Because the hitch occurs within a narrow range, and the entire subspecies could be susceptible to a potential catastrophic event, the hitch will never be at a high level of redundancy. Under this scenario, both populations and the different natal habitat types within each population will continue to be maintained.

Scenario 3

Under Scenario 3, some of the risks we forecasted would continue to occur, and some that are predicted to stay constant may increase. In this scenario, climate change results in more arid conditions throughout the hitch's range and impacts from increased fire and flooding will increase erosion occurring in the tributary streams, further decreasing water quality within the lake to a low condition. As conditions worsen in the tributary streams, the hitch will have to increasingly rely on spawning in the lake or in the mouths of streams. In addition, under this scenario, agricultural production slightly increases in areas currently not prioritized by SGMA, no or very few small-scale restoration projects have been implemented, the Middle Creek Project has not been constructed, and no passage barriers have been removed. Under Scenario 3, Lake County's shoreline ordinance will continue to limit tule habitat loss and take of individuals will be limited by CESA. A detailed analysis of each Clear Lake population analysis unit is shown in Tables 15 and 16 (Service 2020, p. 84, Tables 6.5a and 6.5b). The future condition of each Clear Lake hitch population under Scenario 3 is shown in Table 17 (Service 2020, p. 85, Table 6.6).

Resiliency

Thurston Lake Population

Thurston Lake – Similar to Scenarios 1 and 2, the resiliency of the Thurston Lake population in Scenario 3 will decline to a moderate level due to effects from climate change. Climate change will impact this population by reducing the availability of spawning habitats in some years. The one tributary stream to the lake, Thurston Creek, may not have continual flow to accommodate spawning every year and the water quality within the lake will likely decrease.

Clear Lake Population

SIG 1 (Cole Creek) – In Scenario 3, SIG 1 experiences an increase in aridity during some years due to climate change. The increase in aridity will reduce tributary availability and natal habitat variety, reducing reproduction and connectivity within the analysis unit. Under this scenario, the condition of SIG 1 would decline to low resiliency.

SIG 2 (Kelsey Creek) – SIG 2 experiences an increase in aridity during some years due to climate change in this scenario. Similar to SIG 1, the increase in aridity would reduce natal habitat variety and tributary availability, reducing both reproduction and recruitment to a moderate and low level, respectively. In Scenario 3, the resiliency of SIG 2 will decrease to low.

SIG 3 (Adobe Creek and Clear Lake) – The resiliency of the SIG 3 analysis unit will decrease to a low condition under Scenario 3 for the same reasons SIG 2 declined. Although reproduction and recruitment decline under this scenario, they only decline to a moderate condition. This is due to the presence of the lake within this unit and the increasing reliance on the lake for spawning during drought conditions.

SIG 4 (Rodman Slough) – Conditions in SIG 4 under Scenario 3 will decrease to a low condition. The increase in aridity due to climate change will reduce flow conditions within the tributary streams, reducing connectivity throughout the watershed. Because this unit includes a backwater-like area of the lake, the condition of reproduction and recruitment is maintained at moderate.

SIG 5 (Middle, Clover, and Seigler Canyon Creeks) – Under Scenario 3, the condition of the SIG 5 analysis unit is maintained at low, with reductions in the conditions of some factors/elements. Effects from climate change and a slight increase in agricultural production will reduce tributary availability during the spawning season and ultimately, reproduction.

Table 15 Future condition for each of the Clear Lake population analysis units and the overall future condition of the Clear Lake hitch under Scenario 3 (Service 2020, p. 15, Table 6.5a). See Table 16 for the detailed future recruitment analysis under Scenario 3 (Service 2020, p. 84, Table 6.5b).

Clear Lake Population Analysis Unit (AU)	Demographic Factors		Habitat Elements				Future Condition
	Reproduction	Recruitment (see Table 16 or 6.5b)	Connectivity	Tributary Water Quantity	Wetland/ Tule Habitat	Lake Water Quality	
Cole Creek (SIG1)	Low	Low	Moderate	Low	Low	Low	Low
Kelsey Creek (SIG2)	Moderate	Low	Low	Low	Low	Low	Low
Clear Lake, Adobe Creek (SIG3)	Moderate	Moderate	Low	Low	Low	Low	Low
Rodman Slough (SIG4)	Moderate	Moderate	Moderate	Low	Low	Low	Low
Middle Creek, Clover Creek, Seigler Canyon Creek (SIG5)	Low	Low	Low	Low	Low	Low	Low
Overall Condition	Low	Low	Low	Low	Low	Low	Low

Table 16 Future recruitment condition analysis for the Clear Lake population of Clear Lake hitch under Scenario 3 (Service 2020, p. 84, Table 6.5b).

Clear Lake Population Analysis Unit (AU)	Demographic Factor - Recruitment		Overall Recruitment Condition
	Wetland Habitat	Otolith Analysis	
Cole Creek (SIG1)	Low	Low	Low
Kelsey Creek (SIG2)	Low	Low	Low
Clear Lake, Adobe Creek (SIG3)	Low	Moderate	Moderate
Rodman Slough (SIG4)	Moderate	Moderate	Moderate
Middle Creek, Clover Creek, Seigler Canyon Creek (SIG5)	Low	Low	Low

Overall Clear Lake Population – Under Scenario 3, the Clear Lake population declines to a low level of resiliency. The effects of climate change may reduce or eliminate stream based spawning in some years and will likely increase tributary erosion due to increased incidence of fire and flooding, further reducing lake water quality. Increased reliance on water resources for agricultural purposes further reduce the amount of water retained within tributary streams, especially during drought conditions.

Table 17 Future resiliency for each of the Clear Lake hitch populations under Scenario 3 (Service 2020, p. 85, Table 6.6).

Population	Demographic Factors		Habitat Elements				Future Condition
	Reproduction	Recruitment	Connectivity	Tributary Water Quantity	Wetland/ Tule Habitat	Lake Water Quality	
Thurston Lake	--	--	--	--	--	--	Moderate
Clear Lake	Low	Low	Low	Low	Low	Low	Low

Scenario 3 provides an idea of the Clear Lake hitch's condition over the next 50 years when the effects of agricultural production slightly increase in areas where production is not currently concentrated, effects from climate change impact the entire watershed, and little to no restoration actions occur in the watershed. Overall, Thurston Lake would decline to a moderate condition and the Clear Lake population would decline to a low condition. Within the Clear Lake population, SIG's 1-4 would all decline to a low condition and SIG 5 would be maintained at a low condition.

Over the next 50 years, this scenario could occur, but is not the most likely. Effects due to climate change are projected to continue and the amount of water use within the watershed will likely only slightly increase due to urban development and agricultural production within the Clear Lake area over time. With the implementation of SGMA, analysis units within the Big Valley groundwater basin may not experience any increase in agriculture; however, this may not limit agricultural expansion into the other groundwater basins within the range. This scenario is not the most likely because various restoration projects have been periodically implemented

throughout the watershed and the lack of restoration described under this scenario is not likely to occur, although it is possible.

Representation

Clear Lake hitch representation under Scenario 3 will continue to be at a low level. Because of deteriorated conditions throughout the watershed, the hitch may not have all spawning strategies to utilize in any given year.

Redundancy

Under Scenario 3, the level of redundancy for the Clear Lake hitch will likely decrease to low. Although both populations will still be extant, the Thurston Lake population will decline to moderate resiliency and the Clear Lake population will decline to low resiliency due to the deteriorated condition of the watershed under this scenario. In addition, each of the different natal habitats available to each of the populations may no longer be available or may have only limited availability in the future. The availability of tributary streams for the Clear Lake population in particular are likely to decrease. Under this scenario, the Clear Lake hitch would be particularly susceptible to a potential catastrophic event.

Summary of Future Condition

We used the best available information to forecast the likely future condition of the Clear Lake hitch. Our goal was to describe the viability of the hitch in a manner that will address its needs in terms of resiliency, representation, and redundancy. We considered the possible future condition of the Clear Lake hitch under three different potential scenarios, using the following current and future influencing factors consistently throughout each scenario:

1. The loss spawning habitat due to past watershed modifications that have blocked access to or altered the flow regime of tributary streams. The lack of consistent tributary flow will continue due to the effects of past instream gravel mining, deforestation, and grazing practices, existing flood control project infrastructure, fire activity, and water utilization for agricultural and urban uses. We do not expect the rate of agricultural production or urban development to increase substantially into the future. Furthermore, future climate change is projected to further exacerbate the degradation and inaccessibility of tributary streams by increasing the incidence of fire activity, flood events, and aridity. Various passage barriers, both physical barriers and lack of flow, will continue to persist in the watershed;

2. The loss of wetland/tule habitat. The current remaining wetland/tule habitat surrounding the lake will persist into the future, primarily due to the implementation of Lake County's shoreline ordinance;

3. Continued reductions in lake water quality due to the past loss of wetland/tule habitat surrounding the lake, contamination from past mercury mining along the lake's shore and pesticide use for agricultural and urban uses, the input of sediment and nutrients from degraded tributary streams, and nutrient inputs from surrounding urban and agricultural development. As mentioned above, we do not project agricultural production or urban development to increase substantially into the future. Increased nutrient and sediment

inputs continue to contribute to periodic cyanobacteria blooms, further reducing water quality. Periodic fish kills continue to occur;

4. Non-native fish species are still established within the lake from past introductions; and

5. Drought incidence and intensity increase due to climate change, reducing tributary flow during the spawning season in some years; and

6. The implementation of current regulatory mechanisms (i.e., CESA, Lake County's Clear Lake Shoreline Ordinance) and management actions (i.e., Lake County's Aggregate Resources Management Plan, other miscellaneous restoration actions occurring throughout the watershed).

These influencing factors were used to assess the possible future condition of the Clear Lake hitch under three different scenarios, in terms of the 3 Rs. These influencing factors are likely to continue to both negatively and positively affect the Clear Lake hitch, primarily due to reductions or increases in reproductive success, recruitment, and survival. A summary of our analysis under each of the three different potential future scenarios are as follows (Tables 18 and 19) (Service 2020, p. 87, Tables 6.7 and 6.8):

> **Scenario 1**, those factors that are currently having an influence on each of the Clear Lake hitch populations continue at current rates, or may slightly increase, for all of the influencing factors. Under Scenario 1, we project both Clear Lake hitch populations would be at moderate condition.
>
> **Scenario 2**, those factors that are currently having a negative influence on each of the Clear Lake hitch populations continue at current rates, or slightly increase. Scenario 2 is the best-case scenario for the Clear Lake hitch because all of the analysis units within the Clear Lake population either retain or improve their current condition due to restoration and enhancement activities being implemented throughout the watershed. Under Scenario 2, we project both Clear Lake hitch populations would be at a moderate condition.
>
> **Scenario 3:** Under Scenario 3, some of the risks would continue to occur at their current rates, and some that are predicted to stay constant may increase. In Scenario 3 we project the Thurston Lake population would decline to a moderate condition and the Clear Lake population would decline to a low condition.

Table 18 Summary of Clear Lake population analysis unit resiliency under current conditions and under each future scenario (Service 2020, p. 87, Table 6.7)

Clear Lake Population Analysis Unit (AU)	Current Condition	Scenario 1 Future Condition	Scenario 2 Future Condition	Scenario 3 Future Condition
Cole Creek (SIG1)	Moderate	Moderate	Moderate	Low
Kelsey Creek (SIG2)	Moderate	Moderate	Moderate	Low
Clear Lake, Adobe Creek (SIG3)	Moderate	Moderate	Moderate	Low
Rodman Slough (SIG4)	Moderate	Moderate	Moderate	Low
Middle Creek, Clover Creek, Seigler Canyon Creek (SIG5)	Low	Low	Moderate	Low

Table 19 Summary of Clear Lake hitch population resiliency under current conditions and each of the future scenarios (Service 2020, p.87, Table 6.8).

Population	Current Condition	Scenario 1 Condition	Scenario 2 Condition	Scenario 3 Condition
Thurston Lake	High	Moderate	Moderate	Moderate
Clear Lake	Moderate	Moderate	Moderate	Low

The Clear Lake hitch faces a variety of risks from habitat loss, degradation, and modification, increased predation and competition from the introduction of non-native fish, drought, and climate change. These risks, and the level in which they act upon the Clear Lake watershed, play a large role in the future viability of the Clear Lake hitch. If populations lose resiliency, the subspecies overall will have a further reduced level of representation and redundancy, which increases their risk of extirpation.

FINDING:

Determination of Species Status

Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species meets the definition of "endangered species" or "threatened species." The Act defines an "endangered species" as a species that is "in danger of extinction throughout all or a significant portion of its range," and a "threatened species" as a species that is "likely to become an endangered species within the foreseeable future, throughout all or a significant portion of its range." The Act requires that we determine whether a species meets the definition of "endangered species" or "threatened species" because of any of the following factors (section 4(a)(1) factors):

(A) The present or threatened destruction, modification, or curtailment of its habitat or range;
(B) Overutilization for commercial, recreational, scientific, or educational purposes;
(C) Disease or predation;
(D) The inadequacy of existing regulatory mechanisms; and
(E) Other natural or manmade factors affecting its continued existence.

After evaluating threats to the species under the section 4(a)(1) factors, as described above, including conservation measures and existing regulatory mechanisms, we determined that the Clear Lake Hitch is primarily threatened by habitat loss, degradation, and modification (Factor A) [(due to the loss and degradation of spawning habitat (Factor A), the loss of wetland/tule habitat (Factor A), and poor lake water quality (Factor A)], increased predation and competition (Factor C), drought (Factor E), and climate change (Factor E). Threats eliminated from the analysis due to lack of supportive data include commercial and recreational fishing (Factor B), tribal harvest (Factor B), and disease (Factor C).

The Clear Lake hitch is a subspecies of fish in the freshwater minnow family Cyprinidae and is restricted to the Clear Lake watershed in Lake County, California. Clear Lake is located approximately 100 miles north of San Francisco in the Coast Ranges and experiences hot, dry summers and cool, wet winters, with most precipitation occurring from November to March. The lake is fed by numerous tributaries, most of which are ephemeral and low gradient as they drain into the lake.

Historically, the Clear Lake hitch occurred in several lakes and ponds found throughout the Clear Lake watershed, including: Clear Lake, Thurston Lake, Upper Blue Lake, Lower Blue Lake, and Lampson Pond. During the spring, the Clear Lake hitch were also found in the numerous tributaries to these larger water bodies, including: Kelsey, Scott, Middle, Adobe, Seigler Canyon, Manning, Cole, Morrison, and Schindler Creeks. Currently, the hitch is thought to be extirpated from the Blue Lakes, but still resides in Clear and Thurston Lakes throughout the year. In the spring, reproductive adults migrate into tributary streams to spawn. Although the Clear Lake hitch has been described as once occurring in Lampson Pond, and the location of Lampson Pond has been approximated, it is unclear whether Lampson Pond still exists since both field surveys and visual inspections of maps have failed to detect this pond (B. Ewing in litt. 2020). Therefore, since the status of Lampson Pond is unknown, the status of the Clear Lake hitch within the pond is also unknown.

The Clear Lake hitch grows much faster than other subspecies of hitch (i.e., Monterey hitch (*Lavinia exilicauda harengus*) and Sacramento hitch (*Lavinia exilicauda exilicauda*)) found in lacustrine environments, most likely due to Clear Lake's high productivity and high water temperatures. Females are known to grow larger than males and while males are sexually mature within their first or second year, females are sexually mature in their second or third year. Clear Lake hitch are thought to live 4 to 6 years, but it is possible some individuals can live longer, to 7 or 8 years. Because Clear Lake hitch females are much larger than the other subspecies of hitch within California, they are more fecund. A female Clear Lake hitch that is reproductive at age 3 and lives to age 6 could produce, on average, over 100,000 eggs in her lifetime.

For most of the year, Clear Lake hitch are only found within their lacustrine environment. However, between February and May, a portion of the overall reproductive population begin to migrate into the surrounding tributaries to spawn. Spawning activities include one to five males pursuing a gravid female to fertilize her freshly extruded eggs, which are deposited on fine to medium sized gravel within the tributary stream. Fertilized eggs develop and hatch within 7 to 10 days, fry are free-swimming after another 7 to 10 days, and young migrate to the lake at about a

month old before the streams dry up. Juvenile hitch are found within the nearshore habitat of the lake where they depend on submerged aquatic vegetation for cover and prey (such as adult midges, zooplankton, and other invertebrates). Juvenile hitch move from the nearshore portion of the lake into open water in early- to late-fall. There is evidence that Clear Lake hitch do not require tributary streams with gravel to spawn, but can also spawn successfully in different portions of the lake (i.e., along the shore, the mouths of tributaries, and Rodman Slough) that lack a gravel substrate.

Determination of Status Throughout All of Its Range

We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats to the Clear Lake hitch. Potential threats which may affect the Clear Lake hitch or its habitat include habitat loss, degradation, and modification (Factor A) [(due to the loss and degradation of spawning habitat (Factor A), the loss of wetland/tule habitat (Factor A), and poor lake water quality (Factor A)], predation and competition (Factor C), drought and climate change (Factor E). As described in the Clear Lake hitch SSA we also examined three possible scenarios (Future Scenarios 1, 2, and 3) to give an idea of the breadth of possible future outcomes for the viability of the Clear Lake hitch. For these scenarios, we chose a forecast timeframe of 50 years because that is long enough to capture the temporal range of the available climate model projections; however, beyond that timeframe, the level of uncertainty becomes high, making predictions of the future less dependable. In addition, we expect that a timeframe of 50 years in the future will encompass similar variability for the species and its environment as 50 years in the past.

All threats, as identified above, are acting on the Clear Lake hitch currently and into the future. The Clear Lake hitch faces a variety of risks from habitat loss, degradation, and modification, increased predation and competition from the introduction of non-native fish, drought, and climate change. These risks, and the level in which they act upon the Clear Lake watershed, play a large role in the future viability of the Clear Lake hitch. If populations lose resiliency, the subspecies overall would have a further reduced level of representation and redundancy, which increases their risk of extirpation. Over the next 50 years, we expect climate change is likely to continue (thereby increasing the likelihood of aridity, fire incidence, and flood incidence), future drought conditions are likely to increase, CESA would continue to limit direct take, the Lake County shoreline ordinance would continue to maintain the existing amount of available wetland/tule habitat surrounding the lake, and current small scale restoration projects would continue to be implemented into the future. Under these conditions, we expect that the Clear Lake hitch will continue to maintain a moderate level of resiliency and current low and moderate level of representation and redundancy, respectively.

After further examination of the threats and a range of future scenarios, we have determined that habitat degradation, predation and competition, drought and climate change are not likely to adversely affect the overall viability of the Clear Lake hitch to a point that the species meets the definition of a threatened or endangered species. This is due to the Clear Lake hitch's life history which includes a long life span, high fecundity, and the ability to utilize different spawning strategies, demonstrating its behavioral flexibility to variable environmental conditions. The Clear Lake hitch is a long-lived minnow (possibly up to 7 or 8 years) with high fecundity, which provides it some increased resiliency when faced with challenging environmental conditions. In

addition, there is evidence that Clear Lake hitch is not limited to spawning in tributary streams with gravel, but can also spawn successfully in different portions of the lake (i.e., along the shore, in the mouths of tributaries, and in Rodman Slough) that lack a gravel substrate. This demonstrates the ability of the hitch to exhibit some level of behavioral flexibility and adjust to changing environmental conditions. Furthermore, there continue to be ongoing Federal, State, and County land management actions including Lake County's Aggregate Resources Management Plan, SGMA, Lake Shoreline Ordinance, and other miscellaneous restoration actions occurring throughout the watershed that would continue to help ameliorate or reduce the impact of those threats and protect the Clear Lake hitch and its habitat now and into the foreseeable future. The Chi Counsel, local Pomo tribes, Blue Ribbon Group, and CDFW are likely to continue to work towards restoring tributary streams, restoring lake shore habitat, and addressing fish passage barriers.

The Clear Lake hitch resiliency is measured by assessing the subspecies demographic factors of reproduction and recruitment, and habitat elements of connectivity, lake water quality, tributary water quantity, and availability of wetland/tule habitat. Overall, the resiliency ranges high/moderate currently and should maintain moderate/moderate (Future Scenario 1 & 2) or moderate/low (Future Scenario 3) for the Thurston Lake and Clear Lake populations, respectively, in the future.

Clear Lake hitch redundancy, in the SSA, is measured by the number, resiliency of, and distribution of populations throughout its extant range, which includes a population that occupies Thurston Lake and its tributary Thurston Creek, and one that occupies Clear Lake and its tributaries. We concluded that with two populations the Clear Lake Hitch has always had a moderate level of redundancy because they always had a limited distribution and would likely maintain that status in the future. Within the Clear Lake population, there may be additional redundancy based on the variety of available spawning habitat (tributary, lake or interface between the two) and the number of available tributary streams within the watershed.

Clear Lake Hitch representation in the SSA is the ability of the species to adapt to changing environmental conditions and is measured by the breadth of genetic or environmental diversity within and among the populations. The Clear Lake hitch has never had much environmental diversity and we assume the species doesn't have much genetic diversity because the species has always occupied such a narrow range with very similar habitat characteristics. Because the species lacks genetic and/or environmental diversity, it likely never had a high level of representation and will likely maintain its low representation status currently and into the future. Having different spawning strategies available to each population under variable environmental conditions helps maintain some level of representation, although still within a low range. Drought and climate change would likely affect both populations equally throughout the entire range since they are in such close proximity to each other. Therefore, having different reproductive strategies is advantageous to the species, which can help it respond to changing environmental conditions where there may be future increasing drought conditions and/or climate change.

There are threats such as habitat degradation, predation/competition, drought and climate change that may act together to affect the Clear Lake hitch. Climate change can cause drought conditions

to increase. Wetland habitat loss and drought can result in increased predation pressure and competition. Past habitat loss has left only a small proportion of wetland habitat surrounding Clear Lake and drought conditions can reduce the amount of emergent vegetation growth within those remaining wetland habitats. This reduction in emergent vegetative growth reduces the amount of cover the hitch uses to hide from predators, increasing predation pressure. It can also increase competition as more fish concentrate into this limited habitat type. Although many of the activities that have contributed to habitat degradation throughout the watershed are no longer occurring, they are having lasting impacts on the watershed. The threat of predation/competition is not being addressed currently, and although we do not actually know the level of impact this threat is having on the species due to lack sufficient data, we do not believe it is cause for concern for the overall viability of the species. The threat of drought is also not currently being addressed, but drought conditions are a natural occurrence and the Clear Lake hitch's different spawning strategies and long lifespan are likely adaptations or responses to natural drought conditions. In addition, some of the threats affecting the Clear Lake hitch have been reduced and are anticipated to continue to be reduced by existing management practices developed by the tribes, City, County, State and Federal land management agencies. These actions are anticipated to continue to provide both direct and indirect benefits to Clear Lake hitch by maintaining and/or improving the quality of habitats used by the species.

Based on our review of the best available scientific and commercial information pertaining to the five factors, we find that the threats acting on the species and its habitat, are not of sufficient imminence, intensity, or magnitude to indicate that the Clear Lake hitch is in danger of extinction (an endangered species) throughout all of its range, or likely to become endangered within the foreseeable future (a threatened species) throughout all of its range. Many threats are continuing to impact the Clear Lake hitch and its habitat, and effects from drought and climate change would likely result in a decrease in habitat quality and quantity across the species' range during some years. However, the Clear Lake hitch has shown variability in spawning strategies, has a long life span, and is highly fecund, indicating that they may be adaptable to changing environmental conditions. Additionally, regulatory mechanisms such as CESA and local ordinances are currently acting to ameliorate the severity of some existing threats, such as the take of individuals, degradation of tributary streams, and loss of wetland habitat surrounding Clear Lake. Furthermore, the SSA presented three plausible future scenarios, which included various states of potential future conditions for the species. Our analysis of these scenarios indicates that the Clear Lake hitch will maintain its current resiliency, representation, or redundancy, or undergo only a slight decrease in condition into the foreseeable future. Even under a projection of a slight decrease in future condition, the Clear Lake hitch was not projected to be in danger of extinction in the next 50 years. Therefore, after evaluating threats to the species under the section 4(a)(1) factors, we considered whether the Clear Lake hitch meets either of these definitions, and find that the Clear Lake hitch is not likely to become endangered in the foreseeable future throughout all of its range, nor is it in danger of extinction throughout all of its range.

Because we determined that the Clear Lake hitch is not in danger of extinction or likely to become so in the foreseeable future throughout all of its range, we will consider whether the

Clear Lake hitch is in danger of extinction now or likely to become so in the foreseeable future throughout a significant portion of its range.

Determination of Status Throughout a Significant Portion of Its Range (SPR)

Under the Act and our implementing regulations, a species may warrant listing if it is in danger of extinction or likely to become so in the foreseeable future throughout all or a significant portion of its range (SPR). Having determined that the Clear Lake hitch is not in danger of extinction now or likely to become so in the foreseeable future throughout all of its range, we now consider whether it may be in danger of extinction or likely to become so in the foreseeable future in an SPR. The range of a species can theoretically be divided into portions in an infinite number of ways, so we first screen the potential portions of the species' range to determine if there are any portions that warrant further consideration. To do this we look for portions of the species' range for which there is substantial information indicating that: (1) the portion may be significant, and (2) the species may be in danger of extinction or likely to become so in the foreseeable future in that portion. For a particular portion, if we cannot answer both questions in the affirmative, then that portion does not warrant further consideration and the species does not warrant listing because of its status in that portion of its range. We emphasize that answering these questions in the affirmative is not a determination that the species is in danger of extinction or likely to become so in the foreseeable future throughout a significant portion of its range—rather, it is a step in determining whether a more detailed analysis of the issue is required.

If we answer these questions in the affirmative, we then conduct a more thorough analysis to determine whether the portion does indeed meet both of the "significant portion of its range" prongs: (1) the portion is significant and (2) the species is, in that portion, either in danger of extinction or likely to become so in the foreseeable future. Confirmation that a portion does indeed meet one of these prongs does not create a presumption, prejudgment, or other determination as to whether the species is endangered species or threatened species. Rather, we must then undertake a more detailed analysis of the other prong to make that determination. Only if the portion does indeed meet both prongs would the species warrant listing because of its status in a significant portion of its range.

At both stages in this process—the stage of screening potential portions to identify any portions that warrant further consideration and the stage of undertaking the more-detailed analysis of any portions that do warrant further consideration—it might be more efficient for us to address first the "significance" question or the "status" question. Our selection of which question to address first for a particular portion depends on the biology of the species, its range, and the threats it faces. Regardless of which question we address first, if we reach a negative answer with respect to the first question that we address, we do not need to evaluate the second question for that portion of the species' range.

For Clear Lake hitch, we chose to evaluate the status question (i.e., identifying portions where Clear Lake hitch may be in danger of extinction or likely to become so in the foreseeable future) first. To conduct this screening, we considered whether the threats are geographically concentrated in any portion of the species' range at a biologically meaningful scale. The range of the species, Clear Lake and its tributaries, and Thurston Lake and Thurston Creek, are

geographically close to each other. We examined whether any of the following threats: habitat degradation and modification, predation and competition, drought and climate change, may be acting in some portion of this limited range at a greater scale or magnitude than elsewhere. Due to the close proximity of these two locations, we find that the identified threats are acting uniformly throughout the range. Therefore, we found no concentration of threats in any portion of the Clear Lake hitch's range at a biologically meaningful scale.

If both (1) a species is not in danger of extinction or likely to become so in the foreseeable future throughout all of its range and (2) the threats to the species are essentially uniform throughout its range, then the species could not be in danger of extinction or likely to become so in the foreseeable future in any biologically meaningful portion of its range. For the Clear Lake hitch, we found both: the species is not in danger of extinction or likely to become so in the foreseeable future throughout all of its range, and there is no geographical concentration of threats so the threats to the species are essentially uniform throughout its range. Therefore, we conclude, based on this screening analysis, that no portions warrant further consideration through a more detailed analysis, and the species is not in danger of extinction or likely to become so in the foreseeable future in any significant portion of its range. In making this finding, we strove to be consistent with the courts' holdings in *Desert Survivors v. Department of the Interior*, No. 16-cv-01165-JCS, 2018 WL 4053447 (N.D. Cal. Aug. 24, 2018); *Center for Biological Diversity v. Jewell*, 248 F. Supp. 3d, 946, 959 (D. Ariz. 2017); and *Center for Biological Diversity v. Everson*, 2020 WL 437289 (D.D.C. Jan. 28, 2020).

Determination of Status

Our review of the best available scientific and commercial information indicates that the Clear Lake hitch does not meet the definition of an endangered species or a threatened species in accordance with sections 3(6) and 3(20) of the Endangered Species Act. Therefore, our review of the best available scientific and commercial information regarding the past, present, and future threats to Clear Lake Hitch indicates that the Clear Lake Hitch is not in danger of extinction nor likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Therefore, we find that listing the Clear Lake hitch as an endangered or threatened species under the Act is not warranted at this time.

COORDINATION WITH STATES:

The Clear Lake hitch was listed as threatened under the California Endangered Species Act in 2014. In preparing this finding, we coordinated with the California Department of Fish and Wildlife (CDFW) and through our initial letter to partners and during peer and partner review of the Clear Lake Hitch Species Status Assessment**.** CDFW commented on our Clear Lake Hitch Species Status Assessment and we incorporated this information into our analysis. We continue to coordinate with CDFW on conservation of the Clear Lake hitch.

BATCHED NOTICE LANGUAGE:

The Clear Lake hitch (hitch) (*Lavinia exilicauda chi*) is a large cyprinid (freshwater minnow) that is endemic to the Clear Lake watershed in Lake County, California. The U.S. Fish and Wildlife Service (Service) received a petition from the Center for Biological Diversity on

September 25, 2012 (CBD 2012, entire), to list the Clear Lake hitch as threatened or endangered under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543) (Act). The Service issued a 90-day finding on April 10, 2015 (80 FR 19259), stating the petition presented substantial information that listing the Clear Lake hitch may be warranted. This conclusion was based on our review of the petition and sources cited in the petition, indicating that the petitioned action may be warranted due to: (1) the present or threatened destruction, modification, or curtailment of the species' habitat or range from urban and agricultural development, dams, water diversions, migration barriers, mining activities, and grazing; (2) overutilization for commercial fishing, recreational fishing, and tribal harvest; (3) disease and predation; and (4) other natural or manmade factors affecting its continued existence, including effects from climate change, contaminants, and introduced fish. Therefore, a review of the status of the hitch was initiated to provide the scientific information from which a determination would be made. Based on the information prepared for the Clear Lake Hitch Species Status Assessment (SSA), the Service is issuing this 12-month finding for the Clear Lake hitch. This notice constitutes the 12-month finding on the September 25, 2012, petition request to list the Clear Lake hitch.

Historically, the Clear Lake hitch occurred in several lakes and ponds found throughout the Clear Lake watershed, including: Clear Lake, Thurston Lake, Upper Blue Lake, Lower Blue Lake, and Lampson Pond. During the spring, Clear Lake hitch were also found in the numerous tributaries to these larger water bodies, including: Kelsey, Scott, Middle, Adobe, Seigler Canyon, Manning, Cole, Morrison, and Schindler Creeks. All of the waterbodies, listed above, with the exception of Thurston Lake were hydrologically connected to each other in the past and it appears that Thurston Lake and its tributary, Thurston Creek, have always been isolated from the other waterways. Local opinion is that hitch were introduced into Thurston Lake by a local resident less than 50 years ago. The Clear Lake hitch is restricted to the Clear Lake watershed in Lake County, California, in the central Coast Range mountains. Currently, the hitch is thought to be extirpated from the Blue Lakes, but still occurs in Clear and Thurston Lakes throughout the year. In the spring, reproductive adults migrate into tributary streams to spawn and then migrate back to the lakes after spawning. It is unclear whether Lampson Pond still exists (B. Ewing *in litt.* 2020); therefore, the status of the Clear Lake hitch in Lampson Pond is unknown.

For most of the year, Clear Lake hitch are only found within their lacustrine environment. However, between February and May, a portion of the overall reproductive population begins to migrate into the surrounding tributaries to spawn. Spawning activities include one to five males pursuing a gravid female to fertilize her freshly extruded eggs, which are deposited on fine to medium sized gravel within the tributary stream. Fertilized eggs develop and hatch within 7 to 10 days, fry are free-swimming after another 7 to 10 days, and young migrate to the lake at about a month old before the streams dry up. Juvenile hitch are found within the nearshore habitat of the lake where they depend on submerged aquatic vegetation for cover and prey. Juvenile hitch move from the nearshore portion of the lake into open water in early-to late-fall. There is evidence that Clear Lake hitch do not require tributary streams with gravel to spawn, but can also spawn successfully in different portions of the lake (i.e., along the shore, the mouths of tributaries, and Rodman Slough) that lack a gravel substrate.

We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats to the Clear Lake hitch, and we evaluated all relevant factors under the five listing factors, including any regulatory mechanisms and conservation measures addressing these stressors. The primary stressors affecting the Clear Lake hitch's biological status include habitat degradation, predation and competition, drought and climate change. Based on our examination of the best available scientific information, we have determined that habitat degradation, predation and competition, drought and climate change are not likely to adversely affect the overall viability of the Clear Lake hitch in a biologically meaningful way to such an extent that the species is in danger of extinction or likely to become so in the foreseeable future throughout all or a significant portion of its range for the following reasons: 1) the Clear Lake hitch has a long life span, 2) the Clear Lake hitch are highly fecund, and 3) the Clear Lake hitch has shown the ability to utilize different spawning strategies, which demonstrates its behavioral flexibility to variable environmental conditions. Additionally, regulatory mechanisms such as CESA and local ordinances are currently acting to ameliorate the severity of some existing threats, such as the take of individuals, degradation of tributary streams, and loss of wetland habitat surrounding Clear Lake. Furthermore, the SSA presented three plausible future scenarios, which included various states of potential future conditions for the species. Our analysis of these scenarios indicates that the Clear Lake hitch will maintain its current resiliency, representation, or redundancy, or undergo only a slight decrease in condition into the foreseeable future. Even under a projection of a slight decrease in future condition, the Clear Lake hitch was not projected to be in danger of extinction in the next 50 years.

Therefore, we find that listing the Clear Lake hitch as an endangered or threatened species under the Act is not warranted at this time. A detailed discussion of the basis for this finding can be found in the Clear Lake hitch species assessment form and other supporting documents (see **ADDRESSES**, above).

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APPROVAL/CONCURRENCE:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: MICHAEL FRIS Digitally signed by MICHAEL FRIS Date: 2020.08.31 14:43:48 -07'00'

Regional Director, Fish and Wildlife Service Date

Concur: AURELIA SKIPWITH Digitally signed by AURELIA SKIPWITH Date: 2020.11.19 17:30:12 -05'00'

Director, Fish and Wildlife Service Date

Do not concur: _____

Director, Fish and Wildlife Service Date

Director's Remarks:

Date of annual review: September 7, 2020
Conducted by: Deborah Giglio, Deborah_giglio@fws.gov, (916) 414-6481