State of California
Department of Fish and Wildlife

Memorandum

Date: May ~~19~~ 28, 2014

To: Sonke Mastrup
Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: Status Review of Clear Lake Hitch

The Department of Fish and Wildlife (Department) has prepared the attached Status Review for receipt by the Fish and Game Commission (Commission) at its June 4, 2014 meeting in Fortuna. This Status Review regards the proposal to list Clear Lake hitch *(Lavinia exilicauda chi)* as threatened pursuant to the California Endangered Species Act (CESA), specifically Fish and Game Code section 2074.6. At a future meeting, the Commission will consider the Status Review report and other relevant information it receives to determine whether there is sufficient information to indicate the petitioned action is warranted (Fish & G. Code § 2075.5). I look forward to discussing this issue and our recommendation at that future Commission meeting.

You will recall that on January 31, 2013, the Department recommended to the Commission that there was sufficient information in the petition to indicate that listing may be warranted. On March 6, 2013, the Commission voted to accept the petition and initiate a review of the status of the species in California. Upon publication of the Commission's notice of determination, the Clear Lake hitch was designated a candidate species on March 22, 2013.

Following the Commission's determination, the Department notified affected and interested parties and solicited data and comments on the petitioned action per Fish & G. Code section 2074.4 (see also Cal. Code Regs, Title 14 § 670.1 (f)(2)). Subsequently, the Department commenced its review of the status of the species as required by Fish & G. Code section 2074.6 and Cal. Code Regs, Title 14, section 670.1 (f)(2). The attached Status Review represents the Department's final written review of the status of Clear Lake hitch. In preparing the evaluation and recommendation, the Department adhered to its legal obligation to base the document upon the best scientific information available at the time of preparation (Fish & G. Code § 2074.6)

The Department has reviewed the scientific information as guided by CESA and concluded that several factors represent a threat to the continued existence of the species. The Department considers present or threatened modification or destruction of habitat, predation, and competition to threaten the continued existence of the species (Cal. Code Regs, tit. 14, § 670.1 (i)(1)(A)). In addition, the anticipated impacts from climate change on native aquatic species also may cause threats to the continued existence of the species.

Having considered the CESA specific factors, the Department concludes that the best scientific information available to the Department indicates that the Clear Lake hitch's continued existence is threatened. It is the Department's recommendation that Clear Lake hitch is likely to become an endangered species in the foreseeable future in the absence of the protections and management efforts required by CESA, and the petitioned action is warranted.

If you have any questions or need additional information, please contact Dan Yparraguirre, Deputy Director, Wildlife and Fisheries Division at 916-653-4673 or Stafford Lehr, Chief, Fisheries Branch at 916-445-3181.

Attachment

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State of California
Natural Resources Agency
Department of Fish and Wildlife

REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF CLEAR LAKE HITCH (*Lavinia exilicauda chi*)

May 2014

Clear Lake hitch adult. Photo courtesy of Rick Macedo

Charlton H. Bonham, Director
California Department of Fish and Wildlife

Report to the Fish and Game Commission
A STATUS REVIEW OF CLEAR LAKE HITCH

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AMP	Adaptive Management Plan
BLM	U.S. Bureau of Land Management
BMPs	best management practices
CAP	Conceptual Area Protection Plan
CCCC	California Climate Change Center
CCCLH	Chi Council for Clear Lake Hitch
CDFG	California Department of Fish and Wildlife (formerly Game)
CDFW	California Department of Fish and Wildlife
CEPA	California Environmental Protection Agency
CESA	California Endangered Species Act
CLH	Clear Lake hitch
CLIWMP	Clear Lake Integrated Watershed Management Plan
cm	centimeters
CPUE	catch per unit effort
DDD	dichlorodiphenyldichloroethane
EPA	U.S. Environmental Protection Agency
EPEC	Erosion Prevention and Education Committee
GIS	geographic information system
IBI	index of biological integrity
KHV	koi herpes virus
LCVCD	Lake County Vector Control District
NEPA	National Environmental Policy Act
NGO	non-governmental organization
OHV	off-highway vehicle
RREC	Robinson Rancheria Environmental Center

SL	standard length
SSC	species of special concern
TMDL	total maximum daily load
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
YCFCWCD	Yolo County Flood Control and Water Conservation District

EXECUTIVE SUMMARY

On September 25, 2012, the Fish and Game Commission (Commission) received the petition from the Center for Biological Diversity to list Clear Lake Hitch (*Lavinia exilicauda chi*) (CLH) as threatened under the California Endangered Species Act (CESA) (Center for Biological Diversity 2012). The Commission accepted the Petition on March 6, 2013 and that action initiated the status review that culminated in this document.

The Clear Lake hitch (CLH) is a native minnow of the cyprinid family (Cyprinidae) that can be found only in Clear Lake, Lake County, CA. They ascend tributaries between February and June each year to spawn. Juvenile CLH migrate to the lake and remain near shore as they grow to adults, at which time they migrate to open water where physical adaptations allow for a limnetic lifestyle.

Historically, native fishes were abundant at Clear Lake. Accounts from Pomo tribe members and early European settlers speak of runs of native fish so thick the creeks were difficult to ford. Pomo tribes used CLH for food as well as trade for supplies unavailable to them in their native lands. Tribal members speak of capturing and drying thousands of fish per year to use as food and for trade.

Qualitative information indicates that both the number of spawning individuals and the number of occupied spawning tributaries are greatly reduced from historical levels. There is no quantitative scientific information over a long term, thus population trends are based on a combination of qualitative surveys conducted over the past 60 years.

This qualitative survey information indicates the population of CLH has fluctuated over the past century and the number of spawning tributaries used by CLH has fluctuated as well. This information adds to uncertainties about possible cause and effect relationships among and between CLH and threats to their continued existence.

The Department considers that there is sufficient scientific information to indicate that several factors are threats to the continued existence of CLH. Present or threatened modification or destruction of habitat is impacting the ability of CLH to spawn and rear young. Spawning tributaries and rearing habitat have been degraded by the creation of barriers to spawning areas, diversion of water for municipal and agricultural use, removal and redistribution of substrate for mining, impaired water quality from the introduction of excess nutrients and contaminants, and the removal of wetland habitat around the shoreline. Predation and competition with non-native fishes is impacting the ability of CLH to survive and reproduce. CLH are vulnerable to predation from a variety of non-native fishes that have been introduced for recreational fisheries. Sport fishes such as black bass, sunfish, and catfish are known to prey on all life stages of CLH. Clear Lake hitch must compete directly with non-native fishes for access to spawning area, rearing habitat, and food resources. Qualitative information indicates that a

primary driver for CLH population fluctuations may be competition with other non-native limnetic foragers in the lake. In addition, the anticipated impacts from climate change on native aquatic species also may cause threats to the continued existence of the species.

There is no scientific information indicating other factors, such as overexploitation, disease, and other natural occurrences or human-related activities, are threats to the continued existence of the species.

The Department has provided a list of management actions to improve the likelihood of the continued existence of CLH, including the need for: a scientifically valid population estimate or index; a thorough assessment of barriers to fish movement on primary spawning streams; an analysis of spawning habitat in primary spawning streams and recommendations for restoration actions; a review of reservoir operations at Highland Springs, Adobe Creek, and Kelsey Creek detention dams to assess water release operations that may be impacting CLH including development and implementation of guidelines for minimizing impacts and, other specific actions that could improve the status of CLH.

The Department provides this status review report to the commission based on the best scientific information available pursuant to Fish and Game Code section 2074.6. Based on the best scientific information available to the Department, the Department recommends that the petitioned action to list CLH as threatened under CESA is warranted at this time.

INTRODUCTION

This Status Review report addresses the Clear Lake hitch (*Lavinia exilicauda chi*) (CLH), which is the subject of a petition to list the species as threatened under the California Endangered Species Act (CESA) (Fish & G. Code § 2050 *et seq*.).

Petition History

On September 25, 2012, the Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity (Petitioner) to list the CLH as a threatened species under CESA.

On September 26, 2012 the Commission sent a memorandum to the California Department of Fish and Wildlife (Department, CDFW, and CDFG) referring the petition to the Department for its evaluation.

On October 12, 2012, as required by Fish and Game Code, section 2073.3, notice of the petition was published in the California Notice Register (Cal. Reg. Notice Register 2012, Vol. 41-Z, p.1502).

On December 12, 2012 the Commission granted a 30-day extension on the submission date for the Department's Initial Review of Petition to List the CLH as threatened under CESA.

On January 31, 2013, the Department provided the Commission with its Initial Review of Petition to List the CLH as threatened under CESA. Pursuant to Fish and Game Code, section 2073.5, subdivision (a) (2), the Department recommended that the petition provided sufficient information to indicate the petitioned action may be warranted.

On March 6, 2013 at its scheduled public meeting in Mt. Shasta, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received, and found that sufficient information existed to indicate the petition may be warranted and accepted the petition for consideration.

Subsequently, on March 22, 2013 the Commission published its Notice of Findings for CLH in the California Regulatory Notice Register, designating the CLH as a candidate species (CA Reg. Notice Register 2013, Vol. 12-Z p. 488).

Department Review

Following the Commission's action to designate CLH as a candidate species, the Department notified affected and interested parties and solicited data and comments on the petitioned action, pursuant to Fish and Game Code, section 2074.4 (see also Cal. Code Regs., Title 14, § 670.1(f)(2)) (CDFW 2013). All comments received are included in Appendix D to this report. The Department commenced its review of the status of the species as required by Fish and Game Code section 2074.6.

The Department sought independent and competent peer review, on its draft Status Review report, by scientists with acknowledged expertise relevant to the status of CLH. Appendix E contains the specific input provided to the Department by the individual peer reviewers, as well as a brief explanation on the evaluation and response to the input and any amendments made to the draft Status Review report (Fish & G. Code § 2074.6; Cal. Code Regs., Title 14, § 670.1(f)(2)).

BIOLOGY

Species Description

Clear Lake hitch is a member of the cyprinid family, growing to 35 centimeters (cm) standard length (SL), and with laterally compressed bodies, small heads and upward pointing mouths (Moyle et al. 1995). They are separated from other California minnows by their long anal fin consisting of 11 to 14 rays. The dorsal fin (10 to12 rays) originates behind the origin of the pelvic fins. Juvenile CLH are silvery with a black spot at the base of the tail. As CLH grow older the spot is lost and they appear yellow-brown to silvery-white on the back. The body becomes deeper in color as the length increases (Hopkirk 1973; Moyle 2002). CLH show little change in pigmentation during the breeding season (Hopkirk 1973). The deep, compressed body, small upturned mouth, and numerous long slender gill rakers (26 to 32) reflect the zooplankton-feeding strategy of a limnetic (well-lit, surface waters away from shore) forager (Moyle 2002). This lake adapted subspecies also has larger eyes and larger scales than other hitch subspecies.

Taxonomy

Hopkirk (1973) described CLH as a lake-adapted subspecies based primarily on the greater number of fine gill rakers. CLH are distinguished from other subspecies of hitch by their deeper body, larger eyes, larger scales and more gill rakers (Hopkirk 1973). Recent research on 10 microsatellite loci supports Hopkirk's description of CLH as a distinct subspecies (Aguilar and Jones 2009). However, mitochondrial DNA analysis was not able to distinguish CLH as a distinct subspecies from other hitch in California (Aguilar and Jones 2009). Yet, based upon the morphological and microsatellite analysis there is sufficient evidence to warrant the designation of CLH as a distinct subspecies of hitch (Hopkirk 1973; Moyle et al. 1995; Aguilar and Jones 2009).

CLH can hybridize with other Cyprinidae species and hybridization is known to occur with the genetically similar California roach (*Lavinia symmetricus*) (Miller 1945b; Avise and Ayala 1976; Moyle and Massingill 1981; Moyle et al. *in review*). However, there is no documentation of these hybrids in Clear Lake or its tributaries. CLH were known to hybridize in Clear Lake with the now extinct thicktail chub (*Gila crassicauda*) (Moyle et al. *in review*).

Range and Distribution

The entire CLH population is confined to Clear Lake, Lake County, California, and to associated lakes and ponds within the Clear Lake watershed such as Thurston Lake and Lampson Pond (Figure 1). Populations previously identified in the Blue Lakes, west of Clear Lake, have apparently been extirpated (Macedo 1994).

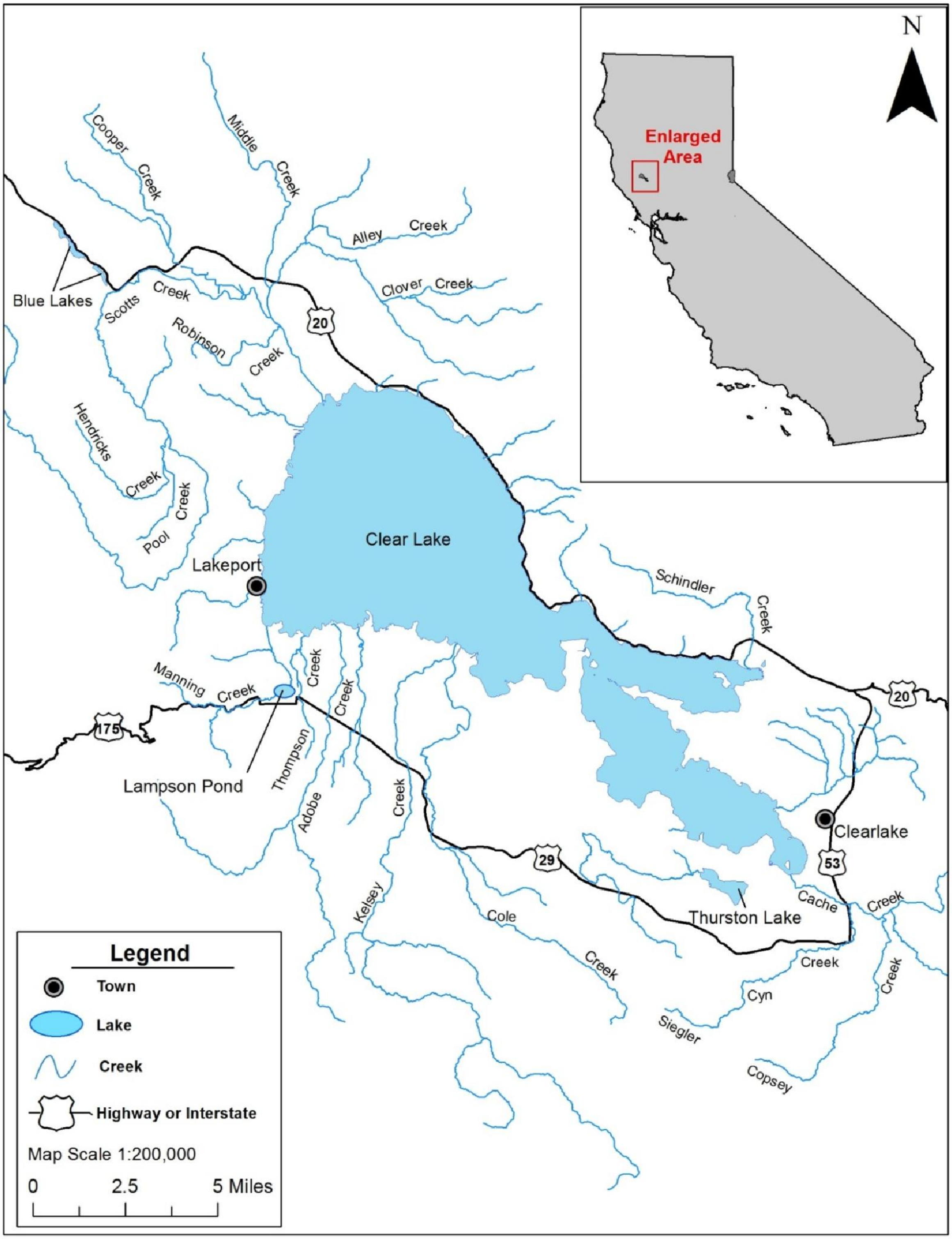

Figure 1. Map depicting Clear Lake and tributaries.

Life History

Physical adaptations to lake conditions allow CLH greater than 50 mm SL to feed largely on water fleas (*Daphnia* spp.) (Geary 1978; Geary and Moyle 1980; Moyle 2002). Stomach analysis indicates that CLH feed primarily in the day rather than at night (Geary 1978). Juveniles less than 50 mm SL are found in shallow, littoral zone (near-shore) waters and feed primarily on the larvae and pupae of Chironomidae; planktonic crustaceans including the genera *Bosmina* and *Daphnia*; and historically on the eggs, larvae, and adults of Clear Lake gnat (*Chaoborus astictopus*) (Lindquist et al. 1943; Geary 1978; Geary and Moyle 1980). Growth in CLH is faster and total size greater than that of other hitch sub-species (Nicola 1974). By three months CLH have reached an average of 44 mm SL and will continue to grow to between 80 and 120 mm by the end of their first year (Geary and Moyle 1980). Females mature in their second or third year, whereas males tend to mature in their first or second year (Kimsey 1960). Scale analysis indicates CLH live up to 6 years but it is likely that some individuals live longer (Moyle 2002). Females grow faster and are larger at maturity than males (Hopkirk 1973; Geary 1978; Ringelberg and McGinnis 2009). The larger size of CLH in comparison to hitch from other locations translates to greater fecundity. Accordingly, spawning females in Clear Lake average 36,000 eggs each year (Geary and Moyle 1980) compared to an average of 26,000 eggs for hitch in Beardsley Reservoir (Nicola 1974).

Clear Lake tributaries are numerous and located around the lake basin (Figure 1). Most streams have headwaters located at higher elevations in surrounding foothills; others have headwaters in lower elevations of the basin, and nearly all are low gradient in their lower reaches as they enter the lake. Some streams are more substantial than others and may have flowing water year round. However, most are seasonal, becoming disconnected with isolated pools by late spring, and are dry during summer months. Those that retain water year round often have long stream sections that are ephemeral. CLH spawn in these low-gradient tributary streams to Clear Lake and have spawning migrations that resemble salmonid runs. Spawning migrations usually occur in response to heavy spring rains, from mid-February through May and occasionally into June (Murphy 1948b; Kimsey 1960; Swift 1965; Chi Council for Clear Lake Hitch (CCCLH) 2013 (unpublished data)). During wet years, CLH spawning migrations may also opportunistically extend into the upper reaches of various small tributaries, drainage ditches, and even flooded meadows (Moyle et al. *in review*). CLH have also been observed spawning along the shores of Clear Lake, over clean gravel in water 1to 10 cm deep where wave action cleans the gravel of silt (Kimsey 1960). The success of these spawning events is not clearly understood and may be limited due to losses from egg desiccation and predation on eggs and larvae (Kimsey 1960; Rowan, J. personal communication, October 10, 2013, unreferenced).

CLH spawn at water temperatures of 14° to 18°C in the lower reaches of tributaries. Egg deposition occurs along margins and mid-channel of streams in very shallow riffles over clean, fine-to-medium sized gravel (Murphy 1948b; Kimsey 1960, Taylor, T., personal communication, February 10, 2014, unreferenced). Eggs are fertilized by one to five males as they are released from the females (Murphy 1948b; Moyle 2002). Eggs are non-adhesive and sink to the bottom after fertilization, where they become lodged among the interstices in the gravel. The eggs immediately begin to absorb water and swell to more than double their original size. This rapid expansion provides a protective cushion of water between the outer membrane and the developing embryo (Swift 1965) and may help to secure eggs in gravel interstices. The embryos hatch after approximately 7 days, and the larvae become free-swimming after another 7 days (Swift 1965). Larvae must then move downstream to the lake before stream flow disconnects with the lake (Moyle 2002).

Within Clear Lake, larvae remain near shore and are thought to depend upon stands of tules (*Schoenoplectus acutus*) and submerged weeds for cover until they assume a limnetic lifestyle (CDFG 2012). Juvenile CLH require rearing habitat with water temperatures of 15° C or greater for survival (Moyle 2002; Franson 2012 and 2013). Juveniles are found in littoral shallow-water habitats and move into deeper offshore areas after approximately 80 days, when they are between 40 and 50 mm SL (Geary 1978; CDFG 2012). Adult CLH are usually found in the limnetic zone of Clear Lake. The limnetic feeding behavior of adult fish is supported by stomach analysis of CLH where very little content of benthic midges was found, even though the fish were collected in the profundal (deep-water) habitat during the survey (Cook et al. 1964). Additional data collected by the Department during the early 1980s indicate CLH are present in the littoral zone from April to July and are scarce in this habitat during other months (Week 1982).

Adult CLH are vulnerable to predation during their spawning migration by many species including mergansers (*Mergus* spp.), herons (*Ardea* spp.), bald eagles (*Haliaeetus leucocephalus*), other birds, river otter (*Lontra canadensis*), northern raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*) (Bairrington 1999). In addition, CLH have been recovered from the stomachs of black bass (*Micropterus* spp.) caught in the lake (Bairrington 1999).

Habitat that May be Essential to the Continued Existence of the Species

Fish and Game Code section 2074.6 requires that a Status Review report include preliminary identification of the habitat that may be essential for the continued existence of the species. At various life stages CLH use stream and lacustrine (lake) habitat present in the watershed (Figure 1). Adult fish spawn in some tributaries of the lake during the spring and juvenile fish emerge from the tributaries and utilize near shore habitat to continue growth and seek refuge from predators. As juveniles mature into adults they move to the main body of the lake and assume a limnetic lifestyle until returning to spawn in the tributaries or shoreline the following spring. The use of tributaries varies from year to year based on habitat conditions present during the spawning period.

SPECIES STATUS AND POPULATION TRENDS

Assessing the status of CLH should include statistically valid population estimates conducted over time, to provide population data and trends. CLH studies to date have consisted primarily of qualitative sampling and are not suitable for deriving population estimates; however, these study results can provide insight into the current status of the species.

The population trends for this Status Review report focus on three sets of data available to the Department for analysis. Commercial catch records, submitted to the Department by operators on Clear Lake, contain incidental catch information on CLH dating back to 1961. Operators were required to keep records of CLH caught incidentally while operations focused on other species in the lake. The Lake County Vector Control District (LCVCD) has been conducting sampling efforts along the shoreline of Clear Lake since 1987. Although sampling efforts are not specific to CLH, incidental data on CLH captured during each sampling were recorded. The CCCLH spawning observation data have been collected by volunteers since 2005. Spawning observation data provides an estimate of the number of CLH in any given spawning tributary during the observation period. Results are summarized by the CCCLH each year following the completion of the spawning season. Information on population trends prior to 1961 is focused on small sampling efforts, published articles, and traditional ecological knowledge from tribal members. Although not quantifiable these data provide an idea of the status and distribution of CLH prior to larger qualitative sampling efforts.

Environmental conditions required for successful spawning and biological impacts to the survivorship of CLH are highly variable from year to year and often result in multiple years with reduced numbers of fish observed spawning or reduced recruitment into the population. The information presented in Figure 2 comes from three qualitative sampling efforts conducted at Clear Lake and an extrapolation of data provided in Bairrington (1999). Trend data in commercial catch records were represented for a given year by totaling the number of CLH captured per year and dividing by the number of days commercial operations occurred. Commercial catch data are comprised primarily of adult CLH. The CLH spawning trend data were calculated by totaling the number of CLH observed and dividing by the number of observation periods. LCVCD data on CLH captures represent the total number of CLH captured per year. LCVCD data are considered to be comprised primarily of juvenile CLH. The data represented in Table 6 of Bairrington (1999) were calculated by using 20,000 as a total catch baseline for percent of total catch for CLH. This graph does not reflect population numbers but rather trends in the abundance of CLH in any given year. As a proxy for changes in an established population size, biologists often use qualitative information as an indicator of population trends.

The trends of all data show a highly variable population that responds both positively and negatively to environmental parameters and varies significantly from year to year. It is likely that a combination of environmental factors is impacting the CLH population. The fluctuating abundance trend has continued throughout the duration of the qualitative sampling efforts and indicates CLH populations have at times been extremely low and at other times relatively high.

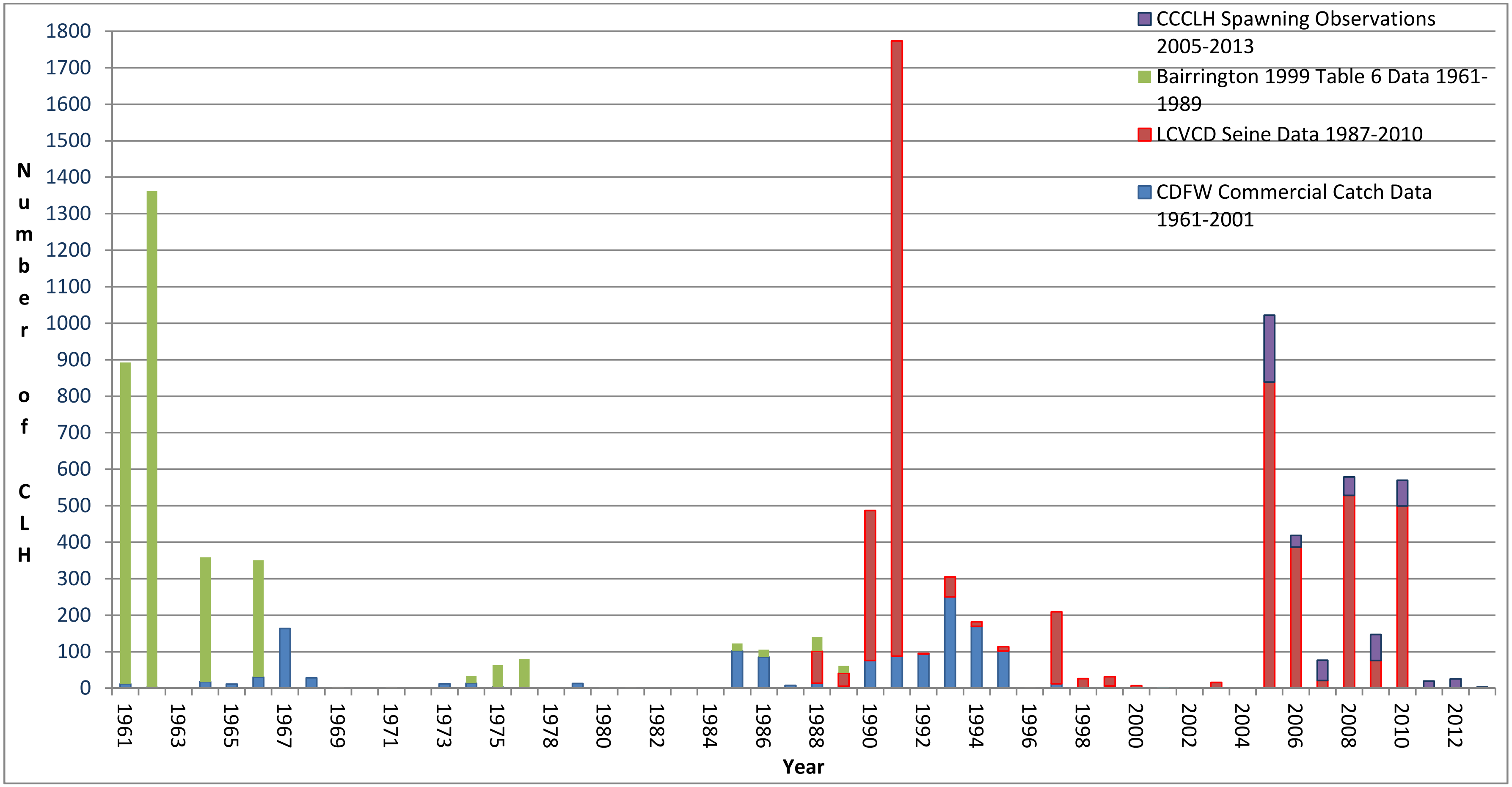

Figure 2. Clear Lake hitch population trends over the past 52 years as measured by three methods of qualitative sampling and one data extrapolation.

In 2013 the Department conducted a mark-and-recapture study to gain a better understanding of the CLH spawning population in Cole and Kelsey creeks. Unfortunately, too few individuals were marked and recaptured to give a statistically valid population estimate (Ewing 2013). Electrofishing surveys in June 2012 identified thousands of young of year CLH in near shore habitats along the southwestern shoreline of Clear Lake (CDFG 2012). Volunteers with the CCCLH conducted direct observations of CLH in spawning tributaries of Clear Lake in 2013, and spawning observations identified less than 500 CLH present (CCCLH 2013). Of those fish, 300 to 400 CLH were found below the Kelsey Creek detention dam. No single day count totaled more than 70 fish in any spawning tributary in 2013 (CCCLH 2013).

CCCLH qualitative spawning observations between 2005 and 2013 indicated peak single day CLH spawning counts of 1,000 to 5,000 fish (CCCLH 2013), and daily observation averages ranged from 3.5 to 183.1 fish (Figure 2). However, these observations make no distinction between previously counted fish, and it may be more prudent to look at fixed location single day counts from this time period. Additionally, numbers of spawning fish moving at night and during high turbidity events cannot be accounted for by these observations. The highest number of CLH observations recorded was approximately 5,000 during 2005; concurring with beach seine data that demonstrate a higher than average number of CLH caught in 2005 as well (CCCLH 2013; LCVCD 2013). The increased number of CLH in 2005 is the likely reason for the increase in spawning observations between 2007 and 2009. Appendix A contains summary graphs and figures, prepared by CCCLH, for observations made between 2005 and 2013.

There is sufficient information from these spawning observations to suggest the number of spawning tributaries being used by CLH decreased in 2013 compared to the average from 2005 to 2012 (Figure 3) (CCCLH 2013). However, the data limitations do not allow for quantitation of observation time on each creek (survey effort) compared with the number of fish observed to aid in understanding the extent of use in each tributary. The years with reduced numbers of tributaries with spawning observations also coincide with dry years when stream flows were reduced. In dry years it is likely only tributary streams with larger watersheds maintain sufficient flow for spawning. Years with the highest number of tributaries being used for spawning coincide with years when stream flows were at or above normal for the spawning period. A comparison between Figure 2 and Figure 3 shows some correlation between the number of spawning tributaries and the abundance of CLH in observational and capture surveys indicating more recruitment in years with increased tributary occupancy. Appendix B contains figures depicting the decline in annual spawning runs in Clear Lake tributaries between 2005 and 2013 (CCCLH 2013). Historic accounts and habitat suitability predications suggest that CLH originally spawned, to some degree, in all the tributaries to Clear Lake (Robinson Rancheria Ecological Center (RREC) 2011). However, reports on Pomo geography speak of Pomo tribes in the area travelling to Kelsey Creek to capture CLH and even of war when a tribe tried to divert Kelsey Creek to gain control of the important CLH supply

(Barrett 1906; Kniffen 1939). Based on these reports it is unclear to what extent CLH spawned in other tributaries to Clear Lake. It can be surmised the largest CLH spawning run occurred in Kelsey Creek during this period. Over the past eight years the number of occupied spawning tributaries has decreased from a high of 12 in 2006 to three in 2013 (CCCLH 2013). Currently, Adobe Creek seems to have the largest spawning run in the Clear Lake watershed while Kelsey and Cole creeks support smaller spawning runs. Based on historical accounts and current data the primary spawning tributary has shifted from Kelsey Creek to Adobe Creek (Kniffen 1939; CCCLH 2013).

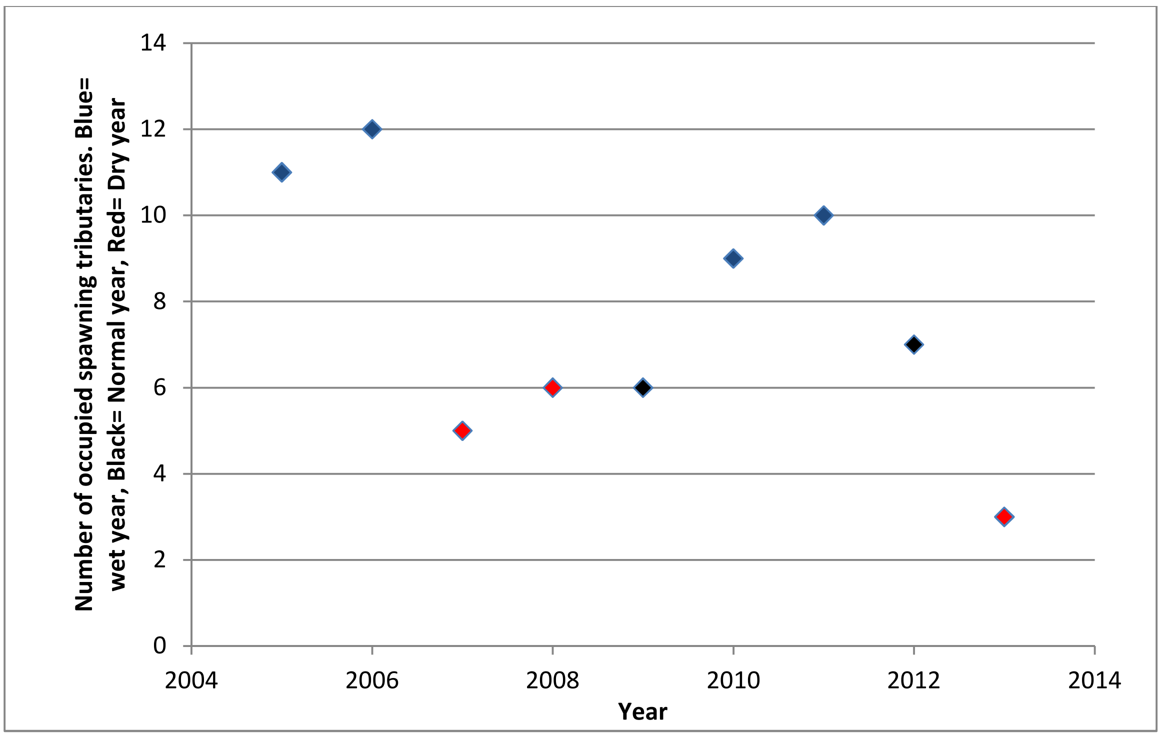

Figure 3. The number of occupied Clear Lake hitch spawning tributaries documented by CCCLH observers between 2005 and 2013.

LCVCD has been collecting beach seine data at various sites around the lake for more than two decades. The sampling is designed to measure abundance of threadfin shad (*Dorosoma petenense*) and Mississippi silversides (*Menidia audens*) as part of a Clear Lake gnat (*Chaoborus astictopus*) surveillance program. Incidental captures of CLH are recorded during these surveys; however, the data collected are not appropriate for a statistically valid evaluation of CLH populations as the sampling was not designed for this purpose. Additionally, sample locations are in areas that contain open unvegetated beaches that are not preferred habitat for CLH. Although surveys were not conducted to assess CLH, capture data for these surveys are consistent with other data sources in demonstrating a population that has poor recruitment in many years interspersed with few years of high levels of recruitment (Figure 4) (LCVCD 2013). In most years less than 100 CLH are captured during the surveys (17 of 24 years). Four of the six years when more than 100 CLH were captured were between 2005 and 2010. The greatest numbers of CLH were captured in 1991, a year that was described by the Department as a boom for juvenile fish in the lake (Bairrington 1999). Commercial fisheries data from 1991 also indicate an increase in CLH numbers captured during operations; over 6,000 CLH were captured and released by commercial fishery operators between March and May of 1991 (CDFW Commercial Fisheries Data). Data from the early 1990s also indicate an increase in zooplankton and macroinvertebrate numbers and a decline in threadfin shad and Mississippi silverside abundance resulting in increased available forage for CLH (Eagles-Smith et al. 2008; Winder et al. 2010).

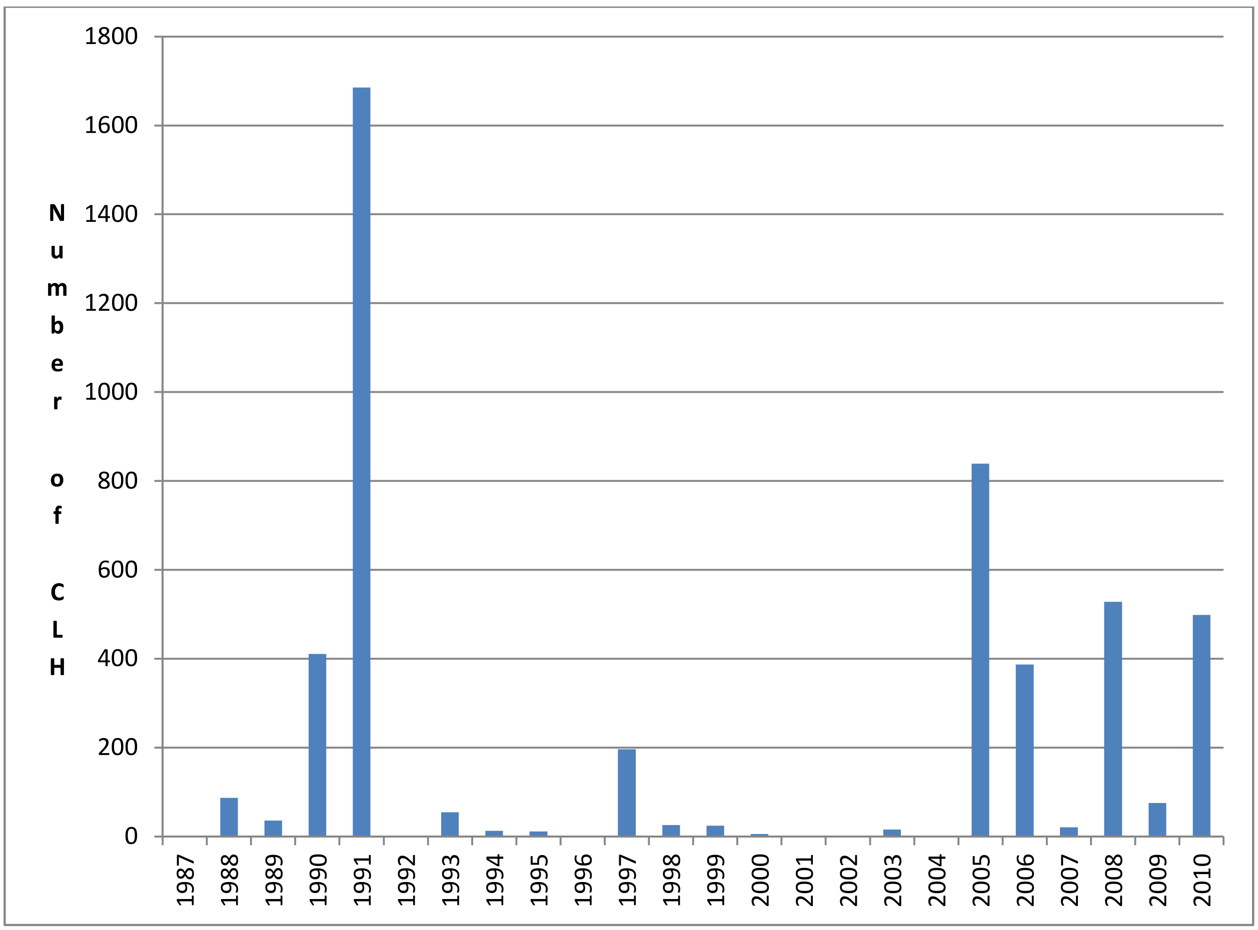

Figure 4. Summary of Clear Lake Hitch captured during Lake County Vector Control District beach seine surveys conducted from 1987 to 2010.

The data available to the Department that cover the greatest timeframe come from commercial harvest records for Clear Lake. The data begin in 1961, continue through 2001, and provide estimates of CLH numbers captured incidentally during operations (Figure 5). Multiple times throughout the past 50 years the number of CLH captured has surpassed 10,000. There are also several years where CLH were almost or entirely absent from sample collections. These data suggest that CLH are able to sustain a population through multiple years, of either one or both, suppressed spawning and recruitment.

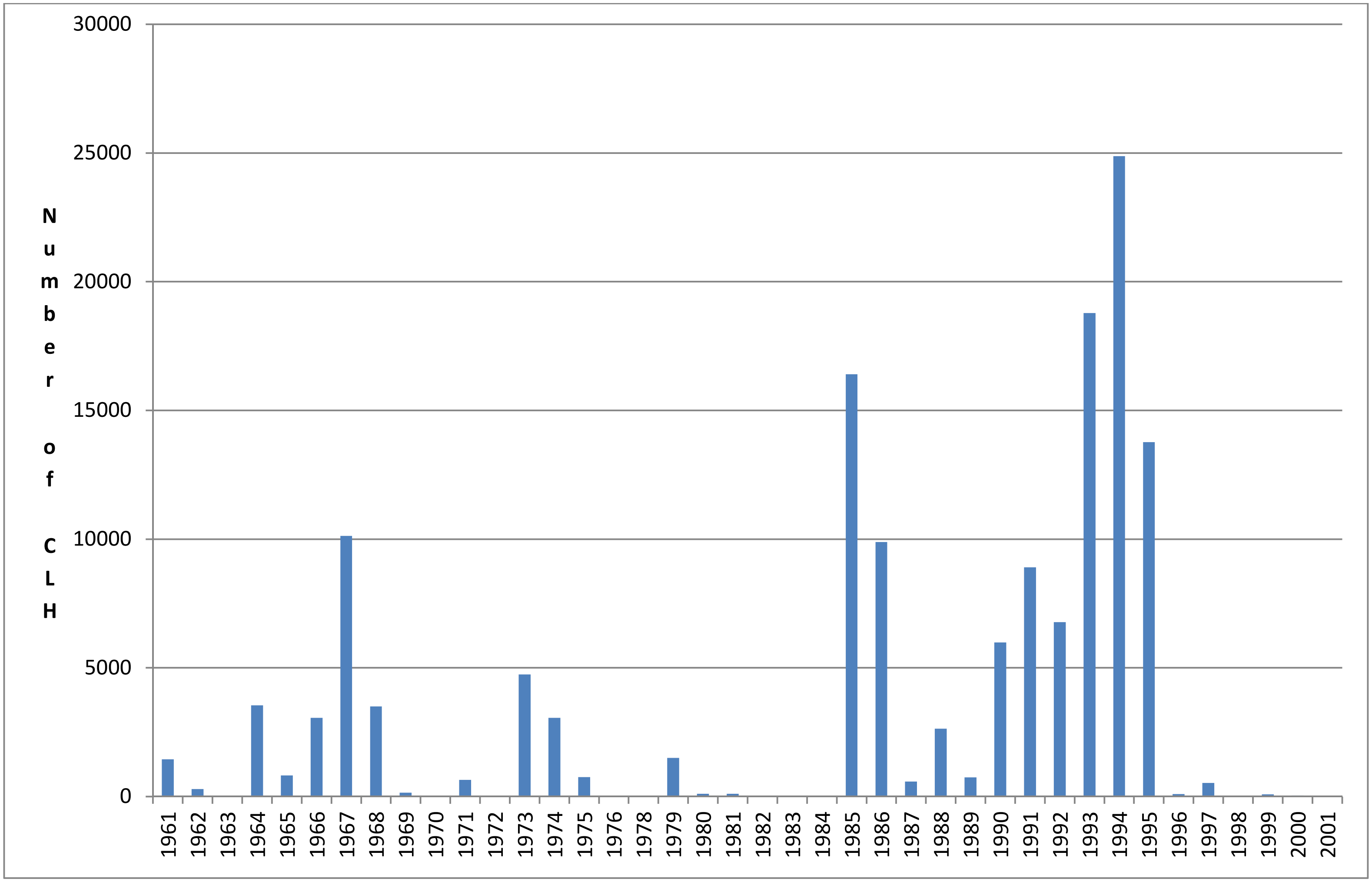

Figure 5. Number of Clear Lake hitch captured incidentally during commercial harvest operations between 1961 and 2001.

In the 1980s, the Department began various sampling at Clear Lake to assess fish assemblages, distribution, and occurrence in the lake. Electrofishing surveys found adult CLH occupying littoral habitat between April and July each year (Week 1982). The surveys were directed towards littoral zone use and provide no information on CLH outside of those months (Week 1982). An electrofishing survey was completed in April of 1987, and CLH was the most abundant fish sampled at locations around Rattlesnake Island and Clearlake Oaks subdivision; however, only a total of 52 CLH were captured during the survey (CDFG 1988). It must be noted that this sampling was on a very small scale, was targeting black crappie (*Pomoxis nigromaculatus*), and occurred in habitats where CLH would likely be found during this time period. Additional spring and fall electrofishing surveys between 1995 and 2006 found CLH to be the most abundant native fish, but the overall capture numbers were relatively low with a peak catch per unit effort (CPUE) of only 0.087 for juvenile fish in the fall of 2000 and 0.169 for adult fish in the spring of 1999. CPUE's were based on the number of fish caught per minute of electrofishing (Cox 2007). Electrofishing surveys conducted during late June 2007 reported low numbers of CLH recorded during the survey (Rowan 2008). The low numbers of CLH may be attributed to the sampling timeframe of late June. As noted in Cook et al. 1964, CLH were absent from littoral zone sampling following the start of summer. In an effort to reduce impacts to CLH while sampling, the Department's Clear Lake surveys between 2008 and 2012 were all confined to the timeframe of late June and July when CLH numbers are greatly reduced in the littoral zone.

As late as 1972, CLH and other non-game fish were described as comprising the bulk of the Clear Lake fishery (Puckett 1972). The Lake County Mosquito Abatement District conducted surveys between 1961 and 1963 examining the relationship between fish and midges. These surveys identified CLH as the third most abundant fish in the lake. The majority of CLH were captured in the littoral and profundal zones using gill nets. However, the limnetic zone was not sampled since midges do not occur in this area. A total of 1,229 fish was taken during these surveys (Cook et al. 1964).

Field notes from CDFG biologists in 1955 note CLH runs with large numbers in Kelsey Creek (CDFG 1955). Similar notes from 1956 indicate spawning CLH in Kelsey Creek as numbering in the hundreds and Seigler Creek containing 400 CLH for every 100 feet of stream above the Anderson Brothers ford (CDFG 1956). CLH were the second most abundant fish caught during various gill net surveys in the lake at that time (Lindquist et al. 1943). Surveys conducted between 1938 and 1941, for examination of fish and gnat interactions, described the runs of Clear Lake splittail (Pogonichthys ciscoides) and CLH as numbering in the tens of thousands (Lindquist et al. 1943). A photograph from 1890 depicts a spawning run so thick that fish formed a blanket across the creek (Figure 6). The photo likely shows a run of fish comprised of different Cyprinid species. Early stories from the area depict tales of fish so thick that streams were difficult to ford by horses and wagons, and residents shoveled spawning fish to bring home for hog feed (Rideout 1899). The volume of dead fish found during spawning runs on Clear Lake tributaries created a stench that was intolerable to lakeshore residents (Dill and

Cordone 1997). Livingston Stone (1876), who lived on the lake in 1872 and 1873, stated "They ran up the streams in spring to spawn in countless numbers". It is not entirely clear if spawning runs such as those depicted in Figure 6 occurred every year or fluctuated based on tributary flows, but it is likely they fluctuated in a similar fashion to what was observed during the past decade of CCCLH spawning surveys. Regardless, the body of evidence lends support for claims of CLH as common and the most abundant fish in Clear Lake during the late nineteenth and early twentieth centuries (Coleman 1930; Jordan and Gilbert 1894).

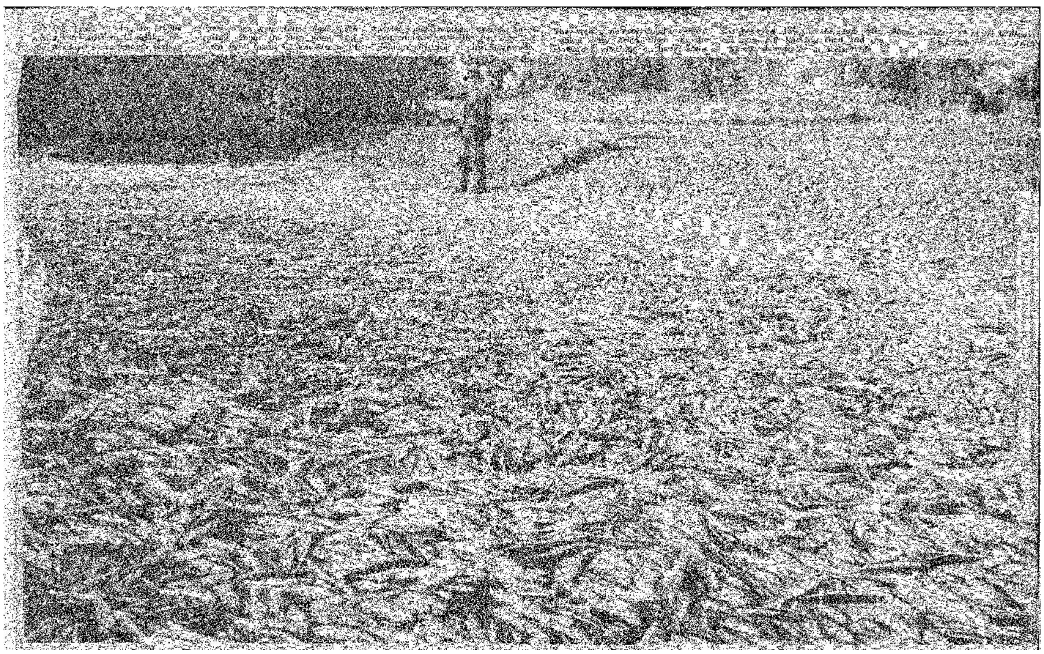

Figure 6. Photo from 1890s depicting spawning fish being stranded in Kelsey Creek.

FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE

Present or Threatened Modification or Destruction of Habitat

Wetland Habitat Loss

Wetlands provide critical rearing habitat for juvenile fishes native to Clear Lake (Geary 1978; CDFG 2012). Wetlands are those areas near shore or adjacent to tributaries that are inundated with shallow water and contain emergent vegetation. Prior to the arrival of European settlers in the mid-1800s, Clear Lake was surrounded by large tracts of wetlands. Throughout the expansion of European settlement around the lake, the wetland habitat was drained and filled to provide urban and agricultural lands. Currently, the Clear Lake watershed contains over 16,000 acres of land dedicated to agricultural production, of which a portion comes from reclaimed wetlands (Lake County Department of Agriculture 2011; Forsgen Associates Inc. 2012). Comparisons of historical versus current wetland habitat reveal a loss of approximately 85%, from 9,000 acres in 1840 to 1,500 acres by 1977 (Week 1982; Bairrington 1999; Suchanek et al. 2002; Lake County Department of Public Works 2003; Giusti 2009; CEPA 2012). Loss of wetland habitat coupled with competition for existing habitat with introduced fishes has led to a decline in available rearing habitat for juvenile CLH (Week 1982).

Spawning Habitat Exclusion and Loss

Dams, Barriers, and Diversions

Cache Creek Dam was constructed at the outlet of Clear Lake in 1915, and Yolo County Flood Control and Water Conservation District (YCFCWCD) manipulates the lake water level several feet seasonally to allow irrigation diversion (CDWR 1975). Clear Lake is allowed to fluctuate on a yearly basis a maximum of 7.56 feet above a mean level plane referred to as the “Rumsey gage” (CDWR 1975). The fluctuations in water level at Clear Lake are not as extreme as traditional reservoirs that can fluctuate tens to hundreds of feet per year. In most years the lake is at its highest level between January and May and if full on May 1, water withdrawals may occur during the summer months. As a result of water withdrawals the lake is usually at its lowest level in October or November prior to the start of the rainy season (Figure 7) (County of Lake 2013). The effects of lake water manipulations on CLH populations have not been quantified but is likely less than those effects would be if Clear Lake was a traditional reservoir. However, manipulation of water levels in the Clear Lake watershed likely results in decreased water quality, a reduction in spawning and rearing habitat, and increased risk of predation (Converse et al. 1998; Wetzel 2001;

Gafny et al. 2006; Cott et al. 2008; Hudon et al 2009). All of these impacts can lead to the extinction of native species that evolved in lakes free of habitat modifications resulting from impoundment structures (Wetzel 2001). Impounded systems also tend to be dominated by non-native species (Moyle and Light 1996).

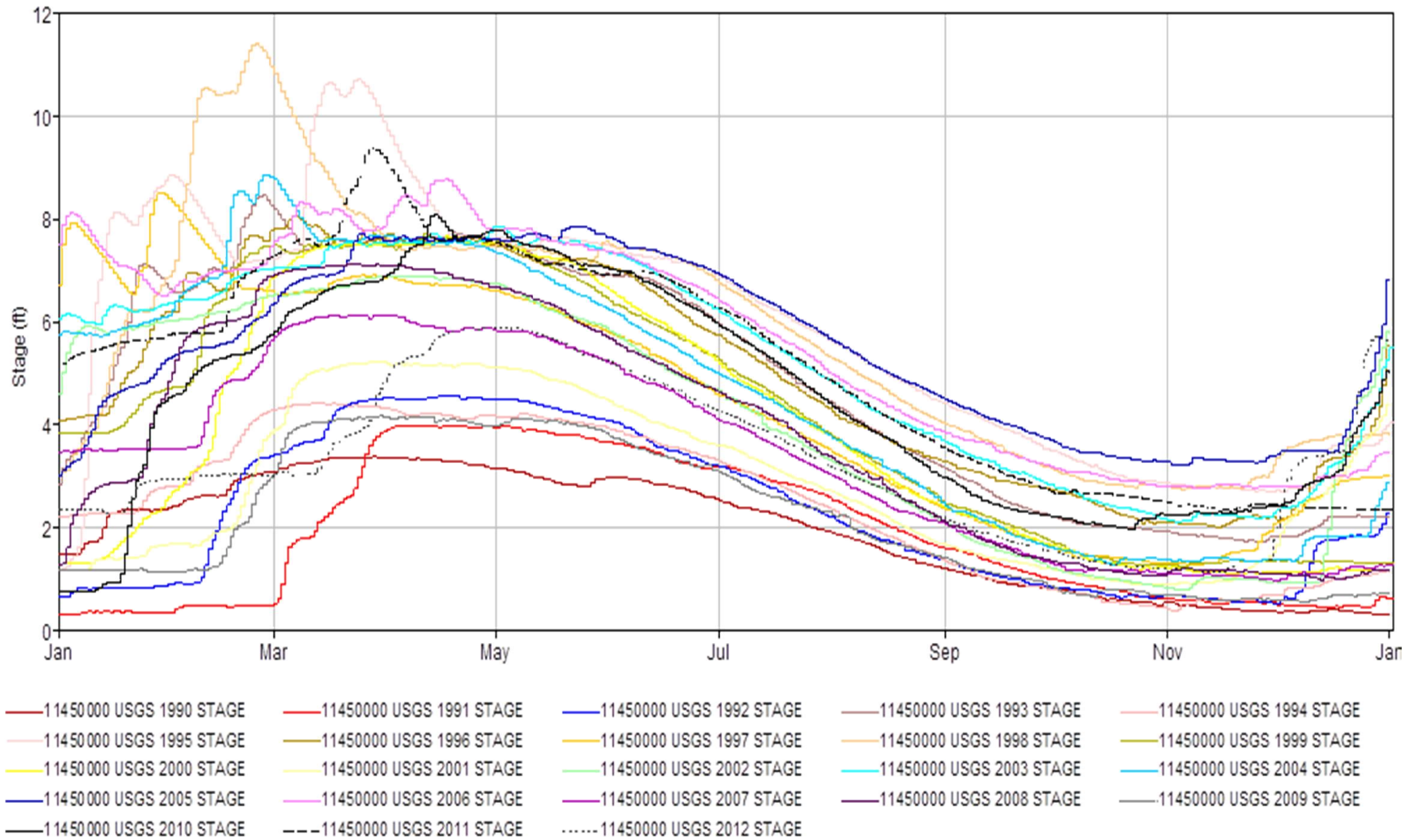

Figure 7. Clear Lake levels from 1990 to 2012 recorded at U.S. Geological Survey storage gage 11450000.

CLH spawn in low-gradient tributary streams to Clear Lake. All of the tributary streams to Clear Lake have been altered to various degrees by dams, barriers, and diversions. Dams, barriers, and diversions consist of manmade structures or habitat modifications that impede the passage of fish; these can be the result of flood control, construction, water diversions, vegetation removal, sedimentation, or any other modification to the existing habitat. Stream alterations can block migratory routes and impede passage necessary for adults to reach spawning areas and for larval fish to gain access to the lake. The result can be direct loss of spawning and rearing habitat, loss of nursery areas or loss of access to these areas, increases in predation, and decreased water quality (Murphy 1948 and 1951; Moyle 2002;). A limited biological survey was conducted in 2013 on the lower reaches of Adobe, Kelsey, Manning, Middle, and Scotts creeks. Results indicate all of the areas surveyed had low Index of Biological Integrity (IBI) scores and are either partially or not supportive of aquatic life (Mosley 2013). Examples of alterations to Clear Lake tributaries that have impacted CLH include agricultural irrigation pumps and diversions, aggregate mining activity, flood control structures, road crossings, bridge aprons, and off-highway vehicle (OHV) use (McGinnis and Ringelberg 2008).

It is clear that Adobe Creek, Highland Creek, Middle Creek, Clover Creek, and Kelsey Creek have experienced a reduction in fish spawning habitat and access to spawning habitat since the installation of dams and increased irrigation (Murphy 1951; Macedo 1994; McGinnis and Ringelberg 2006). In 2006, a barrier assessment was completed for Middle Creek and the Kelsey Creek fish ladder (McGinnis and Ringelberg 2006). The assessment found physical barriers associated with bridge aprons and weirs as well as habitat barriers from historical gravel operations that removed riparian vegetation, redistributed substrate, and altered flows (McGinnis and Ringelberg 2006). The Kelsey Creek fish ladder was found to be insufficient for passage of CLH as the jump heights and velocities found at the ladder were too great for CLH. Spawning observations by CCCLH from 2005 to 2013 witnessed fish stranded below barriers within the watershed (CCCLH 2013).

Many Clear Lake tributaries are no longer used for spawning or have reduced spawning runs as a result of artificial structures that continue to impede spawning migrations (Figure 8). While some operational and physical modifications to these structures have been implemented over the years, they continue to prevent spawning CLH from accessing spawning habitat, especially during dry years when spring flows are low.

In preparation of this report, the Department estimated the loss of CLH spawning and rearing habitat due to constructed barriers and impediments within the tributaries of Clear Lake (Figure 8). The barrier assessment determined the approximate locations of barriers and estimated miles of stream habitat as determined from the California Native Diversity Database, CDFW Geographic Information System, CDFW Fish Passage Assessment Database, California geographic information system (GIS) street layer, and Google Earth Maps. Using that data, the Department estimated 180 stream miles were historically available to spawning CLH and that barriers have eliminated or reduced access to more than 92% of the historically available spawning habitat. Physical barriers, such as the footings of bridges, low water crossings, dams, pipes, culverts, and water diversions in Kelsey, Scotts, Middle, Clover, and other creeks interrupt or eliminate migration to spawning areas (McGinnis and Ringelberg 2008). Appendix C contains a list of several tributaries and some of their associated barriers.

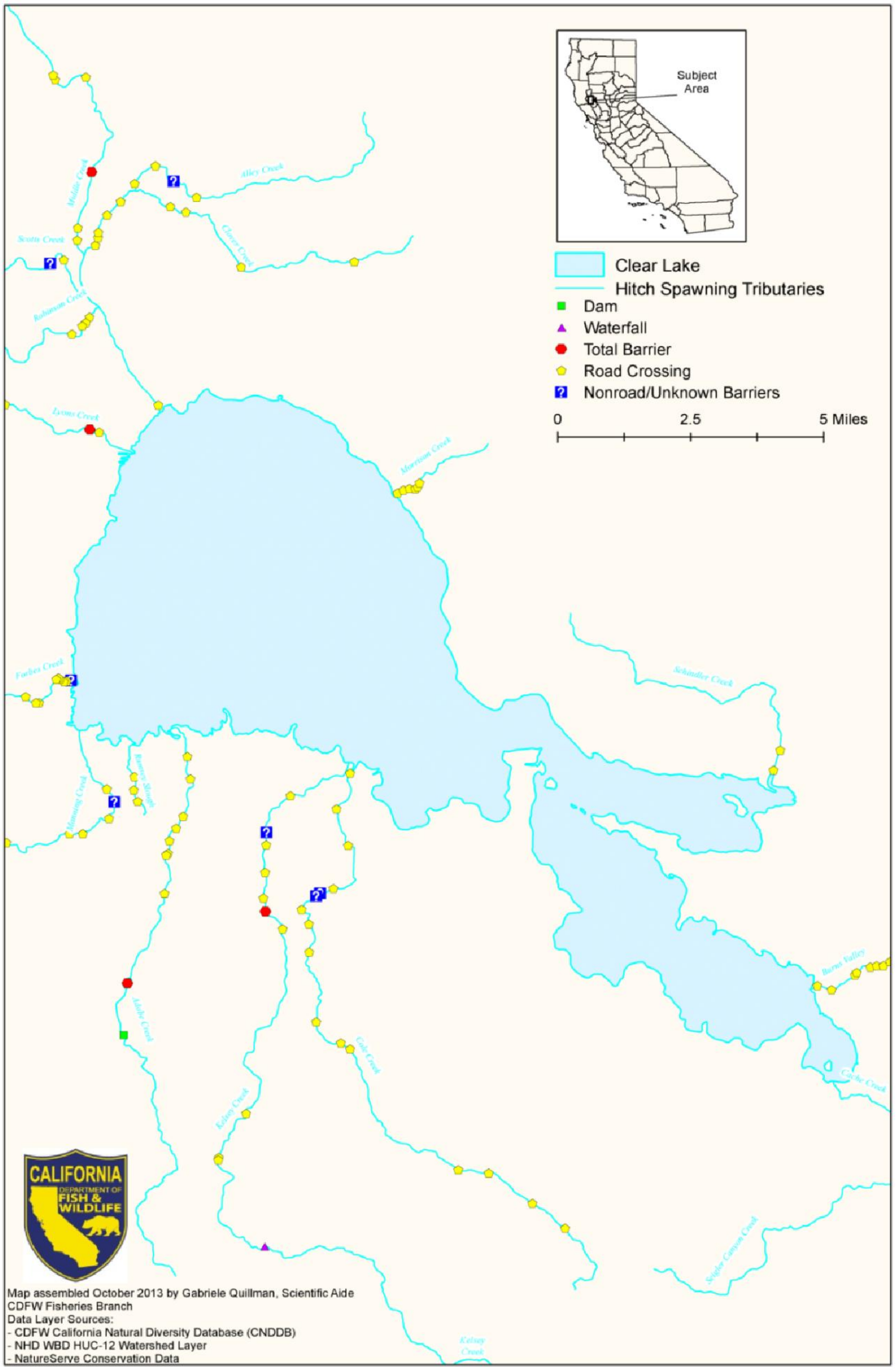

Figure 8. Clear Lake hitch spawning barriers located on tributaries throughout the watershed.

Water is frequently diverted from Clear Lake tributaries, during the CLH spawning season, under riparian and water rights associated with land ownership in the watershed. These water diversions consist of direct diversion from surface water intake pumps and from shallow off-channel wells that capture underflow from adjacent channels. The primary purpose of water diversions from Clear Lake tributaries is for agricultural production, frost protection, various forms of irrigation, and domestic water supply. Water diversions for frost protection have been shown to temporarily reduce in-stream flow by as much as 95% (Deitch et al. 2009). Natural flow regimes are thought to favor the success of native fishes over non-native fishes (Marchetti and Moyle 2001). No studies on water diversions in tributaries have been completed and the impact on CLH spawning tributaries is poorly understood. A review of stream flow data recorded at U.S. Geological Survey station 11449500 (Figure 9), on Kelsey Creek, was conducted to determine if monthly average flows correlated with either increases or decreases in CLH observations or captures. There does not appear to be a strong correlation with increased flows February through April and increases in CLH observations or captures. The highest number of CLH were captured in 1990 and 1991, which were dry water years with lower than average flows during the spawning season. From 1993 to 1995 CLH captures continued to decline even though the flows were average to above average during the spawning season. The flows presented in Figure 9 are averages for each month and may not accurately display the variability of day-to-day flows on all Clear Lake tributaries and do not take into account water diversions downstream of the gaging station. In some tributaries, water diversion has contributed to early drying of stream reaches and desiccation of CLH eggs masses and newly hatched juveniles (Macedo, R., personal communication, November 25, 2013, unreferenced). Additionally, significant flow reductions can lead to increased water temperatures, reduced available aquatic habitat, altered or decreased biodiversity, increases in non-native species, and alterations to fish assemblages (Marchetti and Moyle 2001; Bunn and Arthington 2002; Bellucci et al. 2011).

The impacts of spawning habitat alterations to CLH may be inferred by the fate of another native Clear Lake fish that required tributaries for spawning; the Clear Lake splittail was last recorded in 1972 (Puckett 1972). The Clear Lake splittail formerly spawned later in the season than did CLH, and the drying up of tributaries contributed to its demise (Moyle 2002). Cook et al (1966) noted the Clear Lake splittail “underwent a drastic reduction in the 1940s” and feared it “may disappear if increased demands upon the water further limit reproductive success”. All stream spawners had “declined precipitously” by 1944 (Murphy 1951). Therefore, earlier drying of tributaries by both natural and anthropogenic processes likely impacts the CLH population.

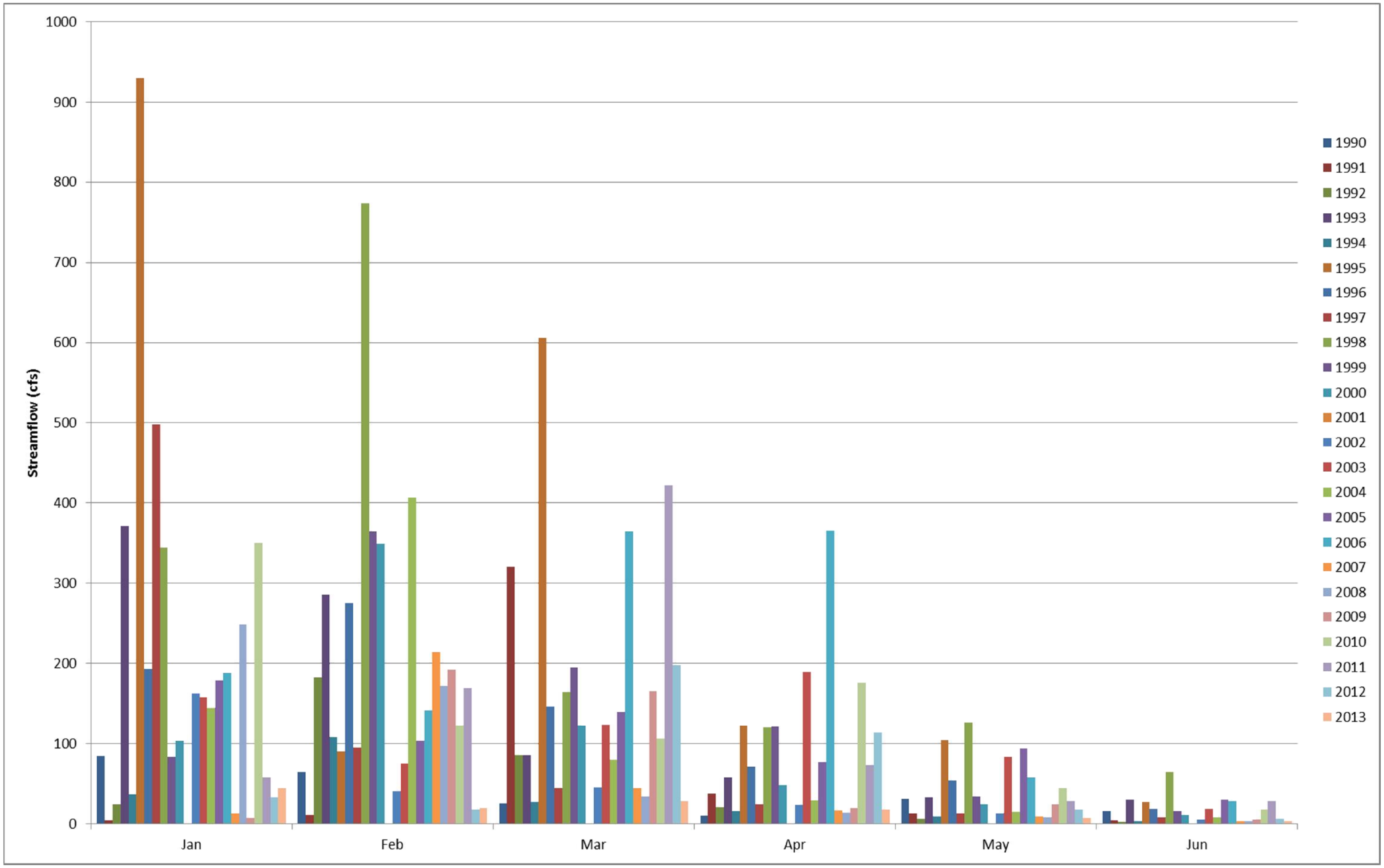

Figure 9. Average January through June flows on Kelsey Creek as recorded at USGS Station 11449500.

Dredging and Mining

Since the first European settlers arrived at Clear Lake and began gravel mining and dredging operations, there have been documented deleterious effects on the watershed (Suchanek et al. 2002). Field notes from CDFW personnel conducting stocking assessments document Kelsey Creek so loaded with silt from gravel operations that creek visibility was zero (CDFG 1955). Smaller scale mining and dredging in tributary streams has occurred since early settlement and has altered the amount and distribution of stream gravels (Thompson et al. 2013). In some tributaries, gravel extraction has resulted in the incising and channelization of the streams, streambed elevation levels have also downcut by as much as 15 feet (Suchanek et al. 2002; Eutenier, D. April 17, 2013 comment letter). After 1965 about one million metric tons of gravel product per year was removed from the watershed until the partial moratorium on aggregate mining in 1981 (Richerson et al. 1994). Gravel was removed from Clear Lake tributaries to provide road base for new roads created to accommodate the expanding population of the area (Suchanek et al. 2002). Currently, approximately 5,000 cubic yards of gravel are removed annually from Scotts Creek and 58 acres in the Clear Lake watershed are used for quarries, strip mines, and gravel pits (Forsgren Associates Inc. 2012).

Many areas along the tributaries to Clear Lake were channelized in response to frequent flooding during the late winter and early spring (Maclanahan et al. 1972; U.S. Army Corps of Engineers 1974). As a result of gravel extraction and channelization, some areas were covered with riprap or confined by levees to prevent further erosion and flooding. Erosion problems have contributed to sediment entering Clear Lake and providing increased phosphorous loads that impair water quality (Richerson et al. 1994). Gravel extraction results in channelization, down cutting of the stream banks, decreases in suitable spawning habitat, increasing flow velocities and amount of coarse material that passes through the system (Brown et al. 1998).

Water Quality Impacts

The Clear Lake watershed has seen a significant increase in the amount of contaminants entering the lake over the past 75 years (Richerson et al. 1994). An increase in agriculture, mining, and a shift to an urban environment, has resulted in adverse water quality impacts in the lake (Mioni et al. 2011; California Environmental Protection Agency [CEPA] 2012).

Sediment

Erosion from construction, dredging, mining, agriculture, OHV use, grazing, and urbanization has resulted in increased sediment loads to the Clear Lake watershed (Forsgren Associates Inc. 2012). Increased sediment loads transport nutrients, particularly phosphorous, into Clear Lake. Increased sediment loads also reduce spawning habitat quality by increasing substrate "embeddedness" (Mosley 2013). During the late 1990s and early 2000s soil erosion and sedimentation became an increasing problem as existing agricultural lands were converted to vineyards (Forsgren Associates Inc. 2012). From 2002 to 2011 vineyard acreage in the Clear Lake watershed increased from approximately 5,500 acres to 8,000 acres (Lake County Department of Agriculture 2011).

Nutrients

Development and expansion of agriculture in the Clear Lake watershed during the late 1890s until present day reclaimed the lake's natural wetland filtration system for agricultural use. An increase in agricultural production and a decrease in wetland filtration increased nutrient flows into Clear Lake. Wetland reclamation projects altered the transport of sediment and nutrients, particularly phosphorous, into Clear Lake, resulting in an increase in noxious cyanobacteria blooms that cover the lake in warmer months (Suchanek et al. 2002). As a result of continued water quality issues, Clear Lake was added to the Clean Water Act Section 303(d) list of impaired water bodies in 1988 (CEPA 2010 and 2012). In recent years, noxious cyanobacteria blooms have at a minimum remained constant and may have increased (CEPA 2012).

Cyanobacteria

Cyanobacteria blooms have occurred at Clear Lake since the mid-1900s. Studies indicate an increase in phosphorous was the driver behind water quality impairments and noxious cyanobacteria blooms (Horne 1975; Richerson et al. 1994; CEPA 2012). The blooms originally consisted primarily of *Microcystis*, but in recent years the blooms have been attributed to both *Microcystis* and *Lyngbya.* These taxa represent both non-nitrogen fixing (*Microcystis*) and nitrogen fixing (*Lyngbya*) cyanobacteria and raise concerns that both phosphorous and nitrogen entering the lake that need to be controlled (Mioni et al. 2011; CEPA 2012). Cyanobacteria blooms have the ability to both directly and indirectly impact CLH by direct interference with the growth of *Daphnia*, a limnetic organism that is a food source for adult CLH, and interference with food web efficiency. No studies have been conducted at Clear Lake to quantify the impact of cyanobacteria blooms on the ecosystem, but studies conducted at other water bodies with varying degrees of cyanobacteria blooms provide information on their impacts to the aquatic environment. Cyanobacteria blooms reduce the amount of light penetration in the water column and cause a reduction in producers that are unable to reposition themselves to gain more light (Havens 2008). Primary producers such as epiphyton, benthic algae, and rooted vascular plants have a reduced ability to function in the ecosystem as a result of cyanobacteria blooms. As the cyanobacteria alter the nutrient cycle of the lake they replace the producers in space and mass. The expanding cyanobacteria begin to deplete CO_2 from the water body, which increases pH and reduces growth of other producers (Havens 2008). The decreased CO_2 and increased pH can create surface scums and result in mortality of fishes, including CLH. In the summer of 1969, a large fish die off, due to heavy cyanobacteria growth and low oxygen levels, was reported at Clear Lake. An estimated 170,000 fish died, consisting primarily of carp, CLH, and blackfish (CDFG News Release 1969). Sub-lethal and lethal effects of toxins released during cyanobacteria blooms are also seen in fish and their associated food web (Havens 2008).

On September 19, 2007, the U.S. Environmental Protection Agency (EPA) approved a control program as a nutrient Total Maximum Daily Load (TMDL) for Clear Lake with the goal of reducing point and non-point source phosphorous entering the lake (CEPA 2012). Sources for phosphorous entering the lake include agricultural and urban runoff, timber harvest, road maintenance, construction, gravel mining, dredging, and fire. Other potential sources of phosphorus from home fertilizers, marijuana culture, sewer, and septic systems cannot be quantified.

Pesticides and Herbicides

To allow for increased yields on agricultural land and to prevent nuisance insect species around the lake, pesticides became commonplace during the early and mid-1900s. Between 1949 and 1957, an important food source of juvenile CLH, the Clear Lake gnat, was targeted with the pesticide dichlorodiphenyldichloroethane (DDD). During these years it is estimated that 99% of the gnat larvae in the lake were killed. Concentrations of DDD were magnitudes higher in invertebrates, fish, and birds than in the surrounding water in which they were found (Lindquist and Roth 1950; Rudd 1964). Sampling conducted during the late 1950s identified CLH, as well as other fish species, contaminated with DDD (Hunt and Bischoff 1960). Contamination levels ranged from 5.27 to 115 parts per million for edible flesh of sampled fishes (Hunt and Bischoff 1960). CLH were at the lower level of DDD (10.9 to 28.1 parts per million for edible flesh content) contamination than other Clear Lake fishes (Hunt and Bischoff 1960). The application of DDD in the Clear Lake watershed resulted in the first major ecological disaster related to the use of pesticides at the lake and the first records of bioaccumulation in the wildlife of the lake (Suchanek et al. 2002).

Following the resurgence of gnat populations in response to growing resistance to DDD, two additional measures were taken to reduce the gnat population. Gnat eggs were targeted with a petroleum product (Richfield Larvicide), and adult gnats were targeted at roosting locations with malathion (Suchanek et al. 2002). Additional applications of methyl parathion were also made in 1962 (Suchanek et al. 2002). Clear Lake gnats are still present at the lake, but populations are significantly reduced from historical levels. The likely cause of the reduced population of gnats is introduced fishes, primarily Mississippi silversides (Suchanek et al. 2002). In 2010 and 2012 Clear Lake gnat populations reached levels not observed in decades.

These gnat population booms appeared to coincide with years of low population levels of Mississippi silversides (Scott, J. 2013 personal communication, Aug 1, 2013, unreferenced). Qualitative sampling data on CLH do not allow for a direct comparison of CLH numbers in years with increases in the gnat population.

In recent years, two herbicides, Komeen™ (copper sulfate) and SONAR™ (fluridone), have been used to manage the *Hydrilla verticillata* infestation of the lake. Applied concentrations of Komeen do not kill fish directly; however, the impacts to macroinvertebrates may indirectly impact CLH populations (Bairrington 1999). These herbicides also pose a threat to non-target vascular aquatic plants, such as tules and submerged vegetation, which juvenile CLH require for habitat. As noted previously, there has already been a significant reduction in wetland habitat around the lake, and any additional reductions would further limit the amount of habitat available for CLH. Initial studies indicate a reduction in tule habitat following Sonar applications (Bairrington 1999). Environmental monitoring of eradication activities in 1996 and 1997 found that invertebrate species declined within the treatment area but rebounded quickly following the toxicity decay of the herbicide (Bairrington 1999). Post-treatment electrofishing surveys noted an increase in the number and abundance of fish species.

Mercury

Mining operations within the watershed contributed to sulphur and mercury contamination in Clear Lake. The Sulphur Bank Mercury Mine began operations in 1865 and ended in 1957 (Osleger et al. 2008; Giusti 2009) Originally the mine focused on extracting sulfur, but as operations continued into the late 1920s and the sulfur was found to be contaminated with mercury sulfide, operations switched to extracting mercury from the large-scale open-pit mine (Giusti 2009). As a result of contamination, the mine was classified as an EPA Superfund Site in 1990 (Suchanek et al. 1993). The mine is thought to have contaminated the lake with both mercury and arsenic (Suchanek et al. 1993). Studies have found the mercury concentrations in sediment to be high (over 400 ppm) in the vicinity of the mine, decreasing as distance from the mine increases (Suchanek et al. 2002). The mine continues to produce low pH acid mine drainage that delivers sulfate to the lake. Over the past decade, the EPA has taken several actions to remediate contamination from the mine. These include erosion control measures, removal of contaminated soil, storm water diversion, and well capping (U.S. EPA 2012).

During the 1970s, elevated concentrations of mercury were found in the fish of the lake (Curtis 1977). High levels of mercury accumulation can lead to significant impacts to the reproductive success of fishes and can result in reduced brain function, altered size and function of gonads and reduced gamete production (Sandheinrich and Miller 2006; Crump and Trudeau 2009). In 2003, a mercury TMDL was developed for Clear Lake to reduce methylmercury in fish by reducing overall mercury loads to Clear Lake (CEPA 2010). The level of mercury found in CLH was 0.19 ug/g, and all other fish were between 0.06 and 0.32 ug/g (CEPA 2002), which resulted in health advisories on their consumption, but are below acute toxicity thresholds (Harnly et al. 1997). Mercury levels are close to the effect thresholds for reproduction and growth for fathead minnow (0.32-0.62 ug/g) and rainbow trout (National Oceanic and Atmospheric Administration [NOAA] 2011). Concentrations with no effect on rainbow trout growth and development are 0.02-0.09 ug/g (NOAA 2011). Lacking specific studies on CLH, based on effect levels for fathead minnows and rainbow trout, it is possible that CLH may be experiencing sub-lethal chronic and reproductive effects from mercury contamination.

Overexploitation

Commercial Harvest

Commercial fish harvest at Clear Lake occurred from the early 1900s through 2007. However, catch records are only available for a portion of the harvest period. Harvested fish were distributed to fish markets in California for sale for human consumption and animal feed. Prior to 1941, the majority of commercial operations centered on harvesting catfish (*Ictalurus* or *Ameiurus* spp.) from the lake. Although exact numbers are unavailable, it is likely that large numbers of catfish were taken during this period (Bairrington 1999). In 1942 commercial harvest of catfish was banned at Clear Lake. Beginning in the 1930s commercial harvest focused on Sacramento blackfish (*Orthodon microlepidotus*), a native species, and common carp (*Cyprinus carpio*), a non-native species. From 1932-1962 the annual average catch rate was 295,000 pounds for the commercial fishery (Bairrington 1999). A ratio of 1.33:1 for blackfish to carp was the average during commercial fishing operations (Bairrington 1999). In 1976 the only recorded capture and sale of CLH for commercial purposes was submitted to the Department, a total of 1,550 pounds was reported captured and sold at market that year (CDFW Commercial Fisheries Data). This is the only instance in the records of CLH being captured for commercial sale, primarily due to lack of interest and low sale price for the species. By 1960 commercial fishing operators were required to count and release all bycatch from commercial operations. CLH were found in large numbers some years and were recorded and returned to the lake when captured (Figure 5; CDFW Commercial Fisheries Data). The Department has received no commercial permit applications for operations on Clear Lake over the past several years. The lack of permit applications indicates that at this time commercial fishing operations at Clear Lake have ceased (CDFW Commercial Fishing Permit Data).

Cultural Harvest

Clear Lake hitch are culturally significant to several Pomo tribes that inhabit the Clear Lake watershed. Two Pomo tribes fought a war over Kelsey Creek and its important CLH supply (Barrett 1906; Kniffen 1939). Historically, large runs of CLH provided a staple food source for the local tribes (RREC 2011). During spawning runs, CLH were captured by constructing a series of dams in the creeks from which the fish were then scooped with baskets. The fish were cured to provide a food source throughout the year (Kniffen 1939). Historical accounts from tribal members speak of CLH being easy to find as they spawned in large numbers in the tributaries to the lake (Scotts Valley Band of Pomo Indians historical accounts 2013). There are no estimates of the number of CLH that were taken for cultural harvest during any specific timeframe. However, an account from a tribal member indicates that a single family would take a couple thousand fish during the spawning run (Big Valley Environmental Protection Agency 2013). Tribal accounts indicate the harvest of CLH continued until the decline in spawning runs in the mid-1980s (Big Valley Environmental Protection Agency 2013). Prior to designation of CLH as a candidate species for listing, regulations in the Clear Lake watershed allowed for the harvest of CLH in spawning tributaries by hand or hand-held dip net. In 2013 the Department issued to three tribes CESA Memoranda of Understanding, pursuant to Fish and Game Code, section 2081, subdivision (a), to collect CLH for scientific research and public education (Kratville, D. personal communication, October 7, 2013, unreferenced).

Predation and Competition

Non-native fish introductions into Clear Lake date back as far as the late 1800s (Dill and Cordone 1997). Prior to the introduction of non-native fish species, between 12 and 14 native fish species occupied Clear Lake (Bairrington 1999; Moyle 2002; Thompson et al. 2013). Currently, approximately ten native species and 20 non-native species inhabit the lake (Bairrington1999; Thompson et al. 2013). Over the past 100 years two native species, thicktail chub (*Gila crassicauda*) and Clear Lake splittail, have gone extinct from the lake and another, Sacramento perch (*Archoplites interruptus*), has not been captured in sampling efforts since 1996 (Bairrington 1999; CDFW Commercial Fisheries Data; Thompson et al. 2013). The majority of non-native species introductions have been conducted by the Department and various local agencies and angling groups in an effort to increase sport fish opportunities. Introductions of fish at Clear Lake have been warmwater sport fish (largemouth and Florida bass (*Micropterus spp.*), sunfish (*Lepomis* spp.), catfish, etc.) or forage species for piscivorous sport fish. The Department has not stocked fish in Clear Lake in the past decade. Four fish species have been introduced without authorization from the Department (Dill and Cordone 1997; Rowan J. personal communication, October 10, 2013, unreferenced). Mississippi silverside, threadfin shad, smallmouth bass (*Micropterus dolomieu*), and pumpkinseed (*Lepomis gibbosus*) were introduced to provide forage for other game fishes, provide Clear Lake gnat control, or as part of a new sport fishery (Anderson et al. 1986; Dill and Cordone 1997; Bairrington 1999). Smallmouth bass and pumpkin seed never established sustainable populations in the lake. Non-native game fishes comprise nearly 100% of the sport catch from the lake. Incidental captures of native species occur infrequently and are rarely recorded during creel and tournament surveys (Rowan J. personal communication, October 10, 2013, unreferenced).

Non-native fish introductions can have significant impacts on native fish species. Mississippi silverside and threadfin shad are thought to compete directly with CLH for food resources (Geary and Moyle 1980; Anderson et al. 1986; Bairrington 1999). A comparison of Mississippi silverside and threadfin shad abundance from graphs in Eagles-Smith et al. (2008) and population trends for CLH (Figure 2) indicate a possible connection between abundances of these species. From 1990 to 2002 a similar pattern exists in increased CLH captures and observations during years of decreased Mississippi silverside and threadfin shad abundance. All three species are limnetic foragers that rely on macroinvertebrates for food. During years with decreased populations of Mississippi silverside and threadfin shad limnetic zooplankton numbers increase in stomach analysis of fishes indicating an increase in their availability to limnetic foragers (Eagles-Smith et al. 2008). Years with declines in threadfin shad and Mississippi silverside are thought to coincide with increases in CLH numbers, and years with decreased threadfin shad and Mississippi silverside result in increased young of year recruitment for other native and non-native species (Eagles-Smith et al. 2008; LCVCD 2013; Rowan J. personal communication, October 10, 2013, unreferenced). Eagles-Smith et al. (2008) found that zooplankton populations declined precipitously as threadfin shad populations increased, causing other common plankton-feeding fishes (juvenile largemouth bass and bluegill, Mississippi silverside) to switch to benthic feeding. Clear Lake hitch, being more specialized for zooplankton feeding and not being able to switch to benthic feeding, may have been strongly affected by the threadfin shad boom-and-bust population cycles in the lake (Eagles-Smith et al (2008).

Competition for juvenile rearing habitat and food has likely increased with the reduction in wetland habitat and increase in non-native fish species. Rearing habitat is essential for CLH recruitment to any year class. A reduction in recruitment leads to a decrease in spawning adults the following years. A species with highly fluctuating population trends, such as CLH, is particularly vulnerable to population level impacts in years with reduced recruitment. Piscivorous fish species such as largemouth bass (*Micropterus salmoides*) and Florida bass (*Micropterus floridae*) prey directly on both juvenile and adult CLH. Although no comprehensive diet studies have been done, incidental data indicate that CLH are found in the stomachs of piscivorous species in the lake (Moyle et al. in progress). Omnivorous species such as bullhead catfish (*Ameiurus* spp.) are known to prey on various life stages of native fishes. It is suggested that the introduction of bullhead catfish to Clear Lake may have played a role in the decline of native fish species (Dill and Cordone 1997). The introduction of white catfish (*Ameiurus* catus) was described, by Captain J.D. Dondero of the Division of Fish and Game, as having solved the problem of large spawning runs of fish dying in tributaries to Clear Lake and that the population of nongame fish diminished following their introduction (Dill and Cordone 1997). Jordan and Gilbert (1894) also describe catfish as being destructive to the spawn of other species. The rates at which CLH are consumed in relation to other prey species and the amount of CLH consumed are unknown.

Disease and Parasites

Disease outbreaks in fishes have been known to occur at Clear Lake. The outbreaks are primarily koi herpes virus (KHV) and impact introduced carp and goldfish. Native minnows, including CLH, show no effects from KHV. Fish fungi (*Saprolegnia* spp.) have been observed on fishes captured in Clear Lake and results from physical injury or infection. CLH are susceptible to fish fungi but it is not readily observed in captured fish. All fish in Clear Lake are susceptible to anchor worms (*Lernaea* spp.) and heavy infestations can lead to mortality. No CLH with heavy anchor worm infestations have been observed during CDFW fishery surveys at Clear Lake (Rowan J. personal communication, October 10, 2013, unreferenced). The Big Valley Rancheria Band of Pomo Indians has documented light loads of anchor worms occurring on CLH (Big Valley Rancheria 2012 and 2013).

Other Natural Occurrences or Human Related Activities

Climate Change

It is likely that native fishes in California will be vulnerable to physical and chemical changes as a result of climate change (Moyle et al. 2012). Research has shown that the annual mean temperature in North America has increased between 1955 and 2005 and is predicted to continue increasing in the future (Field et al. 1999; Hayhoe et al. 2004); however, it varies across North America, is more pronounced in spring and winter, and has affected daily minimum temperatures more than daily maximum temperatures (Field et al. 2007). In general, climate change models for California indicate an increase in overall temperature, decreased and warmer rainfall, and an increase in overall water temperatures (California Climate Change Center [CCCC] 2012). Cold storms are expected to decrease, giving way to warmer storms that create earlier run-off and less water storage capabilities (Field et al. 1999; Hayhoe et al. 2004; CCCC 2012). Climate change in the Clear Lake watershed is likely to cause changes to the interannual variability in rainfall. The change in rainfall variability would likely increase the occurrence of drought and flood years (Clear Lake Integrated Watershed Management Plan [CLIWMP] 2010). Expected climate change impacts to California and the Clear Lake watershed will be significant during annual CLH spawning cycles. CLH require winter and spring storms that provide suitable spawning flows in the tributaries of Clear Lake. A shift in timing, temperature, and amount of runoff will likely significantly impact the ability of CLH to successfully spawn. Anthropogenic driven climate change in the Clear Lake watershed could result in the loss of spawning habitat, reduced access to spawning habitat, stranding of spawning and juvenile fish, and egg desiccation.

A report on the projected effects of climate on California freshwater fishes, prepared for the California Energy Commission's California Climate Change Center, determined CLH to be critically vulnerable to impacts from climate change (Moyle et al. 2013). The report evaluated criteria such as population size, population trends, range, lifespan, and vulnerability to stochastic events to identify the degree of vulnerability of each fish species. The Intergovernmental Panel on Climate Change has stated that of all ecosystems, freshwater ecosystems will have the highest proportion of species threatened with extinction due to climate change (Kundzewicz et al. 2007). Freshwater lake species are more susceptible to extirpation because they are unable to emigrate should habitat changes occur (CA Natural Resources Agency 2009).

Recreational Activities

The natural resources of the Clear Lake watershed are a tremendous recreational resource for residents and visitors to Lake County. As the largest freshwater lake wholly in California, with opportunities for multiple aquatic recreational activities, the lake receives many thousands of visitors a year. According to 2008 data acquired from Lake County quagga mussel (*Dreissena rostriformis*) inspection sticker application forms; there were 11,230 boats that visited the lake that year. Jet skis and pleasure boats accounted for 41% of the boating activity at the lake (CLIWMP 2010).

Permanent structures, associated with boat docks, boat ramps, and swimming beaches, have reduced littoral zone habitat around the lake. These structures require clearing of littoral zone habitat to maintain access for recreational boaters and swimmers. It is estimated that there are over 600 private boat docks and boat ramps on the lake shoreline. In addition to reducing littoral zone habitat these structures provide additional habitat for non-native sport fish, such as largemouth bass, that prey on CLH.

Recreational and tournament angling generate a significant amount of the activity in the Clear Lake aquatic environment. In 2008, 18% of all boats entering the lake identified their recreational activity as angling (CLIWMP 2010). In a single year creel survey conducted in 1988 by the Department, CLH comprised two percent of the recreational sport catch (Macedo 1991).

The number of angling tournaments, primarily targeting largemouth bass, has increased over the last three decades in response to Clear Lake's reputation as a premiere sport fishery. Between 2001 and 2008 the number of permitted angling tournaments increased from 98 to 208 per year (Rowan J. personal communication, October 10, 2013, unreferenced). Since 2008 the number of permitted tournaments has decreased each year proportional to what has been observed throughout the rest of California. In 2013 there were 132 permitted bass tournaments at Clear Lake (Rowan J. personal communication, Feb 13, 2014, unreferenced). It is believed that recreational and tournament anglers' capture CLH incidentally while angling. The impact to CLH from the increase in angling tournaments is unknown, but is likely negligible because tournament anglers do not target CLH and bycatch would be an inadvertent snagging on an artificial lure, a rare occurrence.

REGULATORY AND LISTING STATUS

Federal

On September 25, 2012 the Center for Biological Diversity petitioned the U.S. Fish and Wildlife Service (USFWS) to list CLH as endangered or threatened under the federal Endangered Species Act (ESA). As of the publication of this Status Review report there has been no action taken on the petition by USFWS.

The U.S. Forest Service (USFS) lists CLH as a sensitive species. USFS sensitive species are those plant and animal species identified by a regional forester that are not listed or proposed for listing under the federal ESA for which population viability is a concern.

State

The Department designated CLH as a Species of Special Concern (SSC) in 1994. A SSC is a species, subspecies, or distinct population of an animal native to California that currently satisfies one or more of the following (not necessarily mutually exclusive) criteria:

- Is extirpated from the State or, in the case of birds, in its primary seasonal or breeding role;
- Is listed as Federally, but not State, threatened or endangered;
- Is experiencing, or formerly experienced, serious (noncyclical) population declines or range restrictions (not reversed) that, if continued or resumed, could qualify it for State threatened or endangered status;
- Has naturally small populations exhibiting high susceptibility to risk from any factor(s) that if realized, could lead to declines that would qualify it for State threatened or endangered status.

The intent of designating a species as a SSC is to:

- Focus attention on animals at conservation risk by the Department, other State, local and Federal government entities, regulators, land managers, planners, consulting biologists, and others;
- Stimulate research on poorly known species;
- Achieve conservation and recovery of these animals before they meet California Endangered Species Act criteria for listing as threatened or endangered.

There are no provisions in the Fish and Game Code that specifically prohibit take of CLH or protect its habitat.

Other Rankings

The American Fisheries Society ranks CLH as vulnerable, meaning the taxon is in imminent danger of becoming threatened throughout all or a significant portion of its range (Jelks et al. 2011).

EXISTING MANAGEMENT EFFORTS

Resource Management Plans

An increase in resource management efforts throughout the Clear Lake watershed has been of benefit to CLH, and several plans and strategies are in place to assist in reducing the threats to CLH.

The CLIWMP (2010) provides details of past and current resource management within the Clear Lake watershed. The plan seeks to identify opportunities to improve and protect the health and function of the watershed and identifies specific implementation actions to improve and protect watershed resources. Recommended actions are prioritized on a timeline. As funding allows, implementation of these actions will be undertaken by various non-governmental organizations (NGO) and local, state, tribal, and federal agencies that share an interest in promoting the health and function of the watershed. Multiple action items listed in the plan would benefit CLH and its habitat. Several tributaries to Clear Lake have completed Watershed Assessment plans as well. These include Kelsey Creek Watershed Assessment (2010), Middle Creek Watershed Assessment (2010), and Scotts Creek Watershed Assessment (2010). These plans were all completed by Lake County Water Resources Division for West and East Lake Resource Conservation Districts.

With adoption of the TMDL for Clear Lake, several projects are in process or have been completed to reduce the amount of phosphorous entering the lake. Specifically, the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project seeks to reduce the amount of phosphorous entering the lake by 40% (CEPA 2012). Lake County and the California Department of Transportation have implemented several best management practices (BMPs) for managing storm water runoff to reduce the amount of phosphorous and other contaminants that enter the lake. Both the USFS and Bureau of Land Management (BLM) have undertaken projects to reduce nutrients entering the lake as a result of off-highway vehicles and other land uses. BLM, in coordination with Scotts Valley Band of Pomo Indians, received a grant to implement the Eightmile Valley Sediment Reduction and Habitat Enhancement Project Design. Controlling sediment from Eightmile Valley is crucial to controlling the amount of nutrients entering the lake. Many of these projects are still in design or early implementation and it will be several years before changes in nutrient loads within the lake can be observed and studied.

The adverse effects from an increase in sedimentation as a result of conversion of various types of agricultural land to vineyard resulted in the formation of the Erosion Prevention and Education Committee (EPEC). The EPEC was a group of county agencies and private entities that provide educational outreach regarding erosion control and water quality protection. However, the group has not convened a meeting or completed any actions for several years. The Lake County Grading Ordinance was approved in 2007 and requires grading permits and Erosion Control and Sediment Detention Plans for projects with increased probability of resulting in increased sedimentation (Forsgren Associates, Inc. 2012).

Concerns over the reduction in habitat quality resulting from gravel mining prompted Lake County to adopt an Aggregate Resources Management Plan in 1994. The plan called for a moratorium on gravel mining in several tributaries to Clear Lake. The implementation of gravel mining regulations has resulted in reduced in-stream and bank erosion and increased riparian habitat along the creeks (CEPA 2008).

To prevent further destruction of wetland habitat along the lake shoreline, in 2000 and 2003 amendments, Lake County adopted Section 23-15 of the Clear Lake Shoreline Ordinance prohibiting the destruction of woody species and tules. In addition to the ordinance, there is a no net-loss requirement for commercial, resort, and public properties that wish to clear areas of shoreline (CLIWMP 2010).

RREC produced an Adaptive Management Plan (AMP) for the Clear Lake Hitch, *Lavinia exilicauda chi* (RREC 2011). The AMP describes the current status of CLH habitat and impediments to habitat recovery. The habitat assessments are included in a management plan that identifies action items, issues of uncertainty, stakeholder involvement, sustainability, and AMP amendment procedures. The RREC is currently in the process of revising the AMP.

The Department has created or approved two Conceptual Area Protection Plans (CAPP) for the Clear Lake Watershed. The creation of a CAPP for an area allows the Department, as well as local, federal, and NGOs, to apply for land acquisition funding from the Wildlife Conservation Board. The first, the Clear Lake CAPP, was approved in 2002 and addresses land acquisition needs in the area of Middle Creek. The plan focuses on protecting wetland and riparian habitat for the benefit of natural resources. The second CAPP, Big Valley Wetlands, is currently in development and should be approved in 2014. The Big Valley Wetlands CAPP focuses on land acquisitions in the western portion of the Clear Lake watershed for the purpose of protecting wetland and riparian habitat. Both CAPP's will benefit CLH in the protection of riparian and wetland habitat critical for spawning and rearing CLH. Land acquisitions that seek to protect and restore existing CLH habitat should create a stable environment for CLH populations.

The Department published a Clear Lake Fishery Management Plan in 1999 (Bairrington 1999). The plan provides a review of past and present biological information for Clear Lake. The primary focus of the plan is to maintain fishery resources of the lake and enhance recreational fishing opportunities. The plan identifies areas of controversy between various stakeholder groups in the watershed, stating that "adapting to the biological and social settings at Clear Lake involves a variety of compromises between these groups and the non-angling groups who wish to ensure the well-being of Clear Lake's native fish species." The plan identifies the decline in native fish species at

Clear Lake as being detrimental both socially and biologically. No specific guidelines are given for addressing impacts to native species, but restoration of spawning habitat and natural flow regimes are discussed as critical for native species survival.

Monitoring and Research

In 2013 the Department attempted to conduct a status assessment of the CLH population present in Cole and Kelsey creeks. Sampling produced too few fish to facilitate a statistically valid mark and recapture study. As a result, a population estimate was not completed. The Department has proposed additional funding in 2014 to begin a multi-year mark-recapture study to determine a statistically valid population estimate or index of CLH.

The CCCLH has been conducting annual spawning observations since 2005. A simple protocol is followed that identifies a time, observer, and number of CLH observed to be documented. Volunteers have put in hundreds of hours monitoring CLH spawning runs during this time period. Although not quantitative, the surveys provide a glimpse into the number of spawning CLH and how successful spawning is in a particular season. Results of these surveys are included in Appendices A and B and summarized in Section 4.1 and 4.2 above.

Habitat Restoration Projects

In recent years, local, state, and federal agencies have begun implementing actions to aid in the protection and restoration of Clear Lake wetland habitat. The Middle Creek Flood Damage Reduction and Ecosystem Restoration Project will restore up to 1,400 acres of wetland habitat around Middle Creek and Rodman Slough, essentially doubling the amount of existing wetland habitat in the watershed (CLIWMP 2010).

Impacts of Existing Management Efforts

To date, existing management efforts have focused on CLH habitat restoration. Wetland restoration projects that would significantly benefit CLH have been proposed. These projects have been or will be implemented through the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project and the two CAPPs that cover portions of the watershed. Wetland restoration is expected to aid in increasing spawning success and juvenile recruitment into the population. Increased wetland acreage would enhance filtration of tributary waters resulting in decreased amounts of nutrients entering the lake and an increase in the water table. The increased water table will help maintain surface flow in tributaries, resulting in suitable spawning habitat being maintained throughout the spawning season. The Clear Lake Shoreline Ordinance has resulted in a “no net loss” of shoreline wetland habitat around the lake since its enactment. However, because these wetland restoration projects are either recent or yet to be implemented, a thorough assessment of direct and indirect impacts to CLH populations cannot be included in this Status Review report.

Establishment of TMDLs for mercury and nutrients has led to a reduction in inputs and an increase in monitoring efforts in the Clear Lake watershed. Past and future steps by the federal government will reduce mercury contamination resulting from the Sulphur Bank Mercury Mine. Most of the identified initial actions for cleanup have been implemented. The focus will now be on two long-term projects to address waste pile and lake sediment cleanup, which should result in significant reductions in mercury contamination in the watershed. Nutrient loads entering Clear Lake have been addressed by several measures including wetland restoration, BMPs for storm water runoff, and erosion control measures. Many of these projects are in the early stages of implementation, and a thorough assessment of impacts to CLH is yet to be been completed. Reduced mercury and nutrient loads in Clear Lake will result in a benefit to CLH.

SCIENTIFIC DETERMINATIONS REGARDING THE STATUS OF CLEAR LAKE HITCH IN CALIFORNIA

CESA directs the Department to prepare this report regarding the status of CLH based upon the best scientific information available to the Department. CESA's implementing regulations identify key factors that are relevant to the Department's analyses. Specifically, a "species shall be listed as endangered or threatened ... if the Commission determines that its continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities." (Cal. Code Regs., tit. 14, § 670.1 (i)(1)(A)).

The definitions of endangered and threatened species in the Fish and Game Code provide key guidance to the Department's scientific determination. An endangered species under CESA is one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, over exploitation, predation, competition, or disease." (Fish & G. Code, § 2062). A threatened species under CESA is one "that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [CESA]." (*Id.*, § 2067).

The preceding sections of this Status Review report describe the best scientific information available to the Department, with respect to the key factors identified in the regulations.

Present or Threatened Modification or Destruction of Habitat

Beginning with the arrival of European settlers in the mid-1800s, alterations to habitats in the watershed have directly impacted the ability of CLH to survive. Habitats necessary for both spawning and rearing have been reduced or severely decreased in suitability in the past century resulting in an observable decrease in the overall abundance of CLH and its habitat. Spawning tributaries have been physically altered by a combination of dams, diversions, and mining operations that have altered the course and timing of spring flows and the amount and quality of spawning habitat available for CLH. Dams create barriers to CLH passage that reduce the amount of available spawning habitat while altering the natural flow regime of tributaries. Water diversions on tributaries have resulted in decreased flows during critical spawning migrations for CLH. Loss of eggs, juvenile, and adult fish due to desiccation and stranding from water diversions are likely a significant impact on CLH populations. Gravel mining removed large amounts of spawning substrate during peak operations in the mid-1900s.

Spawning substrate has been restored slowly after gravel mining was discontinued in the majority of the watershed. Water quality impacts to the watershed have resulted in Clear Lake being listed as an impaired water body and led to the establishment of TMDLs for both mercury and nutrients for the lake. It is unclear to what extent the water quality impacts are affecting CLH populations. The Department considers modification and destruction of habitat a significant threat to the continued existence of CLH.

Overexploitation

Harvest of CLH has occurred by both Native American tribes and commercial fishery operators at Clear Lake. Historic accounts from tribal members indicate that significant amounts of CLH were harvested during spawning runs. In recent years, the amount of harvest by the Pomo has been minimal, and the CLH are primarily used for educational and cultural reasons. Since the early 1990s commercial fishery operations have been required to return all CLH captured to the lake. Prior to that, CLH had not been regularly harvested for sale. It is likely that incidental catch during commercial harvest operations resulted in mortality of some CLH. However, there is no information indicating that overexploitation threatens the continued existence of CLH.

Predation

Direct predation of CLH by fish, birds, and mammals is known to occur in occupied habitats within the watershed. Spawning runs are vulnerable to predation from birds and mammals as fish migrate upstream and become stranded at various locations. Stranding occurs both naturally and as a result of habitat modifications described above. Non-native fishes prey directly on different life stages of CLH and represent an introduced impact to the population. CLH have been found during stomach content analyses of largemouth bass. Incidental observations indicate that largemouth bass may target CLH as the CLH stage at the entrance to ascend spawning tributaries in early spring. Other introduced fishes, such as bullhead catfish, also prey on CLH. A detailed diet study on selected introduced fishes is necessary to determine the extent of predation from introduced fishes. There is evidence suggesting that predation by introduced fishes threatens the continued existence of CLH.

Competition

The extent of impacts on CLH from competition with other aquatic species is poorly understood. Studies conducted on diet analysis of CLH indicate that there is competition between CLH and other macroinvertebrate consuming fish species, primarily Mississippi silversides and threadfin shad. Observations by Department biologists and others indicate that CLH populations fluctuate on alternating cycles with Mississippi silverside and threadfin shad populations with CLH being more abundant in years with decreased Mississippi silverside and threadfin shad abundance. CLH directly compete with other native and non-native fishes for juvenile rearing habitat. Many fishes in Clear Lake utilize near shore wetland habitat as juveniles and adults. With the decrease in wetland habitat over the past century, there is increased competition for the remaining habitat. Although no formal studies have been completed, it is likely that competition for resources threatens the continued existence of CLH.

Disease

There are no known diseases that are significant threats to the continued existence of CLH.

Other Natural Occurrences or Human-related Activities

If climate change models are accurate, potential impacts to California and the Clear Lake watershed will be significant during annual CLH spawning cycles. CLH require winter and spring storms that provide suitable spawning flows in the tributaries of Clear Lake. A shift in timing, temperature, and amount of runoff could significantly impact the ability of CLH to successfully spawn. A report on the projected effects of climate on California freshwater fishes determined CLH to be critically vulnerable to impacts from climate change. Climate change is considered a threat to the continued existence of the species.

Numerous recreational activities take place in Clear Lake each year. The majority of recreational activities pose no significant threat to the survival of CLH. It is believed that recreational and tournament anglers' capture CLH incidentally, however the occurrence is considered rare. The significance of impacts to CLH from angling is unknown, but likely do not threaten the continued existence of CLH.

SUMMARY OF KEY FINDINGS

At present time, the species can be found in portions of its historic habitat and qualitative surveys indicate a variable interannual population. Based on qualitative surveys efforts to date a population estimate or index of CLH is not attainable. Without a current population or index for CLH it is necessary to estimate impacts not based on a set baseline but rather against trends seen in abundance and distribution in sampling efforts over the past half century.

It is imperative for the Department and the conservation community to study and monitor the population of CLH over the next decade. A review of the scientific determinations regarding the status of CLH indicates there are significant threats to the continued existence of the species, particularly related to historical and ongoing habitat modification, predation from introduced species, competition, and climate change. Many of these threats are currently or in the near future being addressed by existing management efforts. Monitoring impacts from existing management efforts will be imperative to assessing the future status of CLH.

RECOMMENDATION FOR PETITIONED ACTION

CESA directs the Department to prepare this report regarding the status of CLH in California based upon the best scientific information available. CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)). The Department includes and makes its recommendation in its status report as submitted to the Commission in an advisory capacity based on the best available science.

Based on the criteria described above, the scientific information available to the Department indicates that CLH, while not presently threatened with extinction, are likely to become an endangered species in the foreseeable future, absent the special protections and management efforts required by CESA. The Department recommends that the petitioned action to list CLH as a threatened species is warranted.

PROTECTION AFFORDED BY LISTING

It is the policy of the State to conserve, protect, restore and enhance any endangered or any threatened species and its habitat. (Fish & G. Code, § 2052.) If listed as an endangered or threatened species, unauthorized "take" of CLH will be prohibited, making the conservation, protection, and enhancement of the species and its habitat an issue of statewide concern. As noted earlier, CESA defines "take" as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill. (*Id.*, § 86.) Any person violating the take prohibition would be punishable under State law. The Fish and Game Code provides the Department with related authority to authorize "take" under certain circumstances. (*Id.*, §§ 2081, 2081.1, 2086, 2087 and 2835.) As authorized through an incidental take permit, however, impacts of the taking on CLH caused by the activity must be minimized and fully mitigated according to State standards.

Additional protection of CLH following listing would also occur with required public agency environmental review under CEQA and its federal counter-part, the National Environmental Policy Act (NEPA). CEQA and NEPA both require affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on endangered, rare, and threatened special status species. Under CEQA's "substantive mandate," for example, state and local agencies in California must avoid or substantially lessen significant environmental effects to the extent feasible. With that mandate and the Department's regulatory jurisdiction generally, the Department expects related CEQA and NEPA review will likely result in increased information regarding the status of CLH in California as a result of, among other things, updated occurrence and abundance information for individual projects. Where significant impacts are identified under CEQA, the Department expects project-specific required avoidance, minimization, and mitigation measures will also benefit the species. While both CEQA and NEPA would require analysis of potential impacts to CLH regardless of their listing status under CESA, the acts contain specific requirements for analyzing and mitigating impacts to listed species. In common practice, potential impacts to listed species are examined more closely in CEQA and NEPA documents than potential impacts to unlisted species. State listing, in this respect, and required consultation with the Department during state and local agency environmental review under CEQA, is also expected to benefit the species in terms of related impacts for individual projects that might otherwise occur absent listing.

If CLH is listed under CESA, it may increase the likelihood that State and federal land and resource management agencies will allocate funds towards protection and recovery actions. However, funding for species recovery and management is limited, and there is a growing list of threatened and endangered species.

MANAGEMENT RECOMMENDATIONS AND RECOVERY MEASURES

Current data on CLH suffer from being largely anecdotal and qualitative in nature. Studies designed to provide quantitative data on CLH populations and the factors that affect the ability of CLH to survive and reproduce are necessary for species management. The following list of management recommendations were generated by Department staff with considerations from local agencies, non-profits, and interested parties.

- Derive a statistically valid population estimate or index allowing assessment of impacts to the overall population and provide a baseline to maintain a sustainable population level.
- Conduct a thorough assessment of barriers to fish movement on primary spawning streams and provide recommendations for restoration actions on substantial barriers.
- Complete a detailed analysis of spawning habitat on primary spawning streams and provide recommendations for restoration actions.
- Implement identified restoration activities to increase available spawning and rearing habitat for CLH.
- Conduct a review of reservoir operations at Highland Springs, Adobe Creek, and Kelsey Creek detention dams to assess water release operations that may be impacting CLH, development and implementation of guidelines for minimizing impacts.
- Conduct an in stream flow analysis of primary spawning tributaries to determine impacts of water diversions on stream flows, particularly during spawning season.
- Coordinate with landowners, stakeholders, and permitting agencies on developing strategies for reducing in stream diversions during spawning season.
- Determine the value of wetland habitat in the watershed pertaining to survivorship of juvenile CLH and make appropriate recommendations on restoration or modification.
- Analyze food web interactions of CLH and non-native fish to determine potential impacts to CLH.
- Conduct a diet analysis of selected introduced fish species to determine the extent of their impact on CLH.
- Conduct creel surveys to gain a better understanding of CLH capture rates during both recreational and tournament angling.
- Develop a comprehensive monitoring program that assesses both native and non-native fish populations and their distribution in the watershed.
- Identify habitats within the watershed that may be suitable for CLH translocations.
- Coordinate the above research and restoration efforts with interested stakeholders in the watershed.

  Develop an outreach program to provide updates to stakeholders on recovery and management efforts.

PUBLIC RESPONSE

Comments were invited in response to the current petition in a Department press release dated April 16, 2013. Four of the comment letters received provided the Department with data for the Status Review report or recommendations on how to improve habitat for CLH. Four comment letters provided support for the listing as threatened under CESA and six comment letters were either against the listing as threatened under CESA or were against actions to improve conditions for CLH by removing other sport fish from the lake. Comments received are included in Appendix D.

PEER REVIEW

Independent fishery experts were invited to review the Status Review report prior to submission to the Fish and Game Commission. The letters of invitation and all comments received are included in Appendix E.

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LITERATURE CITED

Aguilar, A. and J. Jones. 2009. Nuclear and Mitochondrial Diversification in two Native California Minnows: Insights into Taxonomic Identity and Regional Phylogeography. Molecular Phylogenetics and Evolution 51 (2): 373-381.

Anderson, N.L., D.L. Woodward and A.E. Colwell. 1986. Pestiferous dipterans and two recently introduced aquatic species at Clear Lake. Proceedings of the California Mosquito Vector Control Association. 54:163-167.

Anderson, N.L., 1989. Letter to Rick Macedo containing notes and data from LCVCD sampling efforts.

Avise, J.C. and F.J. Ayala. 1976. Genetic differentiation in speciose versus depauperate phylads: Evidence from the California minnows. Evolution 30:46-58.

Barrett, S.A., 1906. The Ethno-Geography of the Pomo and Neighboring Indians. University of California Publications in American Archeology and Ethnology. Vol 6 No. 1.

Bairrington, P., 1999. CDFG Clear Lake Fishery Management Plan.

Bellucci, C. J., Becker, M., & Beauchene, M. (2011). Characteristics of macroinvertebrate and fish communities from 30 least disturbed small streams in Connecticut. *Northeastern Naturalist, 18*(4), 411-444.

Big Valley EPA, 2013. Hitch interview notes with families of Big Valley Rancheria and Elem Indian Colony.

Big Valley Rancheria, 2012. Hitch *Lavinia exilicauda* Chi Hopkirk ecology and water quality studies in Big Valley sub-basin creeks in 2012.

Big Valley Rancheria, 2013. Big Valley sub-basin creek water quality, quantity, and Hitch *Lavinia exilicauda* Chi Hopkirk ecology program Spring, 2013.

Brown, A.V., M.M. Little, and K.B. Brown, 1998. Impacts of gravel mining on gravel bed streams. *Transactions of the American Fisheries Society*. 127:979-994.

Bunn, S.E., and A.H. Arthington, 2002. Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity. *Environmental Management*. Vol. 30:4. Pp 492-507.

California Climate Change Center, 2012. Our Changing Climate 2012 Vulnerability and Adaptation to the Increasing Risks from Climate Change in California.

California Department of Fish and Game, 1955-1956. Field notes on Kelsey and Seigler Creeks.

California Department of Fish and Game, 1961-2001. Commercial Catch data for Clear Lake

California Department of Fish and Game, 1969. News Release on Fish Dieoffs at Clear Lake.

California Department of Fish and Game, 1988. Clear Lake Electrofishing Survey, April 2, 1987 Memorandum.

California Department of Fish and Game, 2012. Electrofishing data, Memorandum in progress.

California Department of Fish and Wildlife, 2013. Report to the Fish and Game Commission Evaluation of the Petition from the Center for Biological Diversity to List Clear Lake Hitch (*Lavinia exilicauda chi*) as a Threatened Species under the California Endangered Species Act.

California Department of Fish and Wildlife, 2013. Commercial Fisheries Data from catch records.

California Department of Fish and Wildlife, 2013. Commercial Operators permit applications.

California Department of Fish and Wildlife, April 24, 2013. Press Release – CDFW Seeks Public Comment and Data Regarding Clear Lake Hitch.

California Department of Water Resources. 1975. Clear Lake Water Quality Data.

California Natural Resources Agency, 2009. California Climate Adaptation Strategy Discussion Draft.

California Environmental Protection Agency RWQCBCVR, 2002. Clear Lake TMDL for Mercury Staff Report.

California Environmental Protection Agency RWQCBCVR, 2008, Monitoring and Implementation Plan Clear Lake Mercury and Nutrient TMDL’s.

California Environmental Protection Agency RWQCBCVR, 2010. Clear Lake Mercury Total Maximum Daily Load Update.

California Environmental Protection Agency RWQCBCVR, 2012. Clear Lake Nutrient Total Maximum Daily Load Control Program 5-year Update.

California Regulatory Notice Register, 2012. No. 41-Z. p.1501

California Regulatory Notice Register, 2013. No. 12-Z. p.488

Literature Cited

Center for Biological Diversity, 2012. Petition to List Clear Lake Hitch (*Lavinia exilicauda chi*) as Threatened under the California Endangered Species Act. 58 pp.

Chi Council for the Clear Lake Hitch (CCCLH). 2013. Hitch spawning survey results, 2005-2013. Available at http://lakelive.info/chicouncil/

Clear Lake Integrated Watershed Management Plan, February 2010. Prepared for West Lake and East Lake Resource Conservation Districts.

Coleman, G.A. 1930. A biological survey of Clear Lake, Lake County. *Calif. Fish and Game* 16: 221-227.

Converse,Y.A., C.P. Hawkins and R. A. Valdez, 1998. Habitat Relationships of Subadult Humpback Chub in the Colorado River Through Grand Canyon: Spatial Variability and Implications of Flow Regulation. *REGULATED RIVERS: RESEARCH & MANAGEMENT* **14**: 267–284

Cook, S. F., Jr., J. D. Connors, and R. L. Moore, 1964. The impact of the fishery on the midges of Clear Lake, Lake County, CA, *Annals of the Entomological Society of America*, Vol. 57, pp. 701-707.

Cook, S. F., Jr., J. D. Connors, and R. L. Moore, 1966. Status of the Native Fishes of Clear Lake, Lake County, California. *Wasmann Journal of Biology,* 24: 141-160.

Cott, P. A., Sibley, P. K., Somers, W. M., Lilly, M. R., & Gordon, A. M. (2008). A REVIEW OF WATER LEVEL FLUCTUATIONS ON AQUATIC BIOTA WITH AN EMPHASIS ON FISHES IN ICE-COVERED LAKES1. *Journal of the American Water Resources Association, 44*(2), 343-359.

County of Lake Water Resources, 2013. Memo on Historical Water Levels of Clear Lake.

Cox, B., 2007. CDFG Clear Lake Fishery Surveys Summary Report.

Curtis T.C. 1977. Pesticide Laboratory report. California Department of Fish and Game, E.P. No. P-133. 3pp.

Crump, KL and VL Trudeau, 2009. Mercury-induced reproductive impairment in fish. *Environmental Toxicology and Chemistry*. 28(5):895-907.

Deitch, M.J., G.M. Kondolf, and A.M. Merenlender. 2009. Hydrologic impacts of smallscale instream diversions for frost and heat protection in the California wine country. River Research and Applications, Volume 25, Issue 2, pages 118-134.

Dill, W. A., and A. J. Cordone. 1997. Fish Bulletin 178. History and Status of Introduced Fishes in California 1871-1996. California. Fish and Game. 414 pp.

Eagles-Smith, C.A., T.H. Suchanek, A.E. Colwell, N.L. Anderson, and P.B. Moyle. 2008. Changes in fish diets and food web mercury bioaccumulation induced by an invasive planktivorous fish. Ecological Applications 18(Supplement): A213–A226.

Ewing, B., 2013. Summary of the Clear Lake Hitch Population Estimate for Cole and Kelsey Creeks, Lake County.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller, 1999. *Confronting Climate Change in California: Ecological Impacts on the Golden State.* Union of Concerned Scientists, Cambridge, MA and Ecological Society of America, Washington, DC.

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

Forsgren Associates Inc, 2012. Clear Lake Watershed Sanitary Survey 2012 Update Final.

Franson, S. 2013. Summary of Spring 20-13 Field Monitoring with Locations chosen for observing egg and larval development of Clear Lake Hitch (*Lavinia exilicauda chi*).

Gafny, S., A. Gasith, and M. Goren 2006. Effect of water level fluctuation on shore spawning of *Mirogrex terraesanctae* (Steinitz), (Cyprinidae) in Lake Kinneret, Israel Journal of Fish Biology vol 41:6 pages 863-871

Geary, R.E. 1978. Life history of the Clear Lake hitch *(Lavinia exilicauda chi).* Unpublished Master's Thesis, University of California, Davis. 27 pp.

Geary, R.E. and P.B. Moyle. 1980. Aspects of the ecology of the hitch, *Lavinia exilicauda* (Cyprinidae), a persistent native cyprinid in Clear Lake, California. Southwest. Nat. 25:385-390.

Giusti, G. 2009. Human Influences to Clear Lake, California A 20^{th} Century History.

Harnly, M., S. Seidel, P. Rojas, R. Fornes, P. Flessel, D. Smith, R. Kreutzer, and L. Goldman. 1996. Biological monitoring for mercury within a community with soil and fish contamination. *Environmental Health Perspectives*, Vol. 105:4, 424-429.

Havens, K.E. 2008. Cyanobaterial Harmful Algal Blooms: State of the Science and Research Needs. Chapter 33: Cyanobacteria blooms: effects on aquatic ecosystems.

Hayhoe, K., D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider,K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S.

Kalkstein, J. Lenihan, C.K.Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville. 2004. Emisions pathways, climate change,and impacts on California. Proceedings of the National Academy of Science 101:12422-12427.

Hopkirk, J.D. 1973. Endemism in fishes of the Clear Lake region of central California. University of California Publications in Zoology 96: 160 pp.

Horne, A.J. 1975. The Effects of Copper, Major and Minor Nutrient Element

Additions, and Lake Water Movements on Blue-Green Algal Bloom Development in Clear Lake.

Hudon, C., Armellin, A., Gagnon, P., & Patoine, A. (2010). Variations in water temperatures and levels in the st. lawrence river (quebec, canada) and potential implications for three common fish species. *Hydrobiologia, 647*(1), 145-161.

Hunt, E.G. and A.I. Bischoff. 1960. Inimical effects on wildlife or periodic DDD applications to Clear Lake. California Fish and Game 46:91-106.

Jelks, H L., Stephen J. Walsh, Noel M. Burkhead, Salvador Contreras-Balderas, Edmundo

Diaz-Pardo, Dean A. Hendrickson, John Lyons, Nicholas E. Mandrak, Frank McCormick, Joseph S. Nelson, Steven P. Platania, Brady A. Porter, Claude B. Renaud, Juan Jacobo Schmitter-Soto, Eric B. Taylor & Melvin L. Warren Jr. (2008): Conservation Status of Imperiled North American Freshwater and Diadromous Fishes, Fisheries, 33:8, 372-407.

Jordan, D.S., and C.H. Gilbert. 1894. List of Fishes Inhabiting Clear Lake, California. Bulletin of the United States Fish Commission, Vol. XIV.

Kelsey Creek Watershed Assessment, February 2010. Prepared for East Lake and West Lake Resource Conservation Districts.

Kimsey, J.B. and L.O. Fisk. 1960. Keys to the freshwater and anadromous fishes of California. Calif. Fish Game 46:453-79.

Kniffen, F.B. 1939. Pomo Geography. University of California Publications in American Archaeology and Ethnology. Vol. 36 No. 6 pp. 353-400.

Kratville, D. October 7, 2013. Email correspondence on CESA MOU's issued for CLH.

Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen and I.A. Shiklomanov, 2007: Freshwater resources and their management. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate*

Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210.

Lake County Department of Agriculture, 2011. Crop Report

Lake County Department of Public Works Water Resources Division, 2003. Clear Lake Wetlands Geographic Information Systems Data User Manual.

Lake County Vector Control District, 2013. Copy of verified Beach Seine 1987-2010 CL Hitch with notes.

Lindquist, A.W., C.D. Deonier, and J.E. Hanley. 1943. The relationship of fish to the Clear Lake gnat, in Clear Lake, California. Calif. Fish Game 29:196-202.

Lindquist, A.W. and A.R. Roth. 1950. Effect of dichlorodiphenyl dichloroethane on larva of the Clear Lake gnat in California. *Journal of Economic Entomology* 43:328-332.

Macclanahan, J., E. W. Danley, H. F. Dewitt, and W. Wolber. 1972[app]. Flood control project maintenance and repair, 1971 inspection report. California Department of Water Resources Bulletin 149-71.

Macedo, R., 1991. Creel Survey at Clear Lake, California March – June, 1988. CDFG Administrative Report No. 91-3.

Macedo, R. 1994. Swimming Upstream Without a Hitch. Outdoor California: January/February 1994.

Marchetti, M.P. and P.B. Moyle, 2001. Effects of flow regime on fish assemblages in a regulated California stream. *Ecological Applications*. 11(2). Pp. 530-539.

McGinnis, D. and E. Ringelberg. 2006. Lake County Fish Barrier Assessment. Technical Memo.

Middle Creek Watershed Assessment, February 2010. Prepared for West Lake Resource Conservation District.

Miller, R.R. 1945. A new cyprinid fish from Southern Arizona, and Sonora, Mexico, with description of a new subgenus of *Gila* and a review of related species. Copeia 1945:104-110.

Miller, R.R. 1963. Synonymy, characters and variation of *Gila crassicauda*, a rare California minnow, with an account of its hybridization with *Lavinia exilicauda*. California Fish and Game 49 (1): 20-29.

Mioni, C., R. Kudela, and D. Baxter. 2011. Harmful cyanobacteria blooms and their toxins in Clear Lake and the Sacramento-San Joaquin delta (California). Central Valley Regional Water Quality Control Board: 10-058-150.

Mosley, D. 2013. Biological and Physical Habitat Assessment Report. Prepared for Habematolel Pomo of Upper Lake.

Moyle, P.B. and M. Massingill. 1981. Hybridization between hitch, *Lavinia exilicauda*, and Sacramento blackfish, *Orthodon microlepidotus*, in San Luis Reservoir, California. California Fish Game 67:196-198.

Moyle, P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern in California, 2nd edition.

Moyle, P.B. and T. Light, 1996. Fish Invasions in California: Do Abiotic Factors Determine Success? Ecology 77:1666-1670.

Moyle, P. B. 2002. Inland Fishes of California. Berkeley: University of California Press.

Moyle PB, Kiernan JD, Crain PK, Quiñones RM (2013) Climate Change Vulnerability of Native and Alien Freshwater Fishes of California: A Systematic Assessment Approach. PLoS ONE 8(5): e63883. doi:10.1371/journal.pone.0063883.

Moyle P.B., J.V Katz, and R.M. Quinones. In review. Fish Species of Special Concern for California. Prepared for California Department of Fish and Game, Sacramento

Murphy, G.I. 1948. Notes on the biology of the Sacramento hitch *(Lavinia e. exilicauda)* of Clear Lake, Lake County, California. Calif. Fish Game 34:101-110.

Murphy, G.I. 1951. The fishery of Clear Lake, Lake County, California. *Calif. Fish and Game* 37: 439-484.

National Oceanic and Atmospheric Administration, 2011. Table 2. Toxicity associated with mercury in tissues (ug/g) wet weight.

Nicola, S.J. 1974. The life history of the hitch, *Lavinia exilicauda* Baird and Girard, in Beardsley Reservoir, California. Inland Fish. Admin. Rep. 74-6:1-16.

Osleger, D.A., R.A. Zierenberg, T.H. Suchanek, J.S. Stoner, S. Morgan, and D.P. Adam. 2008. Clear Lake sediments: anthropogenic changes in physical sedimentology and magnetic response. Ecological Applications 18 (Supplement): A239-A256.

Puckett, L., 1972. CDFG Memorandum-Fisheries Survey Clear Lake, Lake County.

Richerson P.J., T.H. Suchanek, and S.J. Why. 1994. The Causes and Control of Algal Blooms in Clear Lake, Clean Lakes Diagnostic/Feasibility Study for Clear Lake, California. Prepared for USEPA Region IX.

Ridout, W.L. 1899. A Fish Jam on Kelsey Creek. *Overland Monthly and Out West Magazine.* Volume 34, Issue 202. p. 333.

Robinson Rancheria Environmental Center (RREC). 2011. Draft Adaptive Management Plan for the Clear Lake Hitch, *Lavinia exilicauda chi*. Available at http://www.robinsonrancheria.org/environmental/water.htm.

Rowan, J., 2008. CDFG Clear Lake, Lake County Memorandum.

Rudd, R.L. 1964. *Pesticides and the Living Landscape*. University of Wisconsin Press, Madison, WI.

Sandheinrich, MB. And KM Miller, 2006. Effects of dietary methylmercury on reproductive behavior of fathead minnows (*Pimephales promelas*). *Environmental Toxicology and Chemistry.* 25(11):3053-3057.

Scotts Creek Watershed Assessment, February 2010. Prepared for West Lake Conservation District.

Scotts Valley Band of Pomo Indians, 2013. Historical accounts provided to CDFW by Steve Elliott and Wanda Quitiquit.

State of California Fish and Game Commission, March 11, 2013. California Fish and Game Commission Notice of Findings

State of California Fish and Game Commission, October 2, 2012. California Fish and Game Commission Notice of Receipt of Petition

Suchanek, T.H., P.J. Richerson, L.A. Woodward, D.G. Slotton, L.J. Holts and C.E. Woodmansee. 1993. Ecological Assessment of the Sulphur Bank Mercury Mine Superfund Site, Clear Lake, California: A Survey and Evaluation of Mercury In: Sediment, Water, Plankton, Periphyton, Benthic Invertebrates and Fishes Within the Aquatic Ecosystem of Clear Lake, California. Phase 1- Preliminary Lake Study Report. Prepared for EPA-Region IX, Superfund Program. 113 pp., plus 2 attachments.

Suchanek, T.H., P.J. Richerson, D.C. Nelson, C.A. Eagles-Smith, D.W. Anderson, J.J. Cech, Jr., G. Schladow, R. Zierenberg, J.F. Mount, S.C. McHatton, D.G. Slotton, L.B. Webber, A.L. Bern and B.J. Swisher. 2002. Evaluating and managing a multiply-stressed ecosystem at Clear Lake, California: A holistic ecosystem approach. “Managing For Healthy Ecosystems: Case Studies,” CRC/Lewis Press. pp. 1233-1265.

Swift, C. 1965. Early development of the hitch, *Lavinia exilicauda,* of Clear Lake, California. Calif. Fish Game 51:74-80.

Thompson, L.C., G.A. Giusti, K.L. Weber, and R.F. Keiffer. 2013. The native and introduced fishes of Clear Lake: a review of the past to assist with decisions of the future. California Fish and Game 99(1):7-41.

U.S. Army Corps of Engineers. 1974[app]. Flood plain information: Big Valley streams (Manning, Adobe, Kelsey, and Cole Creeks), Kelseyville, California. Department of the Army, Sacramento District, Corps of Engineers, Sacramento, California, USA.

U.S. Environmental Protection Agency, 2012. Sulphur Bank Mercury Mine News Release – EPA to Begin Construction of Test Covers in Clear Lake.

Week, L., 1982. Habitat Selectivity of Littoral Zone Fishes at Clear Lake, CDFG California. Administrative Report No. 82-7.

Wetzel, R.G., 2001. Limnology lake and River Ecosystems, 3rd ed. Pg. 834.

Winder, M., J. Reuter and G. Schladow, 2010. Clear Lake Report: Clear Lake Historical Data Analysis.

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Appendix A

Appendix A. Summary graphs of spawning observations between 2005 and 2013

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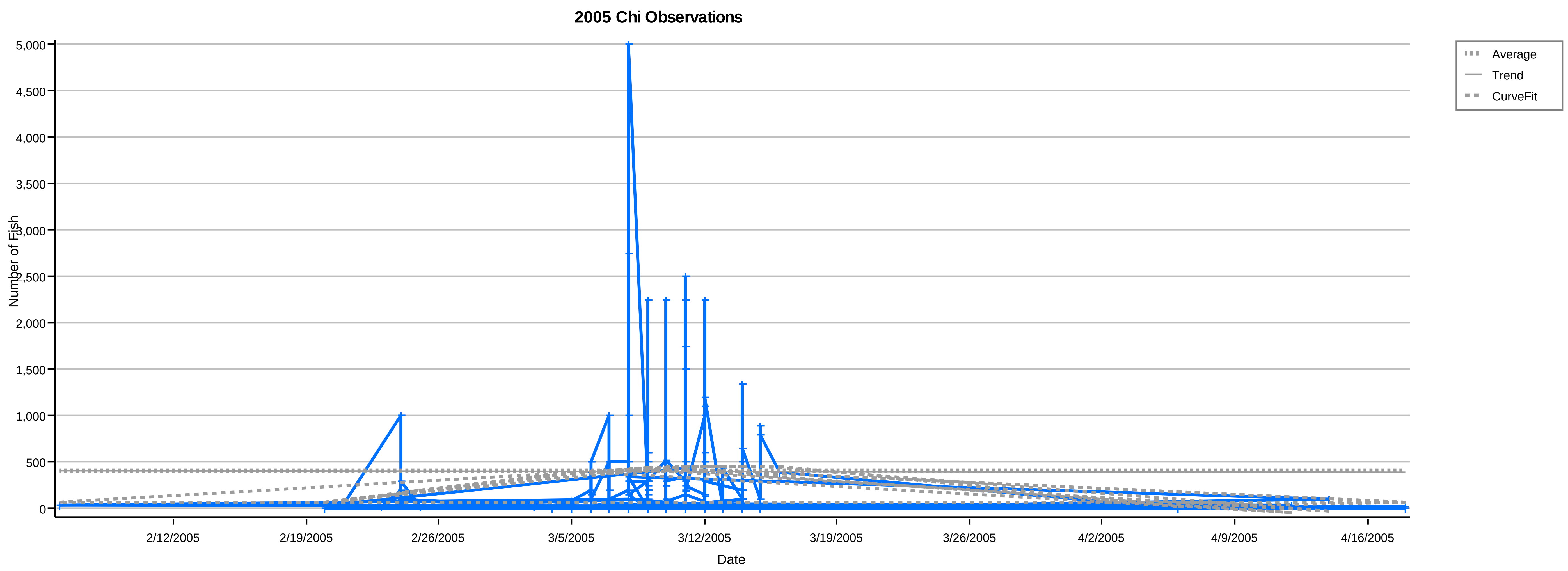
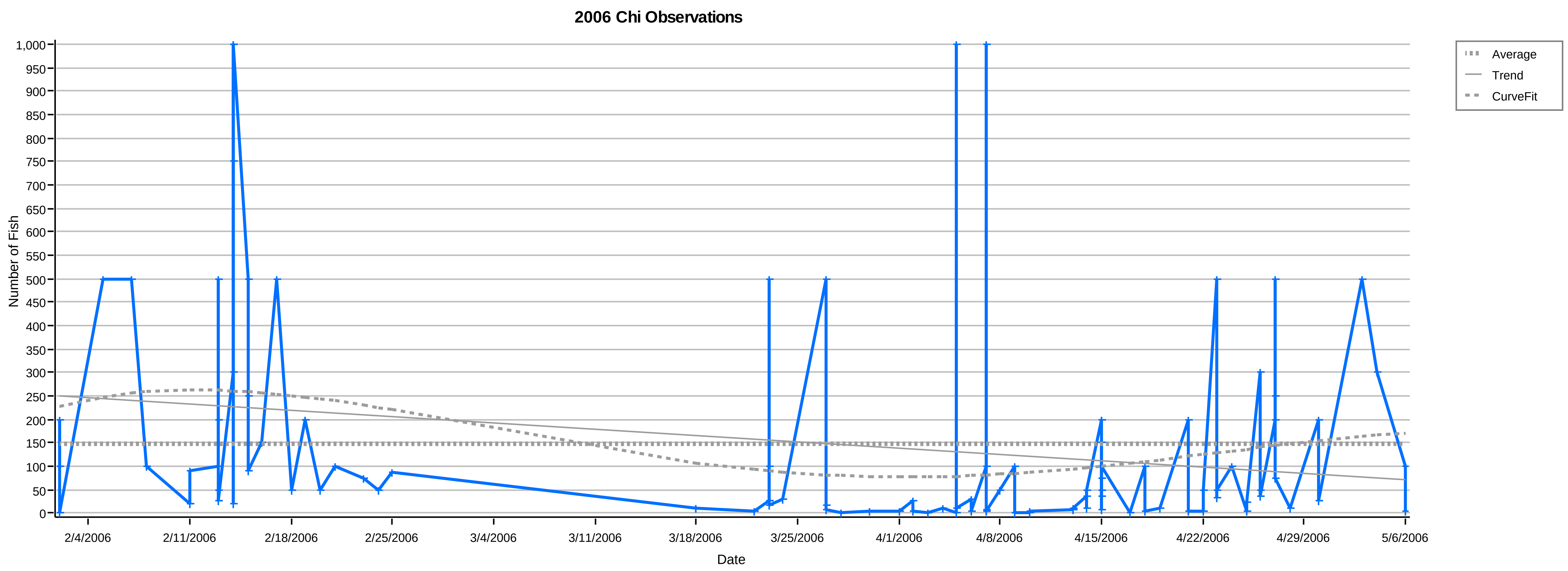
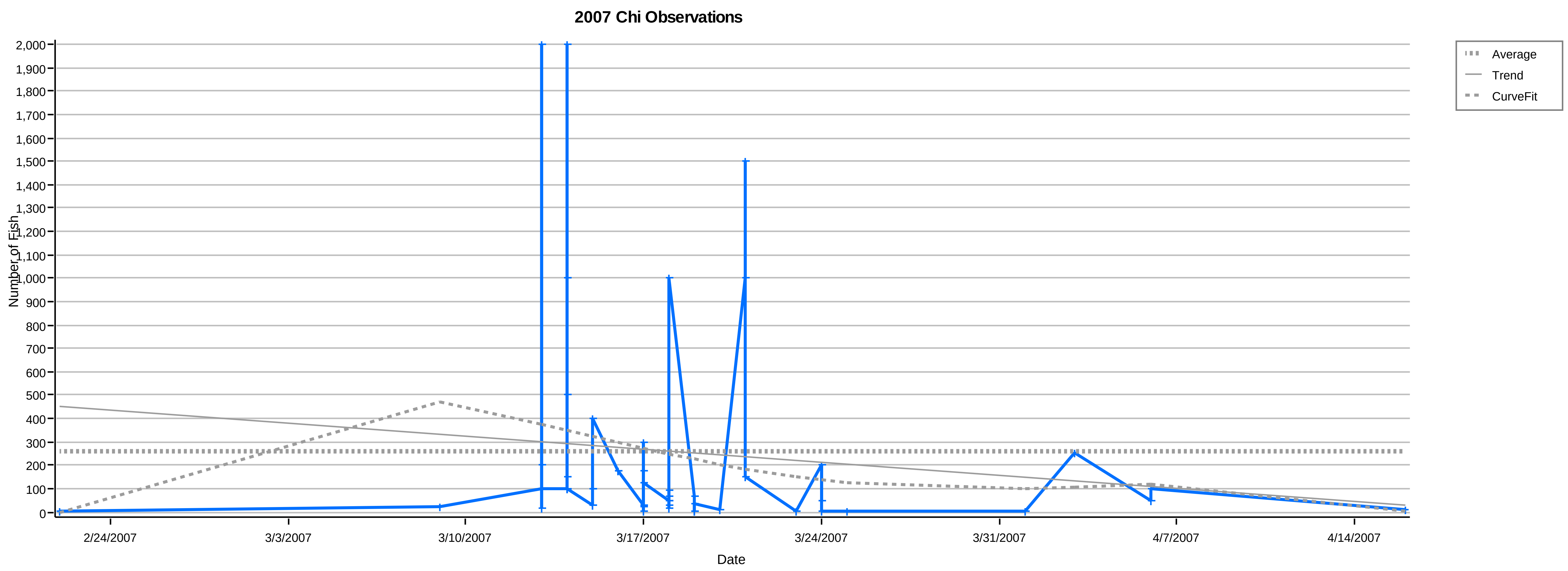


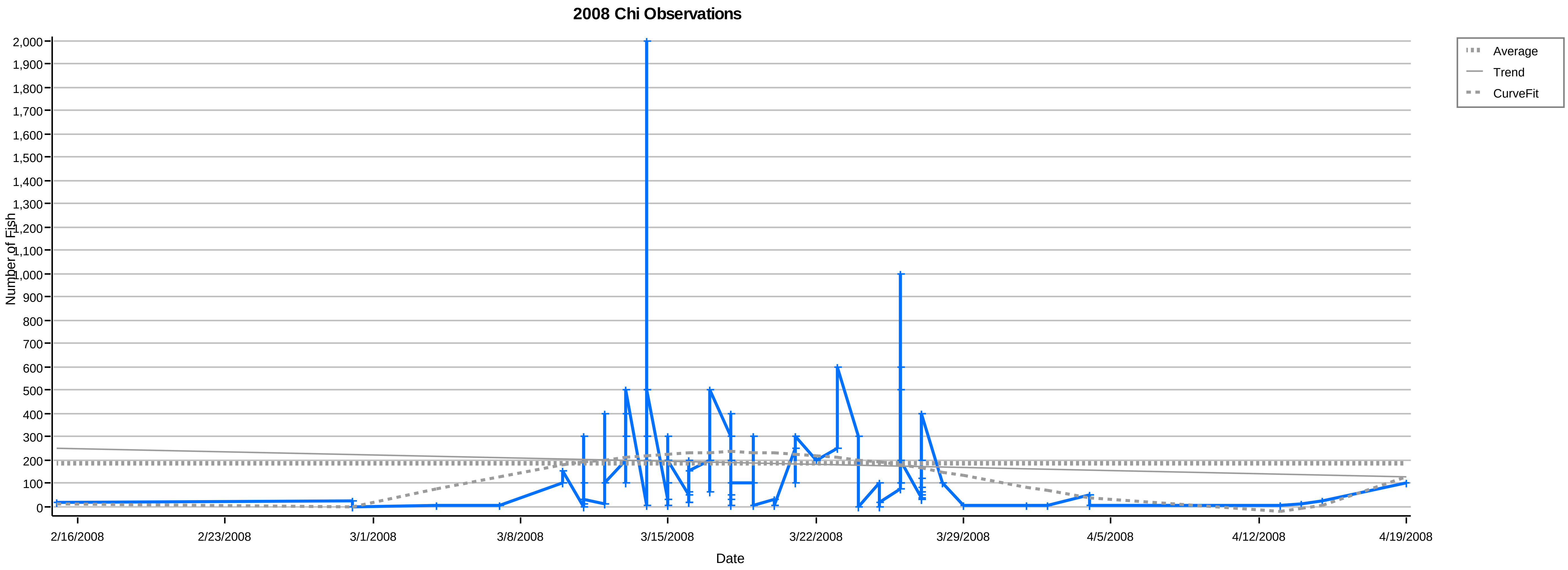
Only observed in 12 streams.



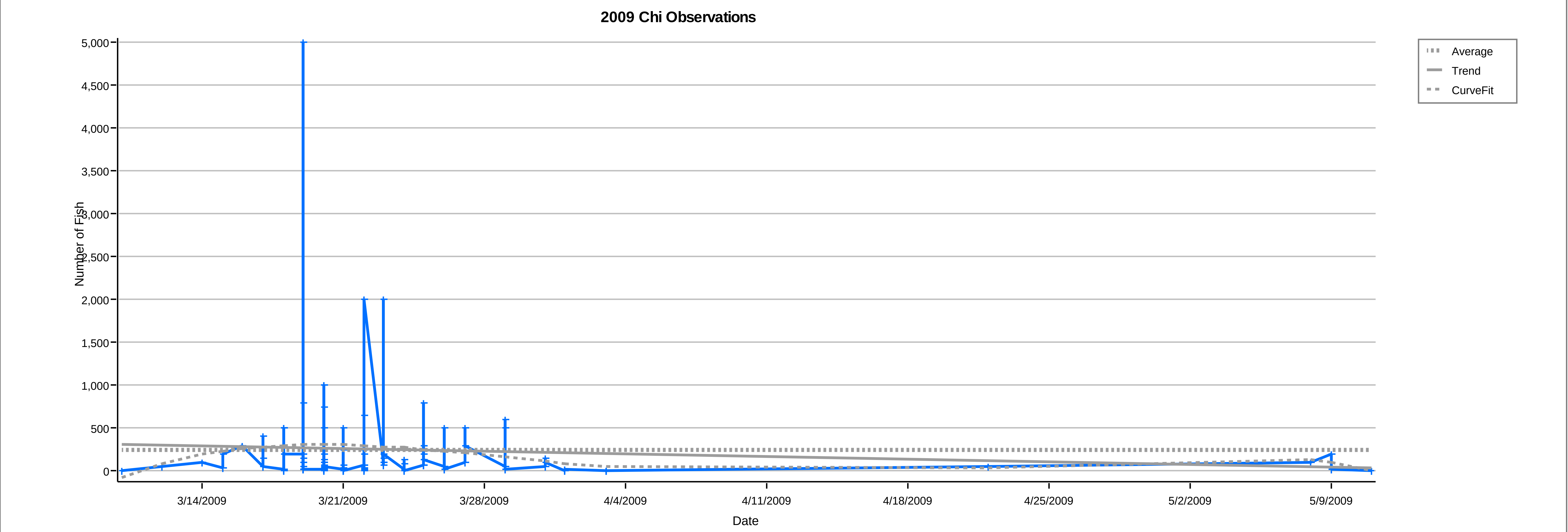
Only observed in 11 streams.



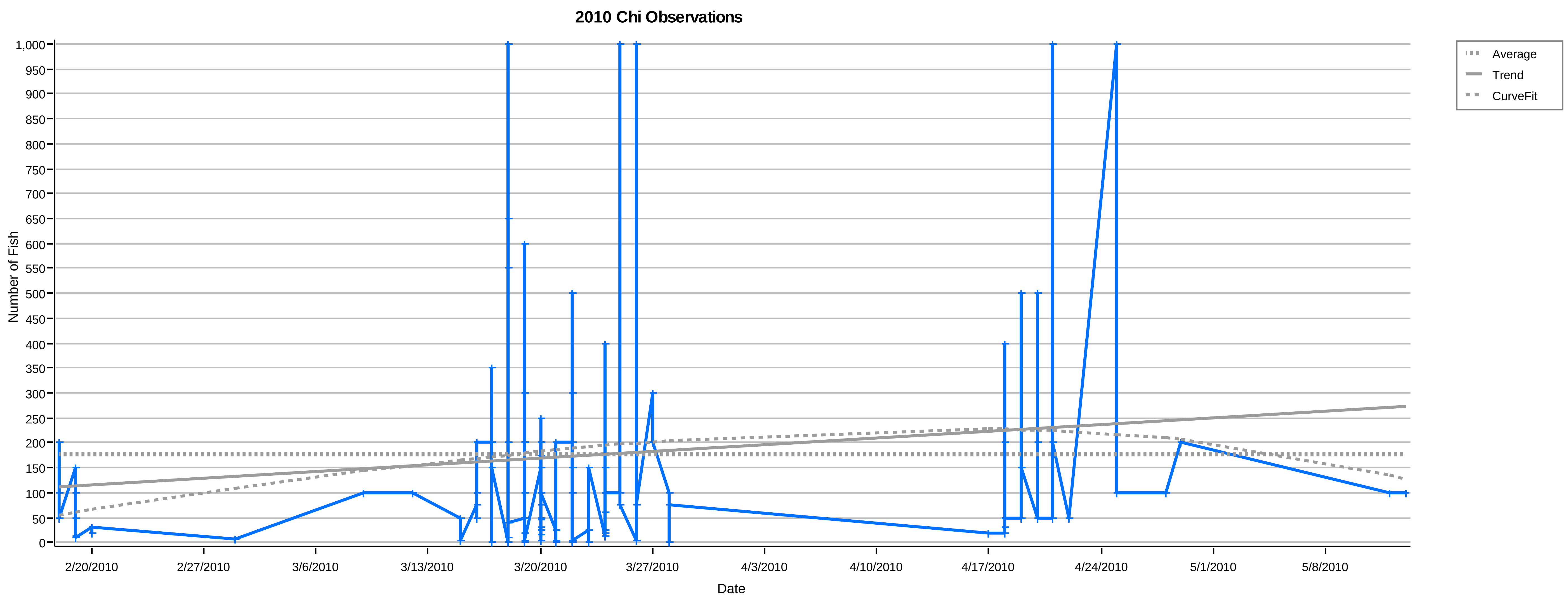
Only observed in five streams.

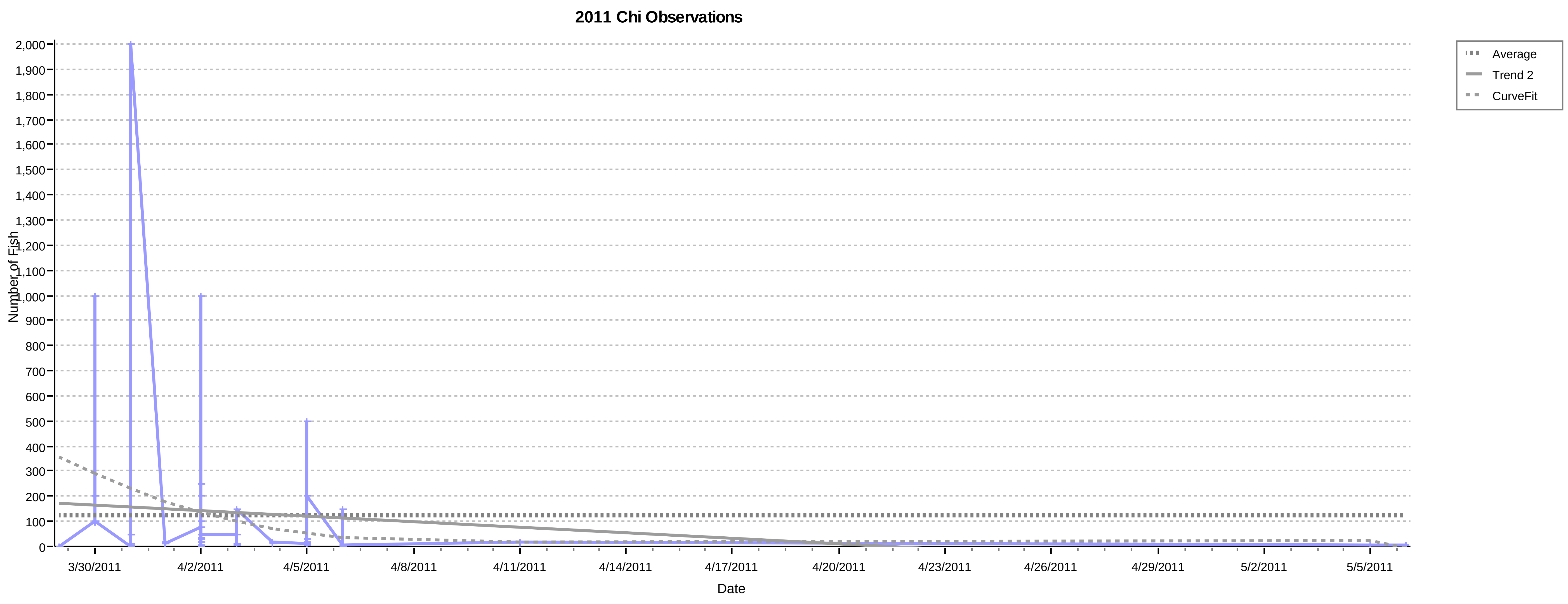


Only observed in six streams.



Only observed in seven streams.


2010 Chi Observations
Number of Fish
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
2/20/2010
2/27/2010
3/6/2010
3/13/2010
3/20/2010
3/27/2010
4/3/2010
4/10/2010
4/17/2010
4/24/2010
5/1/2010
5/8/2010
Date
Average
Trend
CurveFit



2011 Chi Observations
Number of Fish
0
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
1,400
1,500
1,600
1,700
1,800
1,900
2,000
3/30/2011
4/2/2011
4/5/2011
4/8/2011
4/11/2011
4/14/2011
4/17/2011
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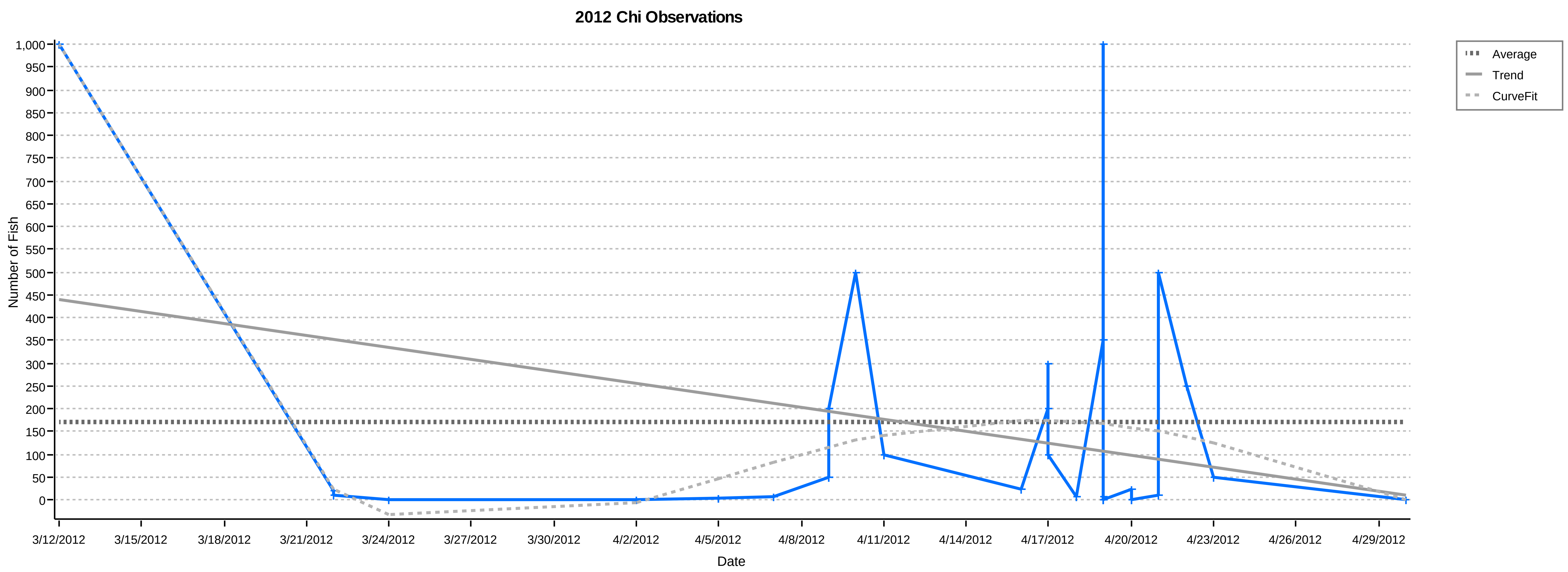
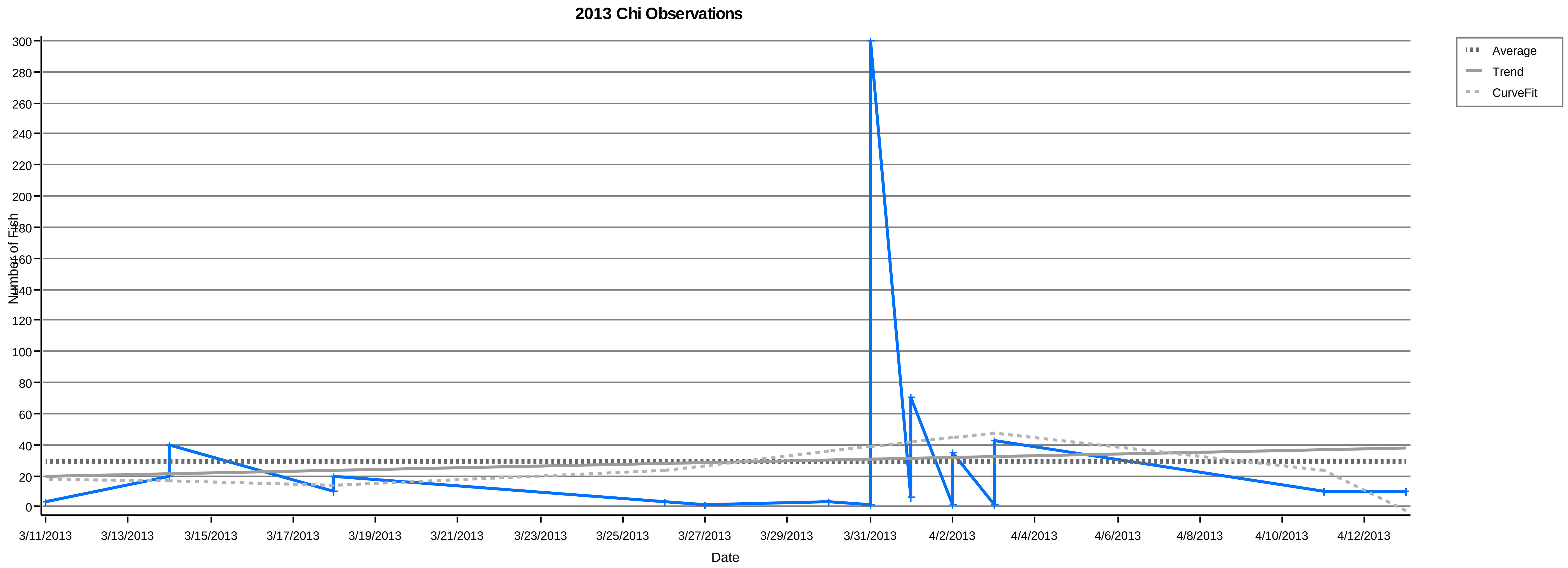
5/5/2011
Date
Average
Trend 2
CurveFit



Only observed in eight streams.



Only observed in four streams.

Appendix B. Figures depicting CLH observations on spawning tributaries

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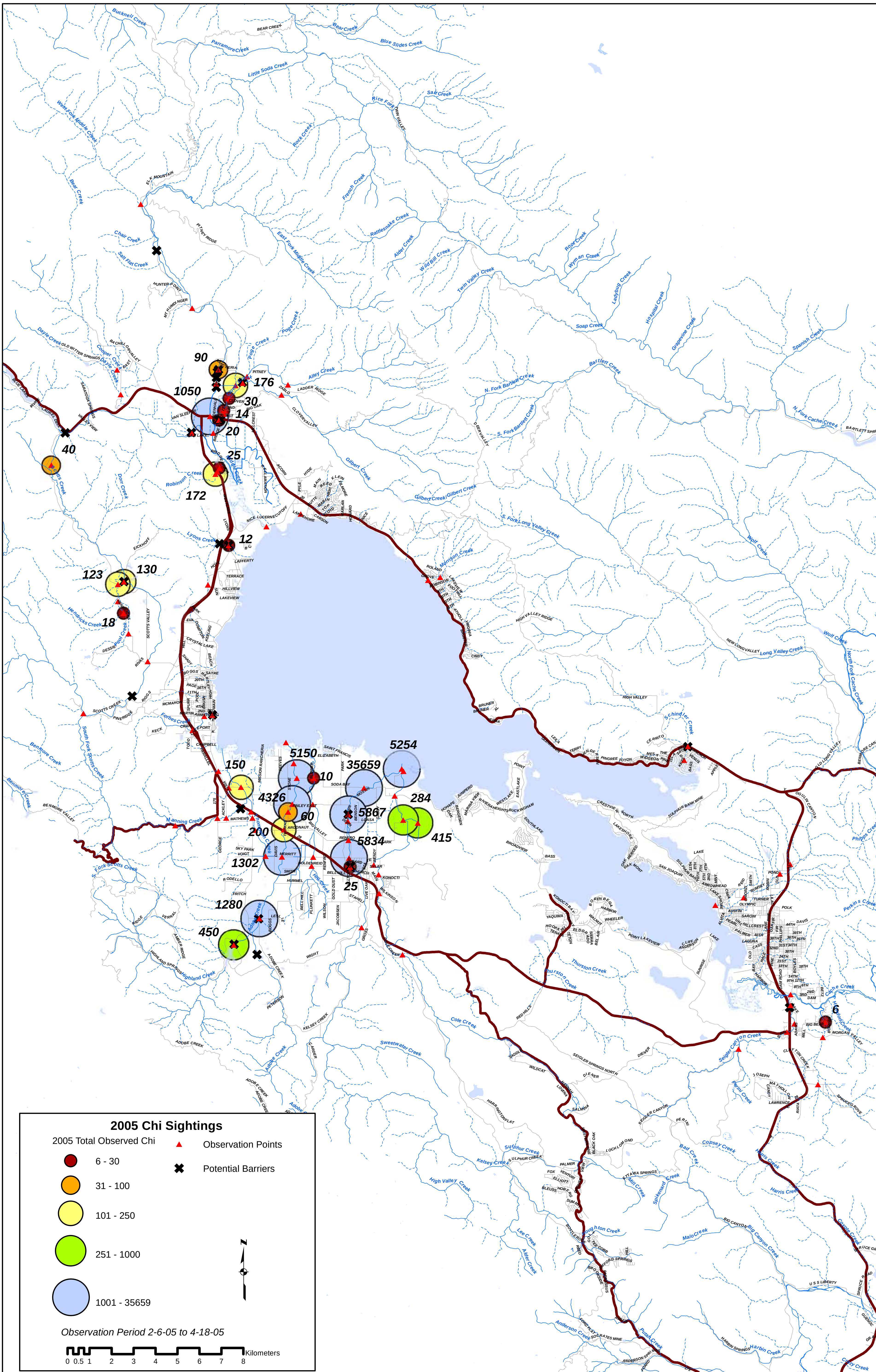
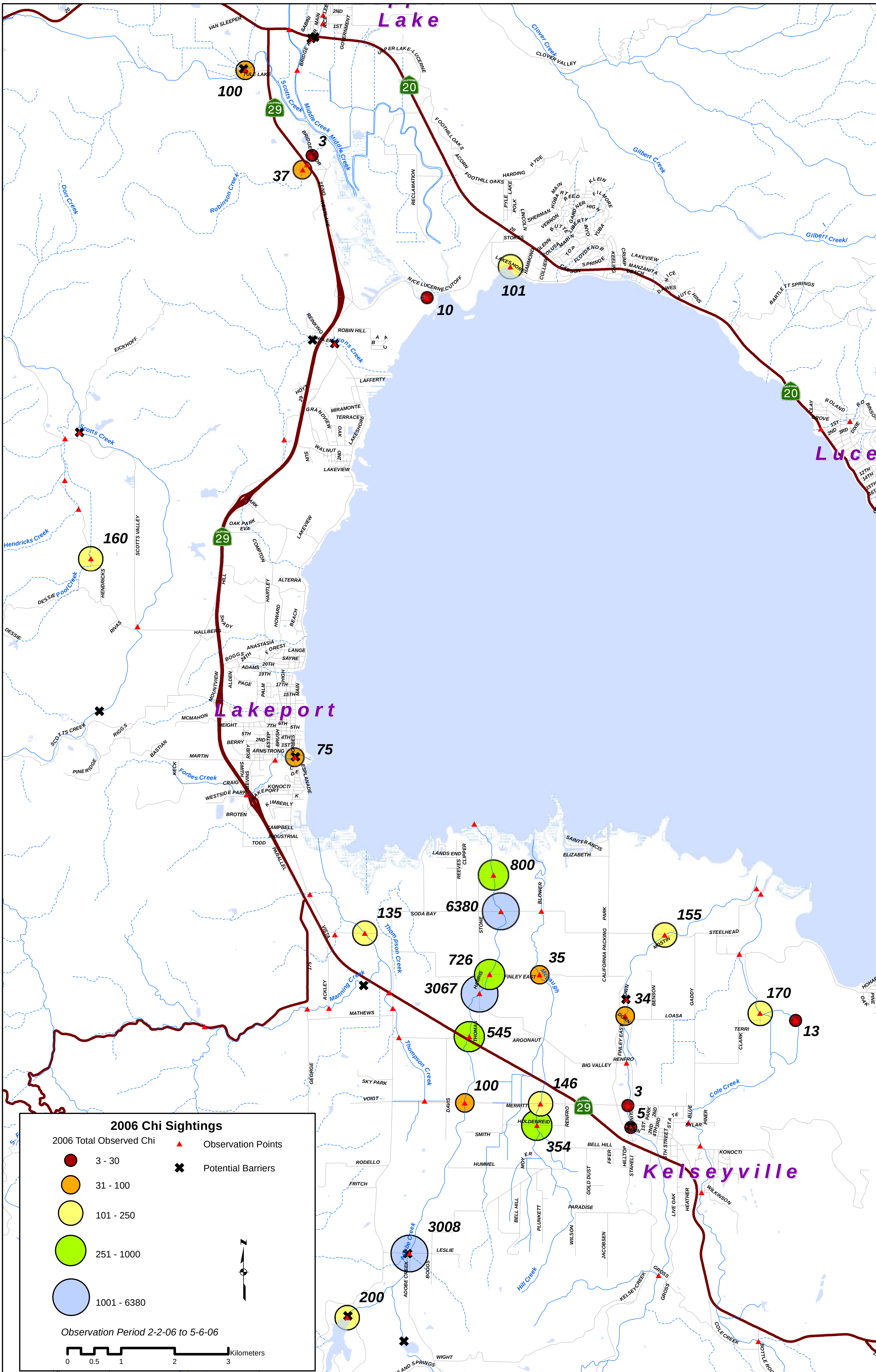
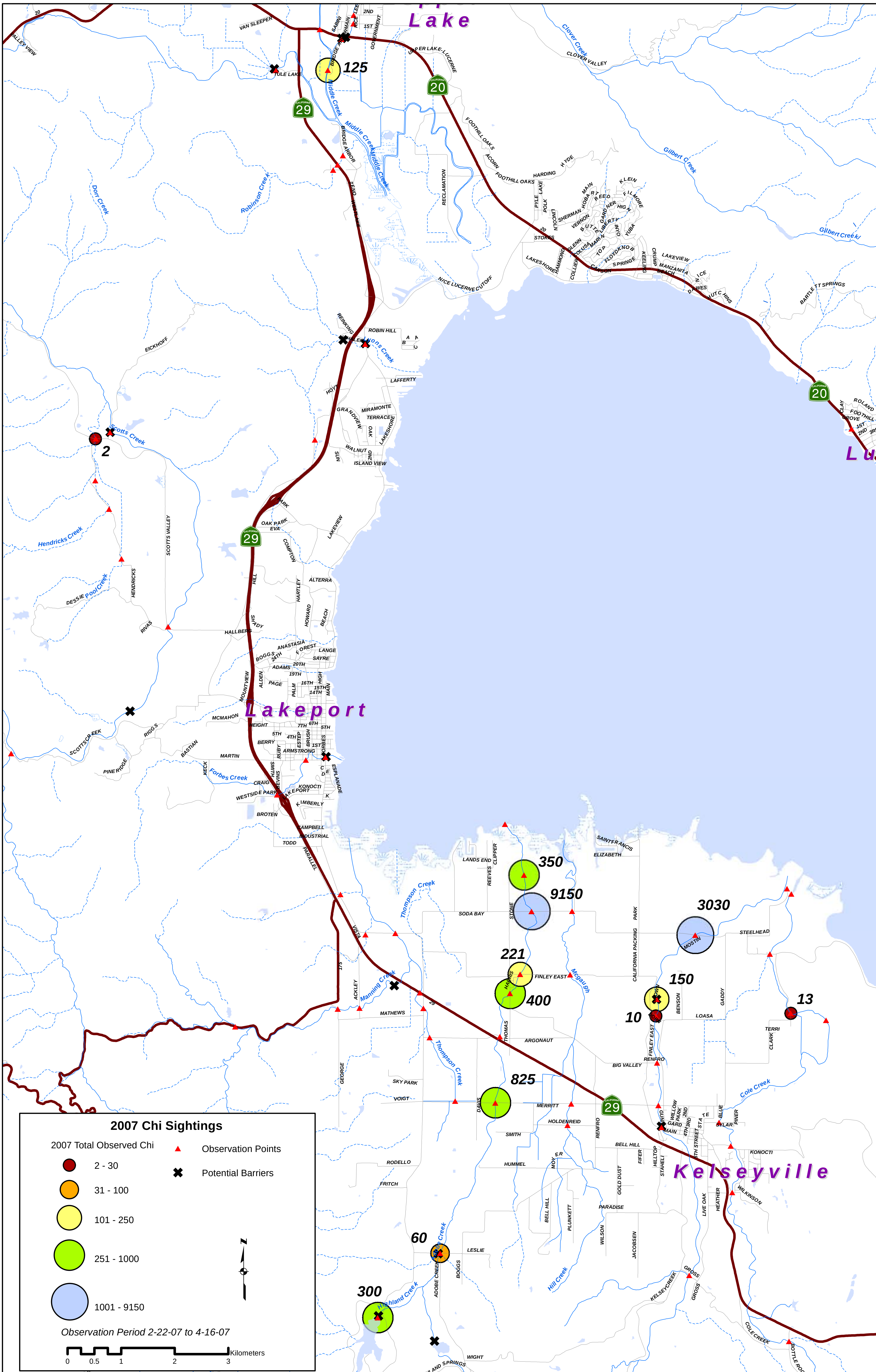
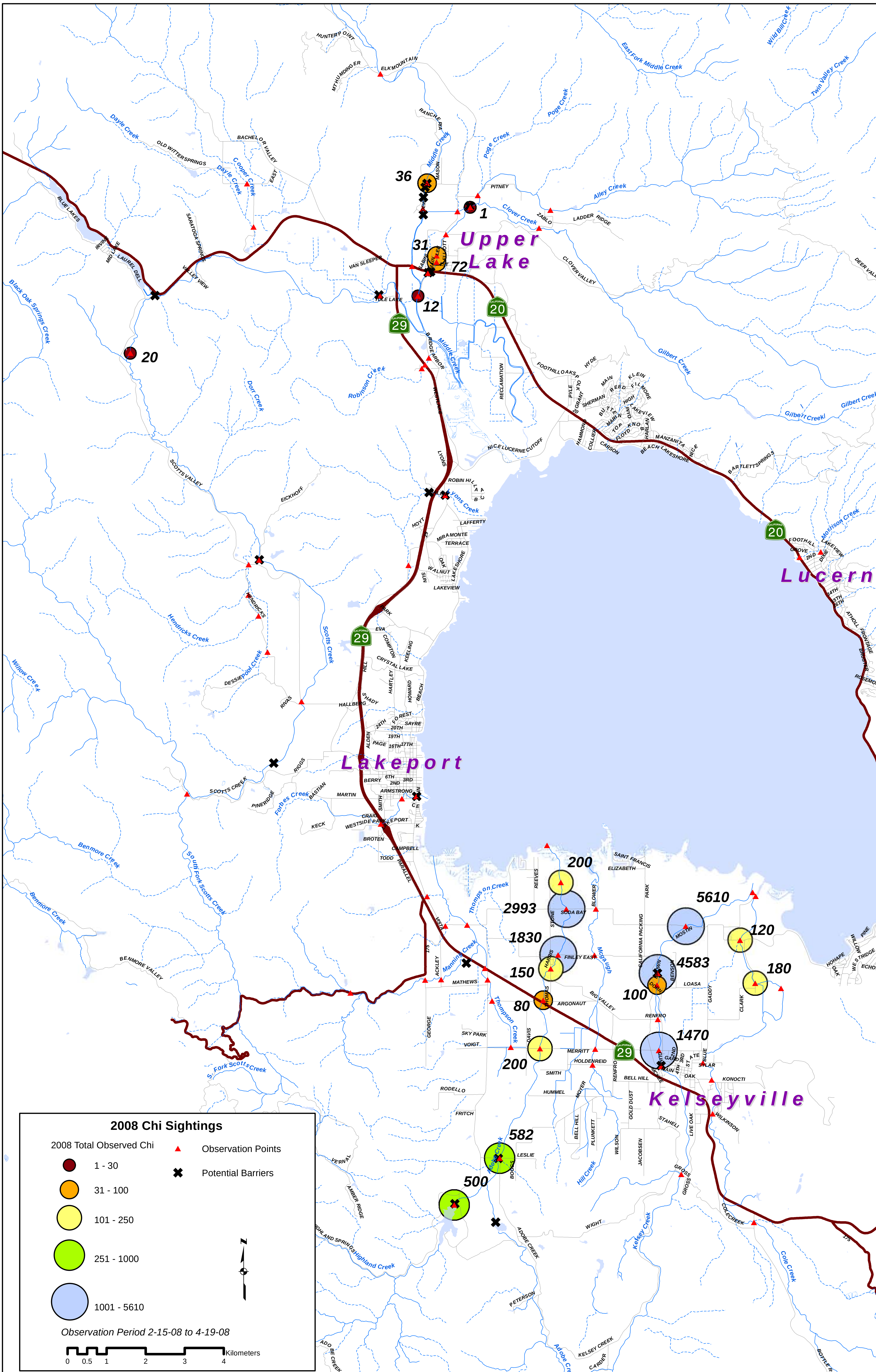
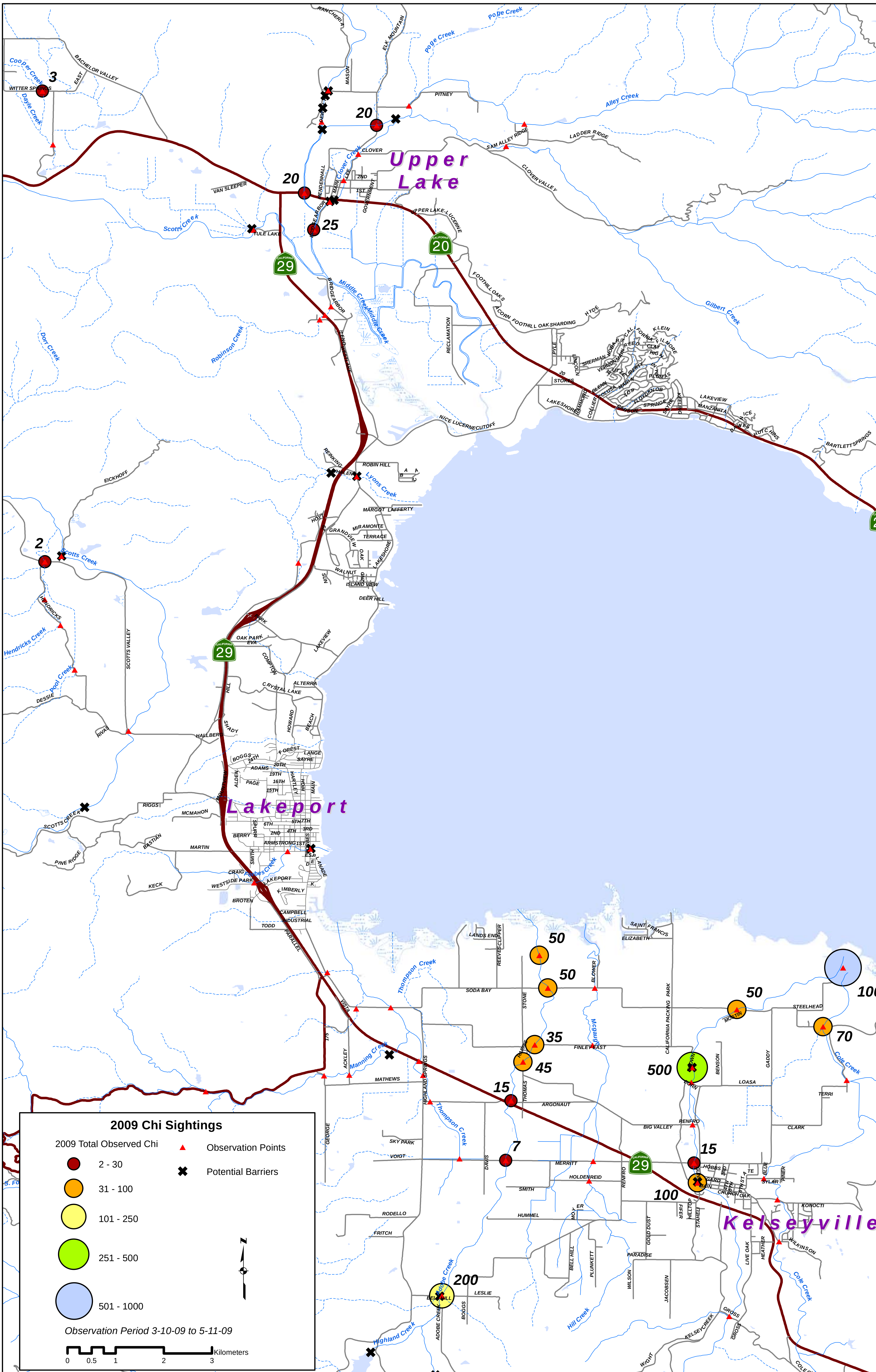

2005 Chi Sightings
2005 Total Observed Chi
6 - 30
31 - 100
101 - 250
251 - 1000
1001 - 35659
Observation Points
Potential Barriers
N
Observation Period 2-6-05 to 4-18-05
0 0.5 1 2 3 4 5 6 7 8
Kilometers

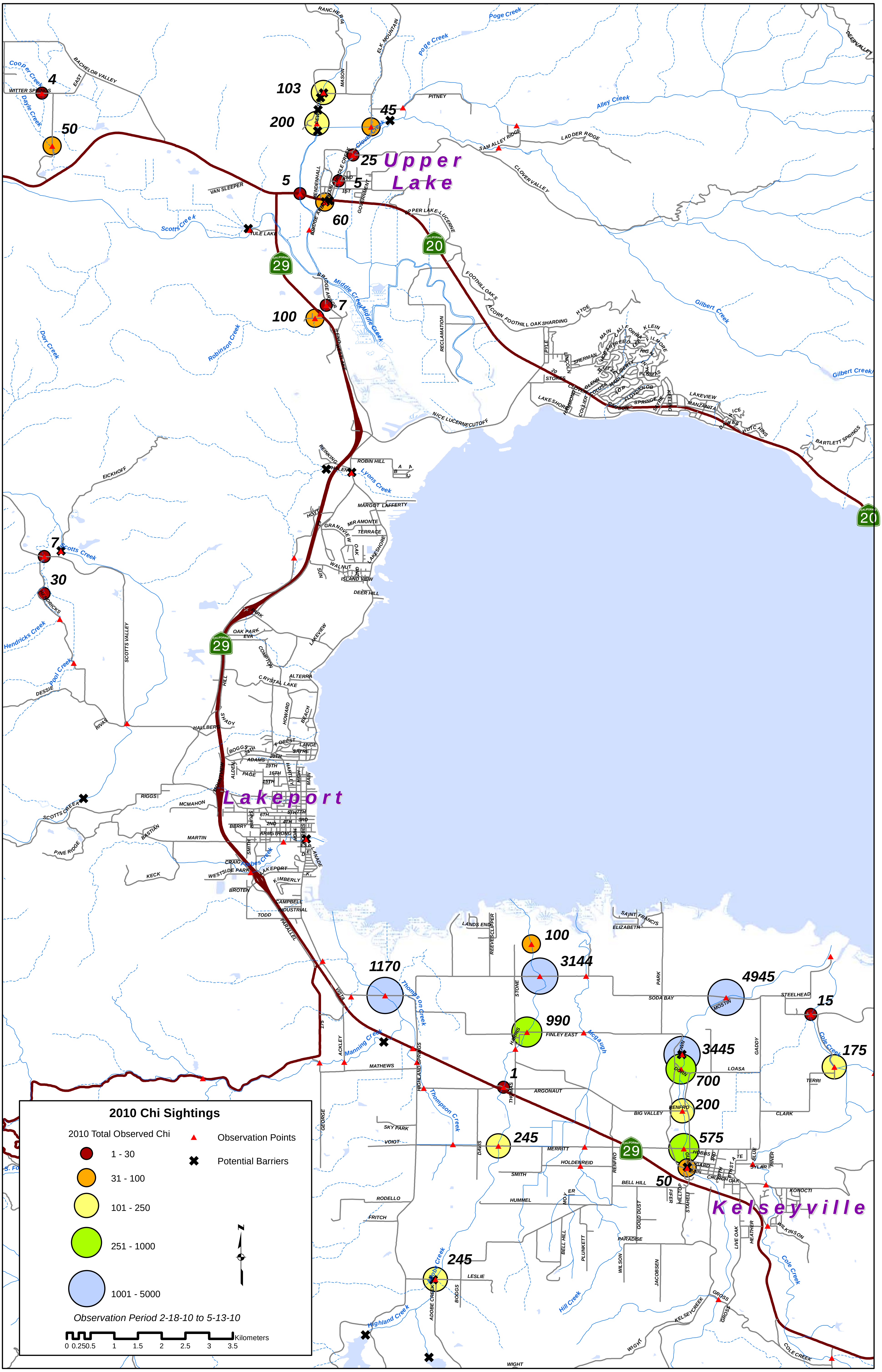


2006 Chi Sightings
2006 Total Observed Chi
3 - 30
31 - 100
101 - 250
251 - 1000
1001 - 6380
Observation Points
Potential Barriers
Observation Period 2-2-06 to 5-6-06
0 0.5 1 2 3 Kilometers
Lakeport
Kelseyville
Lake
Luce
100
3
37
10
101
160
75
800
6380
135
155
726
35
3067
34
170
13
545
100
146
3
5
354
3008
200
Scotts Creek
Middle Creek
Robinson Creek
Dorr Creek
Clover Creek
Gilbert Creek
Hendricks Creek
Pool Creek
Forbes Creek
Manning Creek
Thompson Creek
Cole Creek
Hill Creek
Adobe Creek

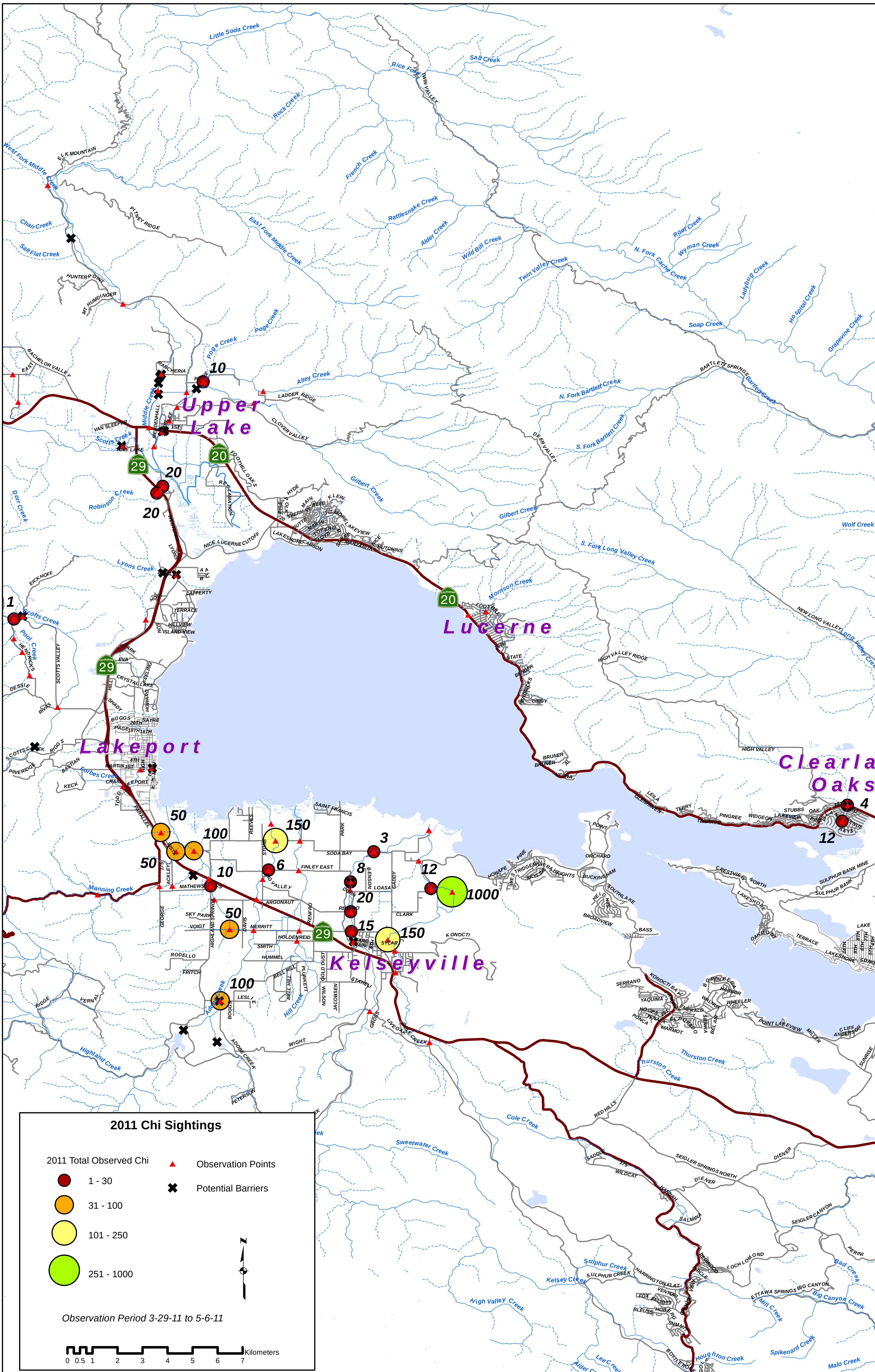

2007 Chi Sightings
2007 Total Observed Chi
2 - 30
31 - 100
101 - 250
251 - 1000
1001 - 9150
Observation Points
Potential Barriers
Observation Period 2-22-07 to 4-16-07
0 0.5 1 2 3 Kilometers
N
Lake
Lakeport
Kelseyville
125
2
350
9150
3030
221
400
150
10
13
825
60
300
Scotts Creek
Hendricks Creek
Forbes Creek
Manning Creek
Thompson Creek
Middle Creek
Clover Creek
Gilbert Creek
Robinson Creek
Cole Creek
Highland Creek
Hill Creek
Adobe Creek
Kelsey Creek
Mcgaugh
29
20

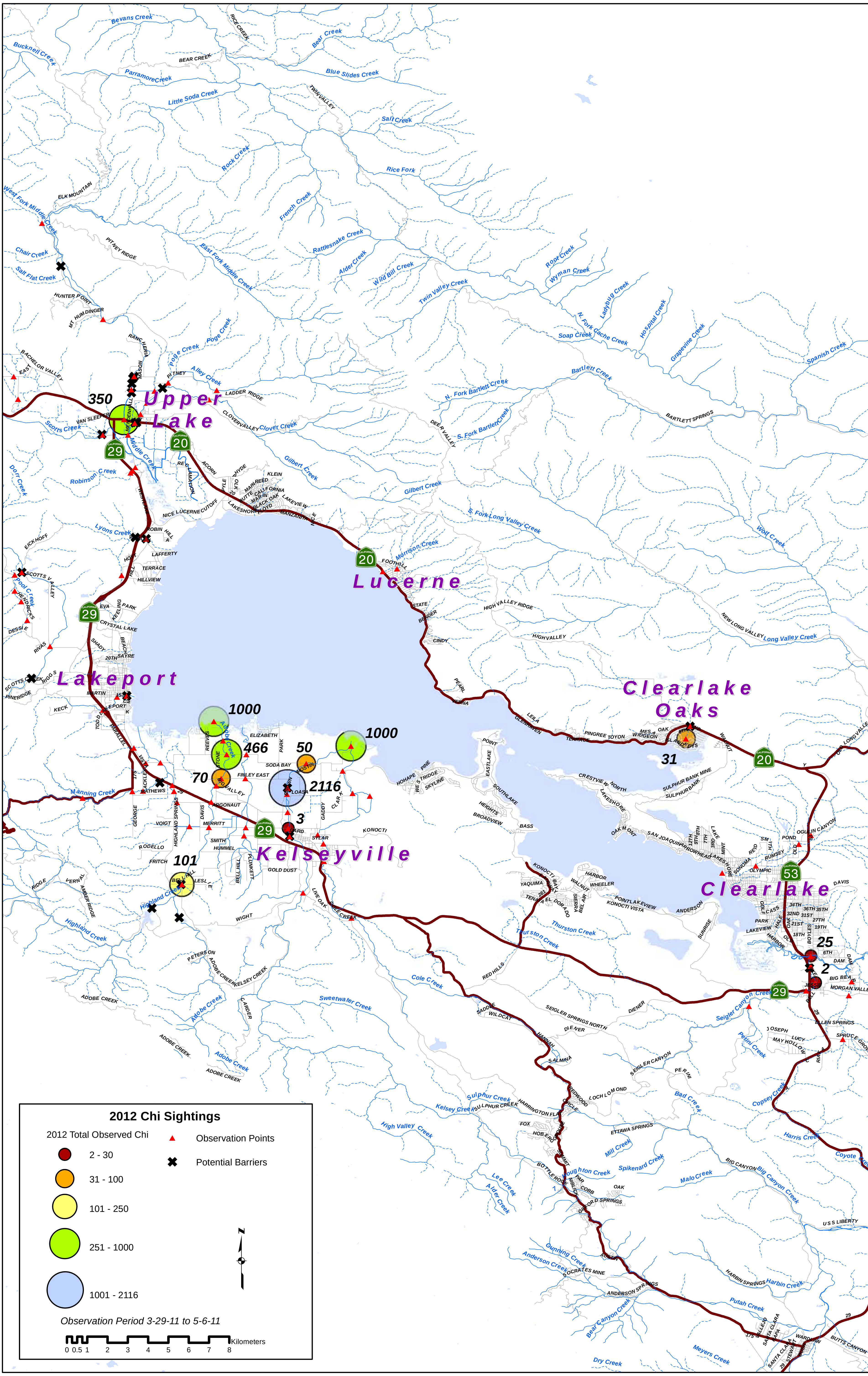

2008 Chi Sightings
2008 Total Observed Chi
1 - 30
31 - 100
101 - 250
251 - 1000
1001 - 5610
Observation Points
Potential Barriers
Observation Period 2-15-08 to 4-19-08
0 0.5 1 2 3 4
Kilometers
N
Upper Lake
Lakeport
Lucerne
Kelseyville
36
1
31
72
12
20
200
2993
5610
1830
120
4583
150
180
100
80
1470
200
582
500
29
20
Middle Creek
Clover Creek
Alley Creek
Pool Creek
Scotts Creek
Forbes Creek
Manning Creek
Thompson Creek
Adobe Creek
Kelsey Creek
Cole Creek
Highland Creek
Hill Creek
Lyons Creek
Hendricks Creek
Dayle Creek
Gilbert Creek
Robinson Creek
Willow Creek
Benmore Creek
South Fork Scotts Creek
Black Oak Springs Creek
Twin Valley Creek
Wild Bill Creek
East Fork Middle Creek
Poge Creek
Cooper Creek
Dorr Creek
Morrison Creek

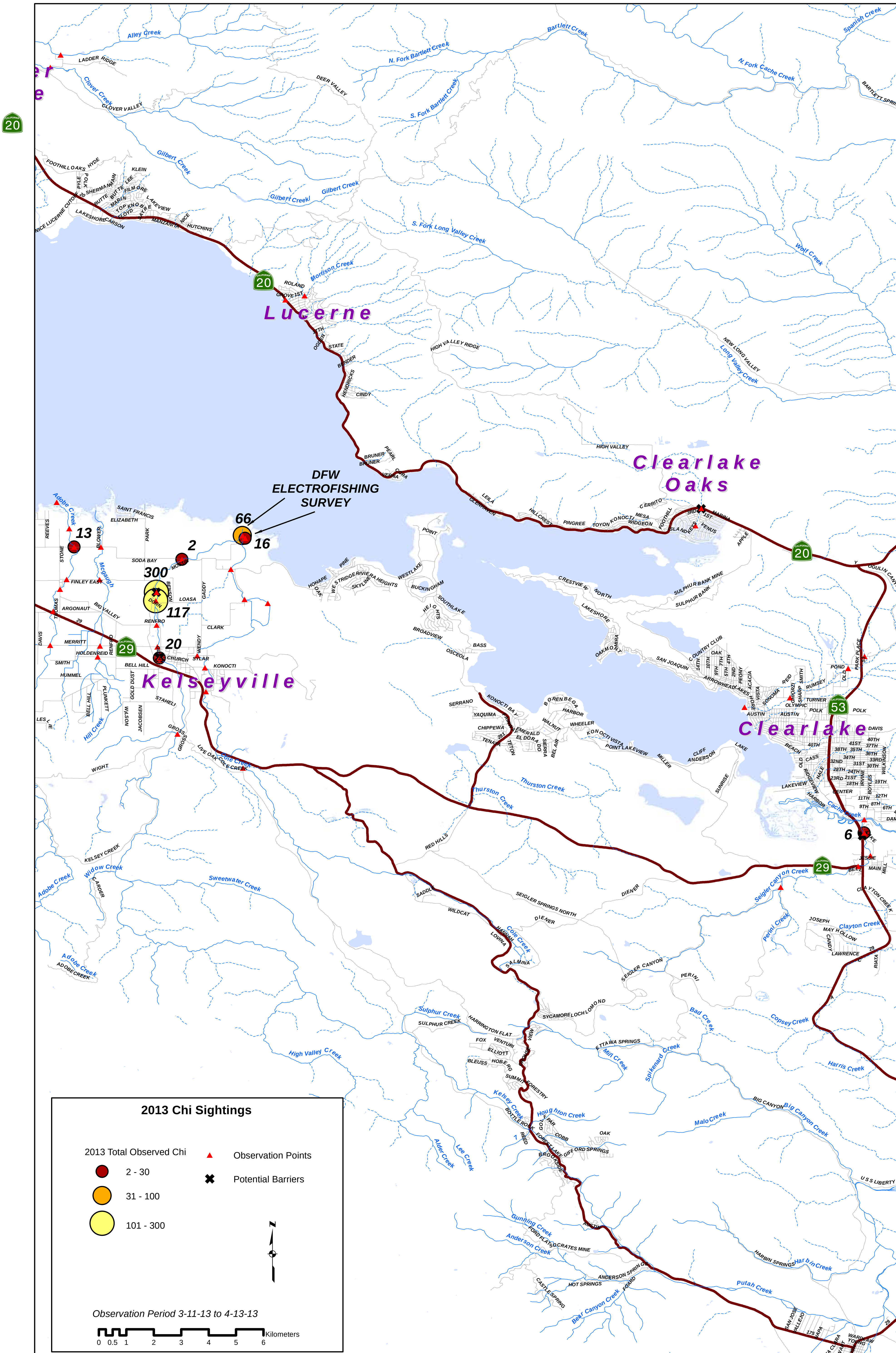

2009 Chi Sightings
2009 Total Observed Chi
2 - 30
31 - 100
101 - 250
251 - 500
501 - 1000
Observation Points
Potential Barriers
Observation Period 3-10-09 to 5-11-09
Kilometers
0
0.5
1
2
3
N
Upper Lake
Lakeport
Kelseyville
20
29
3
20
20
25
2
50
50
35
45
15
7
200
500
15
100
50
70
1000
Cooper Creek
Dayle Creek
Scotts Creek
Clover Creek
Middle Creek
Robinson Creek
Dorr Creek
Alley Creek
Pope Creek
Gilbert Creek
Lyons Creek
Hendricks Creek
Pool Creek
Forbes Creek
Thompson Creek
Manning Creek
Mcgaugh Creek
Cole Creek
Hill Creek
Highland Creek
Adobe Creek



2010 Chi Sightings
2010 Total Observed Chi
1 - 30
31 - 100
101 - 250
251 - 1000
1001 - 5000
Observation Points
Potential Barriers
Observation Period 2-18-10 to 5-13-10
0 0.250.5 1 1.5 2 2.5 3 3.5
Kilometers
N
Upper Lake
Lakeport
Kelseyville
4
50
103
200
45
25
5
5
60
7
100
7
30
100
3144
1170
4945
990
15
3445
175
700
1
200
245
575
50
245
Scotts Creek
Middle Creek
Clover Creek
Lyons Creek
Hendricks Creek
Thompson Creek
Manning Creek
Adobe Creek
Highland Creek
Hill Creek
Cole Creek
Kelsey Creek
Gilbert Creek
Alley Creek
Poge Creek
Robinson Creek
Dorr Creek
Dayle Creek
Cooper Creek
Forbes Creek
Mcgaugh
20
29


2011 Chi Sightings
2011 Total Observed Chi
1 - 30
31 - 100
101 - 250
251 - 1000
Observation Points
Potential Barriers
N
Observation Period 3-29-11 to 5-6-11
0 0.5 1 2 3 4 5 6 7
Kilometers
Upper Lake
Lakeport
Lucerne
Clearlake Oaks
Kelseyville
Little Soda Creek
Salt Creek
Rice Fork
Rock Creek
French Creek
Rattlesnake Creek
Alder Creek
Wild Bill Creek
Twin Valley Creek
East Fork Middle Creek
Chair Creek
Salt Flat Creek
Pogie Creek
Alley Creek
N. Fork Bartlett Creek
S. Fork Bartlett Creek
Gilbert Creek
Robinson Creek
Dorr Creek
Lyons Creek
Scotts Creek
Forbes Creek
Manning Creek
Highland Creek
Morrison Creek
S. Fork Long Valley Creek
Wolf Creek
Thurston Creek
Cole Creek
Sweetwater Creek
Sulphur Creek
Kelsey Creek
High Valley Creek
Houghton Creek
Spikenard Creek
Malo Creek
Big Canyon Creek
Mill Creek
Bad Creek
Soap Creek
Hospital Creek
Grapevine Creek
Ladybug Creek
Root Creek
Wyman Creek
N. Fork Cache Creek
20
29


2012 Chi Sightings
2012 Total Observed Chi
2 - 30
31 - 100
101 - 250
251 - 1000
1001 - 2116
Observation Points
Potential Barriers
Observation Period 3-29-11 to 5-6-11
0 0.5 1 2 3 4 5 6 7 8
Kilometers
N
Upper Lake
Lucerne
Lakeport
Clearlake Oaks
Kelseyville
Clearlake
350
1000
466
50
70
2116
3
101
1000
31
25
2
20
29
53
Bevans Creek
Bucknell Creek
Bear Creek
Blue Slides Creek
Parramore Creek
Little Soda Creek
Salt Creek
Rock Creek
Rice Fork
French Creek
West Fork Middle Creek
Rattlesnake Creek
Alder Creek
Wild Bill Creek
Chair Creek
Salt Flat Creek
East Fork Middle Creek
Twin Valley Creek
Roop Creek
Wyman Creek
Ladybug Creek
Hospital Creek
Soap Creek
N. Fork Cache Creek
Grapevine Creek
Spanish Creek
Bartlett Creek
N. Fork Bartlett Creek
S. Fork Bartlett Creek
Poge Creek
Pope Creek
Alley Creek
Clover Creek
Scotts Creek
Middle Creek
Gilbert Creek
Robinson Creek
Dorr Creek
S. Fork Long Valley Creek
Wolf Creek
Lyons Creek
Morrison Creek
Long Valley Creek
Adobe Creek
Manning Creek
Highland Creek
Thurston Creek
Cole Creek
Sweetwater Creek
Seigler Canyon Creek
Petrini Creek
Adobe Creek
Sulphur Creek
Kelsey Creek
High Valley Creek
Bad Creek
Copsey Creek
Harris Creek
Coyote Creek
Mill Creek
Spikenard Creek
Houghton Creek
Malo Creek
Big Canyon Creek
Lee Creek
Alder Creek
Gunning Creek
Anderson Creek
Harbin Creek
Putah Creek
Bear Canyon Creek
Meyers Creek
Dry Creek



Lucerne
Clearlake Oaks
Kelseyville
Clearlake
DFW ELECTROFISHING SURVEY
66
16
13
2
300
117
20
6
20
29
53
Alley Creek
Bartlett Creek
N. Fork Bartlett Creek
S. Fork Bartlett Creek
N. Fork Cache Creek
Spanish Creek
Clover Creek
Gilbert Creek
S. Fork Long Valley Creek
Wolf Creek
Morrison Creek
Long Valley Creek
Adobe Creek
Mcgaugh
Cole Creek
Thurston Creek
Kelsey Creek
Widow Creek
Sweetwater Creek
Seigler Canyon Creek
Perini Creek
Clayton Creek
Cache Creek
Sulphur Creek
High Valley Creek
Bad Creek
Copsey Creek
Mill Creek
Spikenard Creek
Harris Creek
Houghton Creek
Malo Creek
Big Canyon Creek
Alder Creek
Lee Creek
Gunning Creek
Anderson Creek
Harbin Creek
Putah Creek
Bear Canyon Creek
Hill Creek
2013 Chi Sightings
2013 Total Observed Chi
2 - 30
31 - 100
101 - 300
Observation Points
Potential Barriers
N
Observation Period 3-11-13 to 4-13-13
0 0.5 1 2 3 4 5 6 Kilometers

Appendix C. Description of barriers associated with CLH spawning tributaries

Highland Springs Creek: There is a flood control dam on Highland Springs Creek, a tributary to Adobe Creek, which is impassable to hitch.

Adobe Creek: There is a flood control dam on Adobe Creek above Bell Hill Road that is impassable to hitch. There are two culverts on Adobe Creek that are mitigation barriers to spawning hitch when the water flows and velocity are not too great, but these culverts block hitch migration.

Alley Creek: Alley Creek has been channeled and diverted into Clover Creek. Alley Creek historically supported hitch runs. During some time and under certain conditions migrating hitch can access Alley Creek via the Clover channel bypass, but not when the diversion has silt or sand obstructing it.

Clover Creek: There was a diversion barrier on Clover Creek, a tributary of Middle Creek, which prevented fish passage into Clover Creek and Alley Creek. In 2004 the Robinson Rancheria received a Tribal Wildlife Grant to mitigate the diversion barrier. The work has been completed and the barrier has been modified and no longer obstructs fish passage. However, hitch must pass a concrete diversion structure at the junction with Alley Creek to the northwest of Upper Lake to gain the upper reaches of Clover Creek. This diversion structure usually becomes a complete barrier when filled with gravel and sediment.

Forbes Creek: Forbes Creek has a concrete storm water diversion structure that impedes and at times blocks hitch passage.

Kelsey Creek: On Kelsey Creek, the main barriers to hitch migration are a detention dam 2 to 3 miles upstream of Clear Lake, and the Main Street Bridge in Kelseyville. The rock and concrete weir constructed at the base of the Main Street Bridge is a barrier to the passage of hitch (Peter Windrem, personnel communication, 2012). The structure has a fish ladder which is nonfunctional and the site is nonetheless a total barrier to hitch (McGinnis and Ringelberg, 2008). The Kelsey Creek detention structure below Dorn Crossing has retractable gates which can be opened during the hitch spawning season. However, altered flow patterns and slight increases in the slope of the streambed have been enough to reduce the number of spawning hitch that can pass through the detention structure and move upstream. Also, rock riprap situated below the retention dam seems to have impeded the upstream migration of hitch and needs to be modified to provide a clear channel for fish transit. A number of drop-structures in Kelsey Creek intended for gravel aggradation impede migration. Some of these do not seem to impede hitch passage under current conditions, but hitch navigate them with difficulty especially on the downstream passage. Further upstream, culverts that once tended to clog with debris and block fish migration at the Merritt Road crossing have been removed and replaced by a bridge that poses no impediment to hitch passage.

Lyons Creek: A high culvert on Lyons Creek at Lakeshore Drive prevents hitch from moving upstream. Lyons Creek also has a concrete barrier at the County's Juvenile Hall facility that completely prevents fish passage.

Manning Creek: A dam upstream of known hitch spawning areas in the lower reaches of Manning Creek may prevent hitch from spawning further upstream.

Middle Creek: On Middle Creek, a rock and concrete weir at the Rancheria Road Bridge has been a total fish passage barrier for hitch. Remedial work has been done downstream, with more weirs installed in an effort to elevate the gradient so that hitch could surmount the barrier and work was done to improve their stability after high flows, but it remains to be seen if this will allow hitch passage. Similar weirs to capture and hold gravel were installed many years ago in Adobe Creek and Kelsey Creek that do not impede hitch passage, but there is concern the installed weirs on Middle Creek may be potential barriers to hitch. A downstream weir at Rancheria Road is a partial barrier and improperly sized rip rap at this location acts as partial migration barrier (McGinnis and Ringelberg 2008). Hitch were seen recently at Middle Creek Bridge and Highway 20 and although there are no obvious barriers, they did not appear to be able to navigate the swift currents there due to the lack of resting pools. If hitch could surmount Rancheria Bridge, many additional miles of spawning grounds would be accessible to hitch up to areas south of Hunter Bridge, where habitat suitability ends because the channel is braided and shallow due to gravel mining.

Scotts Creek: On Scotts Creek, a rock and concrete weir at the Decker Bridge is a total barrier to the passage of hitch. As water levels have been lower, a barrier at the lower end of Tule lake is problematic for fish passage to Tule lake and its tributary Mendenhall Creek, Scotts Creek and tributaries, Bachelor Valley/Witter Springs area tributaries, and Blue Lakes and tributaries. There is a one-way flow gate on the Blue Lakes outlet at Scotts Creek that prevents hitch from entering Blue Lakes.

Seigler Canyon Creek: There are two barriers to hitch migration into Seigler Canyon Creek, an exposed sewer pipe and a road crossing. The sewer pipeline which crosses Seigler Canyon Creek for Anderson Marsh State Park was modified in the 1990s and completely blocks hitch access to that creek, once a major spawning tributary.

Appendix D. Comments from affected and interested parties on the petitioned action

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From: Roberta Alba <rbtaalba@gmail.com>
Sent: Friday, May 31, 2013 1:16 PM
To: Clear Lake Hitch
Subject: CLEARLAKE HITCH

To Whom It May Concern at CDFW: What a shock to hear that the #3 rated bass lake in the United States could be wiped out by something most people consider a trash fish. It is hard to imagine that the hitch is so valuable and sacred to a certain Indian tribe. Subsidize them. If the hitch population and propagation is low, obviously there are many factors. To solely blame and remove bass would be a gross misunderstanding of the food chain and predation. If you remove bass, you MUST remove eagles, ospreys, otters, minks, seagulls, pelicans, mergansers, crappie, bluegill, catfish, carp, grebes, herons, egrets, turtles, bullfrogs and even mallard ducks, which I have seen eating clouds of fry. All of the above eat the hitch or the eggs. Let's not forget that the last two years have seen below-average rainfall to feed the spawning creeks. Also, have any studies been done to see what is being FLUSHED out of orchards/vineyards and off the streets by runoff? Various chemicals might be the real culprit, as well as the spraying of aquatic weeds. Economically, shutting down fishing at Clear Lake would surely be a disaster for an already depressed county. We spend over $8,000 a year between Lakeport and Glenhaven. We could easily stay in the Bay Area and fish the local reservoirs and the delta, but we choose Clear Lake. Clearly, there will be a domino effect curtailing fishing, especially bass fishing. Just think how the casinos, motels, resorts, grocery stores, gas stations, bait shops, and other local merchants will lose. Even the State Park will lose a lot of revenue. Please do not let a special interest group torpedo the incomes and lives of so many people who really enjoy the lake. Clear Lake is a treasure which should be shared by all and preserved as such. Sincerely, Ted and Roberta Alba 2808 Euclid Avenue, Richmond, CA 94804

May 29, 2013

California Department of Fish and Wildlife
North Central Region
Attn: Kevin Thomas
1701 Nimbus Road
Rancho Cordova, CA 95670
Kevin.thomas@wildlife.ca.gov
CLH@wildlife.ca.gov

California Fish and Game Commission
Sonke Mastrup, Executive Director
P.O. Box 944209
Sacramento, CA 94244-2090
fgc@fgc.ca.gov

Re: Comments on Status of Clear Lake Hitch

The Center for Biological Diversity submits the following comments on the status of Clear Lake hitch (*Lavinia exilicauda chi*).

We have enclosed the 2013 spawning survey results from the Chi Council for the Clear lake Hitch (see http://lakelive.info/chicouncil/2013results.html), which indicate that the Clear Lake hitch spawning run was almost nonexistent this spring. Despite more than 275 observational surveys conducted in 14 former hitch spawning streams, during the entirety of the 2013 hitch spawning season from February 9 through April 22, spawning hitch were found in only three streams.

More disturbingly, the numbers of hitch observed were the lowest since regular surveys began in 2005. Only one school of spawning hitch of any biological significance was observed in the entire Clear Lake basin: 300-400 hitch seen in Kelsey Creek in late March. Kelsey Creek had been the stronghold for spawning Clear Lake hitch, with more than 10,000 fish observed as recently as 2010. In Adobe Creek, which has been the other Clear Lake tributary with recent successful hitch reproduction, the hitch run was almost nonexistent in 2013, with only 53 fish seen on three occasions. Adobe Creek had 2,000 spawning hitch as recently as 2011. Six hitch were also observed in Seigler Creek in 2013. A DFW electrofishing survey also found small numbers of hitch (only 13 fish) at the mouth of Cole Creek on two occasions in March of 2013, but there is no evidence that hitch spawned in Cole Creek in 2013.

In short, the entirety of the spawning population of Clear Lake hitch has collapsed during the dry spring of 2013 to a critically low level which indicates that Clear Lake hitch are in imminent danger of going extinct in the immediate future without swift management and restoration efforts. **Accordingly, we urge the Department and Commission to promptly list the Clear Lake hitch as endangered, on an emergency basis.**

A July 2012 white paper by researchers at the University of California, Davis for the California Energy Commission's California Climate Change Center systematically evaluated climate change impacts on freshwater fishes in California.[1] A copy of that report is attached. Clear Lake hitch were found to be "critically vulnerable" to climate change. The researchers, including California native fish expert Dr. Peter Moyle, designate the conservation status of the Clear Lake hitch as endangered, based on climate change vulnerability scores, standards of the International Union for the Conservation of Nature, and conservation status information from Moyle et al. (2011).[2]

Sincerely,

Jeff Miller
Center for Biological Diversity
351 California Street, Suite 600
San Francisco, CA 94104
E-mail: jmiller@biologicaldiversity.org
Phone: (510) 499-9185

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[1] Moyle, Peter B., Joseph D. Kiernan, Patrick K. Crain, and Rebecca M. Quiñones (University of California, Davis). 2012. ***Projected Effects of Future Climates on Freshwater Fishes of California.*** California Energy Commission. Publication number: CEC‐500‐2012‐028.

[2] Moyle, P. B., J. V. E. Katz, and R. M. Quiñones. 2011. "Rapid decline of California's native inland fishes: A status assessment." *Biological Conservation* **144**: 2414–2423.

Chi Council for the Clear Lake Hitch
P. O. Box 1081, Kelseyville, CA 95451
www.lakelive.info/chicouncil

June 14, 2013

Via Email to clh@wildlife.ca.gov & U.S. mail

Mr. Kevin Thomas, Environmental Scientist
California Department of Fish & Wildlife
1701 Nimbus Road, Suite A
Rancho Cordova, CA 95670

Re: Clear Lake Hitch

Dear Mr. Thomas:

The Chi Council for the Clear Lake Hitch was formed in 2004 as a Coordinate Resource Management and Planning Project (CRMP) in Lake County, California. The Council was formed with the assistance of the Eastlake & Westlake Conservation Districts to facilitate coordinated activities between public agencies, tribes, private landowners and other interest groups interested in the welfare of the Clear Lake Hitch. The goal of the Council is to maintain a viable hitch population and a properly functioning habitat. The specific goals are to:

- Study, protect, restore, and maintain the watershed ecosystem leading to a restored population of Clear Lake Hitch
- Study and recognize the "lake effect" on the hitch population by the introduction of non-native fish, the condition of the shoreline habitat, the effects of pollutants in the water column, and aquatic conditions in general
- Study the fish population during migratory runs

Among its various activities, the Council sponsors a program to monitor the annual spawning migration of the hitch up the tributaries to Clear Lake. Specifically, the Council organizes volunteers and others to monitor streams to determine each year:

- When the spawning migration begins and ends
- In which streams the hitch spawn
- The sizes of the schools of hitch observed

Monitors are asked to make observations from specific locations on streams, principally from bridges. They post their observations on tally sheets with the following information:

- The date of the observation
- The time of day
- The name of the stream
- The location, typically the name of the road on which the bridge is located
- The total number of hitch seen and, if no hitch are seen, that fact is entered
- Any other observations of interest, in particular hitch predators or water quality

The tally sheets are sent to the secretary of the Chi Council who enters the information onto a spreadsheet that is then posted to the Council's website at www.lakelive.info/chicouncil.

Accompanying this letter is a chart for each year from 2005 through 2013, derived from the data contained in those spreadsheets, that:

- Lists the names of the principal tributaries to Clear Lake
- Identifies the time periods during which monitoring of a stream occurred
- Identifies the time periods in which hitch were observed in each stream
- Identifies the time periods during which no monitoring occurred
- Contains notes on the significant characteristics of the migration

From these reports, the following conclusions may be drawn:

- The number of streams where significant numbers, i.e., thousands, of hitch spawn has declined since 2005.
- Most spawning now occurs in Adobe and Kelsey Creeks and, to a lesser extent, Cole Creek.
- Hitch spawning in Middle Creek and Scotts Creek and their tributaries, Clover Creek and Hendricks Creek, has declined to where no significant numbers of hitch spawn in those major tributaries to Clear Lake.
- The overall population of hitch has declined as fewer streams are populated with spawning fish.

We hope you find this information useful. If you have questions, please do not hesitate to contact us.

Very truly yours,

Peter F. Windrem
Chair of the Chi Council

Enclosures

Chi Council for the Clear Lake Hitch

Summary report on spawning migrations of the

Clear Lake Hitch

2005 - 2013

Prepared for Kevin Thomas, Environmental Ecologist
California Department of Fish & Wildlife
June 14, 2013

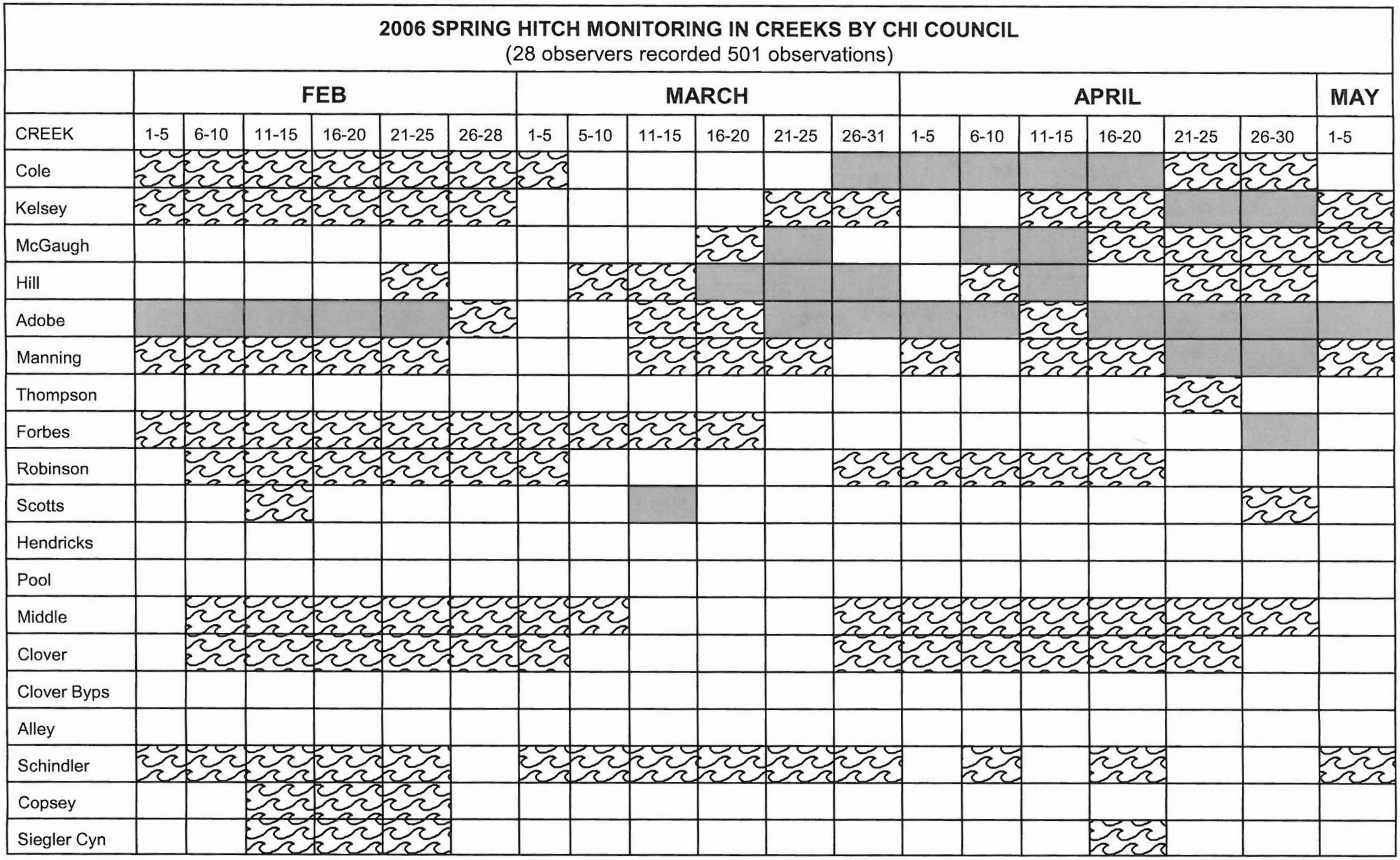
2005 SPRING HITCH MONITORING IN CREEKS BY CHI COUNCIL

(33 observers recorded 380 observations)

	FEB						MARCH						APRIL						MAY
CREEK	1-5	6-10	11-15	16-20	21-25	26-28	1-5	5-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20	21-25	26-30	1-5
Cole					■		■	■	■			≈							
Kelsey	≈	≈	≈	≈	■		■	■	■	■	≈	≈	≈	≈	≈	≈	≈	≈	≈
McGaugh																			
Hill							≈		≈						≈				
Adobe	≈	≈	≈	≈	■		■	■	■	≈	≈	≈			■				
Manning					≈		≈	■	■						≈				
Thompson									≈										
Forbes					≈														
Robinson							■	■								■			
Scotts		■ ?					≈	■	■ ?										
Hendricks																			
Pool																			
Middle							≈	■				≈	≈		■	≈			
Clover						≈	≈	■								≈			
Clover Byps																			
Alley																			
Schindler	≈			≈			≈	≈											
Copsey					≈				■										
Siegler Cyn						≈	≈	≈	≈	≈	≈	≈			≈				

KEY & COMMENTS

≈	Periods of time during which observations were made with no fish observed.	Kelsey Creek has large schools of 2000+; Adobe Creek 1000+; Middle Creek 400+. Schools of less than 100 fish were typically seen in other streams. Too few observations were made on Scotts or Hendricks creeks to draw any conclusions. The early February siting on Scotts Creek was probably not hitch, but Sacramento suckers begin to spawn earlier than hitch. Heavy rain and stream flows stopped the migration in late February. The migration ended around March 16th. A few small schools were sited in mid-April.
■	Periods of time during which hitch were observed in varying numbers.	
	Period of time during which no monitoring was conducted.	



KEY & COMMENTS

Key	Description
(wave pattern)	Periods of time during which observations were made with no fish observed.
(grey shading)	Periods of time during which hitch were observed in varying numbers.
(blank)	Periods of time during which no monitoring was conducted.

Adobe has hitch spawning for 3 months interspersed with heavy rainfall and high flows at the end of February and first 3 weeks of March. Kelsey has only 3 schools reported on April 23, 24 & 27 of 34, 100 & 50 fish only. No fish are observed in Middle and Clover Creeks; Scotts valley has only 1 unconfirmed sighting. Schindler and Seigler Canyon have no fish.

2007 SPRING HITCH MONITORING IN CREEKS BY CHI COUNCIL
(22 observers recorded 279 observations)

≈ = periods of time during which observations were made with no fish observed; ▒ = periods of time during which hitch were observed in varying numbers; blank = no monitoring conducted.

	FEB			MARCH						APRIL						MAY			
CREEK	16-20	21-25	26-28	1-5	5-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20	21-25	26-30	1-5	5-10	11-15	16-20
Cole	≈			≈	≈	≈	≈	▒	≈	≈									
Kelsey	≈			≈	≈	▒	▒	▒	≈	≈	▒	≈	▒						
McGaugh							≈												
Adobe	≈	≈		≈	≈	▒	▒	▒	≈	▒									
Manning					≈	≈		≈											
Thompson		≈																	
Robinson				≈	≈	≈	≈												
Scotts				≈			≈												
Cooper																			
Hendricks					≈														
Pool																			
Middle				≈	≈	≈	≈	≈	≈	≈	≈								
Clover				≈	≈	≈	≈									≈			
Clover Byps																			
Alley																			
Schindler	≈		≈	≈	≈	≈	≈												
Copsey								≈		≈		≈							
Siegler Cyn	≈				≈	≈	≈	≈		≈		≈							

KEY & COMMENTS

Key	Description
≈	Periods of time during which observations were made with no fish observed.
▒	Periods of time during which hitch were observed in varying numbers.
	Period of time during which no monitoring was conducted.

Adobe Creek has very large runs with schools in excess of a thousand fish. Kelsey Creek has generally smaller schools numbering the hundreds. Cole Creek very few fish seen – the largest count is 11 fish. In no other tributary to Clear Lake are hitch observed.

2008 SPRING HITCH MONITORING IN CREEKS BY CHI COUNCIL

(31 observers recorded 405 observations)

	FEB			MARCH						APRIL						MAY			
CREEK	16-20	21-25	26-28	1-5	5-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20	21-25	26-30	1-5	5-10	11-15	16-20
Cole		≈				≈	▒	▒	▒	≈	≈		≈						
Kelsey	≈	≈	≈	≈	≈	▒	▒	▒											
McGaugh		≈				≈		≈											
Adobe	≈	≈	≈	≈	▒	▒	▒	▒	▒	▒	▒		▒						
Manning						≈	≈												
Thompson																			
Robinson	≈			≈			≈												
Scotts	≈		≈	≈	≈	≈	≈	≈	≈	≈		≈							
Cooper																			
Hendricks	≈	≈	≈	≈	≈	≈	≈	≈	≈										
Pool																			
Middle	≈			≈	≈	≈	▒	≈	≈	≈		≈							
Clover					≈	≈	≈	≈	▒	▒		▒		▒					
Clover Byps																			
Alley					≈														
Schindler	≈	≈		≈		≈	≈	≈											
Copsey			≈		≈		≈			≈									
Siegler Cyn	≈	≈	≈	≈	≈	≈	≈	≈	≈	≈	≈		≈		≈		≈		

KEY & COMMENTS

≈	Periods of time during which observations were made with no fish observed.	Adobe, Kelsey & Cole creeks had substantial runs. Adobe reported schools of 500+; Kelsey reported schoolds of 500+; Cole Creek had schools of 300+. No other creek reported hitch in any significant number. The largest schools in Middle Creek and Clover Creek were 30 fish. Monitoring of Scotts & Hendricks creeks revealed no fish.
▒	Periods of time during which hitch were observed in varying numbers.	
	Period of time during which no monitoring was conducted.	

2009 SPRING HITCH MONITORING IN CREEKS BY CHI COUNCIL

(21 observers recorded 361 observations)

	FEB			MARCH						APRIL						MAY			
CREEK	16-20	21-25	26-28	1-5	5-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20	21-25	26-30	1-5	5-10	11-15	16-20
Cole																			
Kelsey																			
McGaugh																			
Adobe																			
Manning																			
Thompson																			
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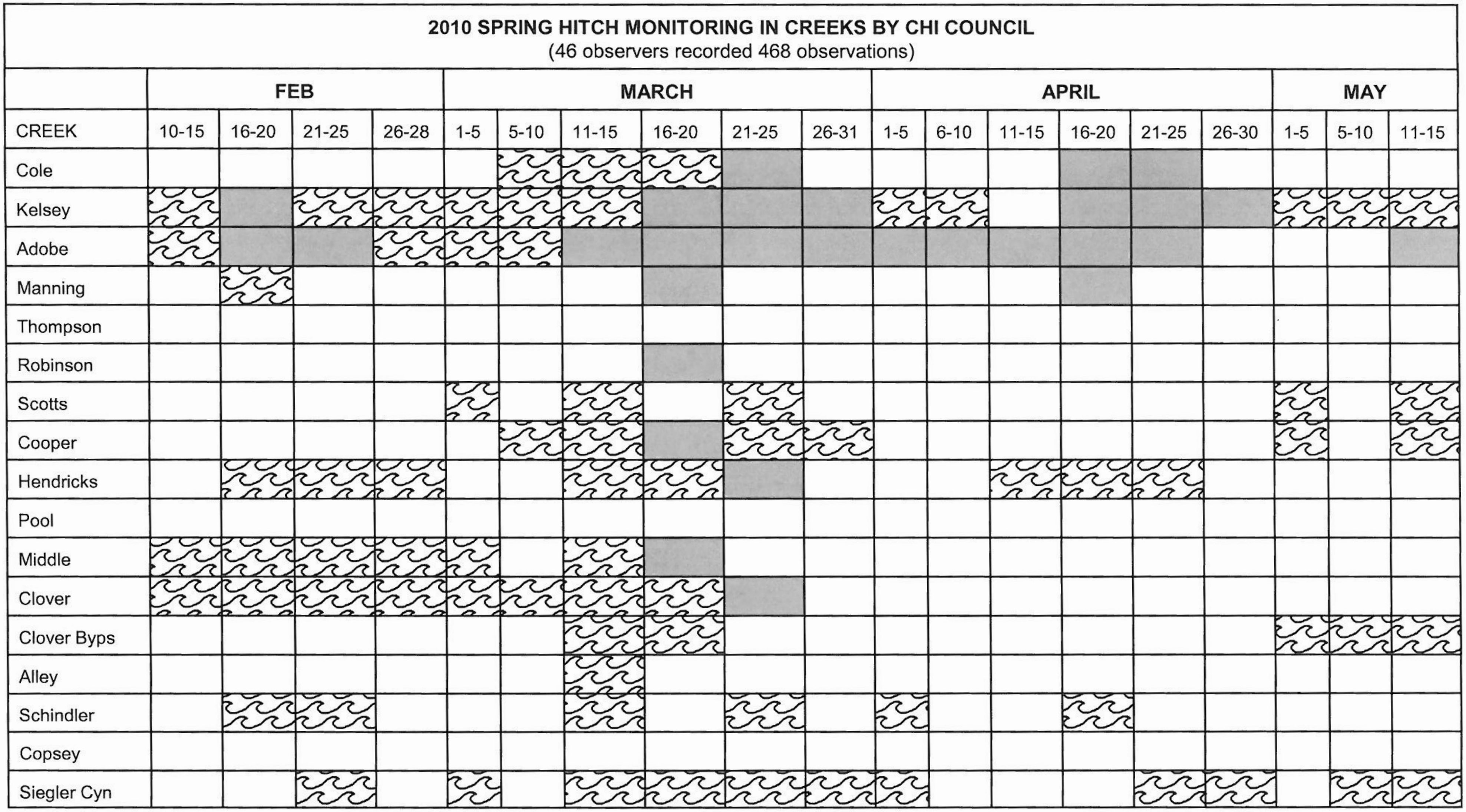
Clover Byps																			
Alley																			
Schindler																			
Copsey																			
Siegler Cyn																			

KEY & COMMENTS

	Periods of time during which observations were made with no fish observed.
	Periods of time during which hitch were observed in varying numbers.

Kelsey Creek had large schools of 1000+ fish seen; Adobe had schools of 800+ fish. Middle Creek had a single confirmed sighting of 20 fish. Hendricks Creek, a major tributary to Scotts Creek, had no sightings. If there are fish in Scotts Creek, they migrate into Hendricks. From the lack of fish in Hendricks, one may conclude there were no hitch in Scotts Creek.



KEY & COMMENTS

Key	Meaning
(hatched)	Periods of time during which observations were made with no fish observed.
(grey)	Periods of time during which hitch were observed in varying numbers.
(blank)	Period of time during which no monitoring was conducted.

The spawning season stretched in Adobe Creek from mid-February to mid-May. Periodic high water flows interrupted the spawning. As noted in earlier years, Adobe Creek is the most consistent and largest spawning creek followed by Kelsey Creek. No large runs were reported for Middle, Clover or Scotts Creek; any reported sightings were less than 100 fish and there were very few of those. Some fish were observed in small tributaries on the west side of Clear Lake, e.g. in a ditch at the intersection of Hiway 175 and South Main Street.

2011 SPRING HITCH MONITORING IN CREEKS BY CHI COUNCIL

(34 observers recorded 329 observations)

	FEB				MARCH						APRIL						MAY		
CREEK	10-15	16-20	21-25	26-28	1-5	5-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20	21-25	26-30	1-5	5-10	11-15
Cole																			
Kelsey																			
Adobe																			
Manning																			
Thompson																			
Robinson																			
Scotts																			
Cooper																			
Hendricks																			
Pool																			
Middle																			
Clover																			
Clover Byps																			
Alley																			
Schindler																			
Copsey																			
Siegler Cyn																			

KEY & COMMENTS

	Periods of time during which observations were made with no fish observed.	The spawning run was compressed and late because of high flows from heavy rains throughout March. Turbid conditions prior to recorded sightings may have obscured presence of migrating fish. Predators were observed, e.g., osprey, mergansers, herons, fishing in Adobe Creek a week before the hitch could be seen because of turbid water. The largest schools were in Adobe Creek (2,000+) and Cole Creek where over 1,000 were trapped in a flood basin by receding water. Thompson Creek had fish because the high water flows allowed rare passage over a low water crossing barrier on Manning Creek. Kelsey Creek had very few fish; nothing like prior years. Hitch were reported in Schindler Creek on April 4th (13 fish) & 5th (12 fish)for the first time since 2005.
	Periods of time during which hitch were observed in varying numbers.	
	Period of time during which no monitoring was conducted.	

2012 SPRING HITCH MONITORING IN CREEKS BY CHI COUNCIL

(26 observers recorded 216 observations)

	FEB				MARCH						APRIL						MAY		
CREEK	10-15	16-20	21-25	26-28	1-5	5-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20	21-25	26-30	1-5	5-10	11-15
Cole																			
Kelsey																			
Adobe																			
Manning																			
Thompson																			
Robinson																			
Scotts																			
Cooper																			
Hendricks																			
Pool																			
Middle																			
Clover																			
Clover Byps																			
Alley																			
Schindler																			
Copsey																			
Siegler Cyn																			

KEY & COMMENTS

	Periods of time during which observations were made with no fish observed.
	Periods of time during which hitch were observed in varying numbers.
	Period of time during which no monitoring was conducted.

The hitch run did not begin until April. The stream flows in February and March were very low. A school of 1000+ hitch was seen off the mouth of Adobe Creek on April 12th. The largest school seen in Adobe Creek was 250 fish seen on April 22nd during a tribal fish tagging operation. Most fish were seen in Kelsey Creek below the detention structure. One school of 350 fish was seen in Middle Creek on April 19th and 1 fish in Clover Creek the same day. No other fish were seen in Middle Creek and none were seen in Scotts Creek or its principal tributary, Hendricks Creek.

2013 SPRING HITCH MONITORING IN CREEKS BY CHI COUNCIL

(12 observers recorded 175 observations)

	FEB				MARCH						APRIL						MAY		
CREEK	10-15	16-20	21-25	26-28	1-5	5-10	11-15	16-20	21-25	26-31	1-5	6-10	11-15	16-20	21-25	26-30	1-5	5-10	11-15
Cole																			
Kelsey																			
Adobe																			
Manning																			
Thompson																			
Robinson																			
Scotts																			
Cooper																			
Hendricks																			
Pool																			
Middle																			
Clover																			
Clover Byps																			
Alley																			
Schindler																			
Copsey																			
Siegler Cyn																			

KEY & COMMENTS

	Periods of time during which observations were made with no fish observed.	There was effectively no hitch run this year. The stream flows were extremely low because a lack of rainfall beginning in early January 2013. Less than 2000 hitch were seen in Kelsey Creek and less than 200 in Adobe Creek. Six hitch were reported in Seigler Canyon Creek on April 1st; there was no other sighting in that creek. No hitch were observed in any other stream. CA Department of Fish & Wildlife conducted electrofishing tests at the mouths of Kelsey Creek and Cold Creek. Small numbers of hitch were detected.
	Periods of time during which hitch were observed in varying numbers.	
	Period of time during which no monitoring was conducted.	

Thomas, Kevin@Wildlife

From: Sunny Franson <sunny@pacific.net>
Sent: Wednesday, May 29, 2013 1:29 PM
To: Ewing, Ben@Wildlife; Thomas, Kevin@Wildlife
Subject: for review
Attachments: observations2013.pdf; ATT00001.txt; ATT00002.txt; ATT00003.txt; ATT00004.txt

Ben and Kevin,

Your deadline for sending material for review is coming up. Ben, I'm attaching a recap of the observations I did this spring. You probably already know my thoughts - habitat loss is primary, I think.

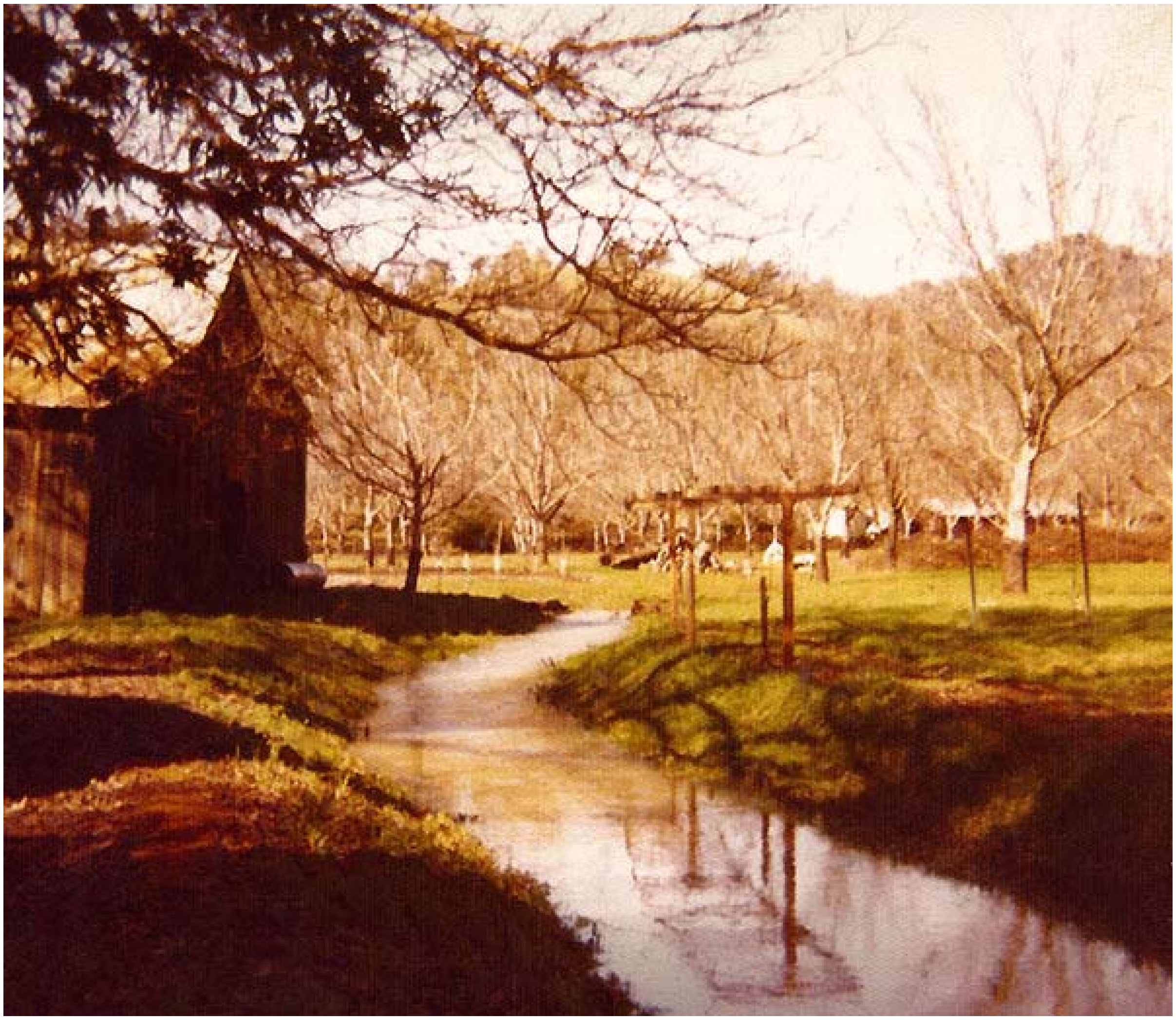
Just FYI, a diver told one of us, Meyo Marrufo, at Robinson a few years back that he's been diving in Clear Lake for decades and has never seen a hitch in the lake proper. A fisherman with decades of experience told me the same thing.

Something bothering me is that creeks seems to be drying up earlier and earlier, water flows downhill, and it appears that water sold to Yolo might be released April-June. I'm not knowledgable about specifics because I haven't done that research. I have a few notes on measurements we made for App.3 of the adaptive management plan - 2010 levels and flow: lowered levels, reduced-to-0 currents at Rodman (see draft plan, appendix 3, pg.15), and calculations for acre-feet lost by early summer. It's staggering. You expect to see juvenile fish in the creeks April-June.

Here are a few photos of Mendenhall, that used to be Middle Creek. Mendenhall runs more to the side of the Upper Lake basin. I lived next to it for many years; I was a piano teacher then. It was a creek that ran most of the year, lower in dry years and flooded in rainy years. Now it's dry except for runoff, and even that dries quickly. If memory serves this began about the mid-80's.

I don't know why this is happening, and the answer could be something completely unexpected. However if people are involved I don't feel anybody has the right to kill a beautiful little creek like this. It belongs to everyone - hitch used to migrate in it, mallards raised clutches in it. It's sad.

Good luck with all that you are doing.
Kind regards,
Sunny



Thomas, Kevin@Wildlife

From: Sunny Franson <sunny@pacific.net>
Sent: Friday, March 29, 2013 11:06 AM
To: Thomas, Kevin@Wildlife; Ewing, Ben@Wildlife
Cc: Peter WIndrem
Subject: re: Clear Lake hitch

Hello Kevin and Ben,

Work that I know has been done within the last several years includes Chi Council counts, tagging by local Tribes, the Draft Hitch Adaptive Management Plan, the final report to the US FWS for Robinson's Tribal Wildlife grant, and the very small study I did last year. I sent your Department copies of the last 3 as they came out, so you already have work I've done and/or organized and written. I wish I had more to send.

I think hitch need critical habitat of flooded grasses and wetlands and when crowded, shallow gravel beds in creeks. Temperatures and timing for egg and larval development appear to be crucial. It appears to me that these Cyprinids have evolved to fill specific spatial and temporal niches in the basin for all phases of their life cycle. When prey items that they need become available would be an integral part of those niches. I found support in references listed, especially in the last 2.

In the Upper Lake basin I know of a creek that used to run most of the year round, and hitch used to use it to migrate to a large, marshy field where they spawned. Since about the mid-80's this creek is generally dry. It used to have water even before winter rains. Folks have told me similar stories about other places close by, but I don't know exact timelines for those. Several large pear orchards have been pulled over the last couple of decades. It's puzzling, you wonder about the aquifer, and you see habitat loss.

You have your work cut out for you. Sending many good wishes, and hoping that we can all move forward with this.
Peter is right, being proactive is best.
Sunny

California Fish and Wildlife. April 29, 2013

North Central Region-c/o Mr. Kevin Thomas

Rancho Cordova, CA

Dear Mr. Thomas:

I am submitting a comment letter regarding the Clear Lake hitch for your group's consideration. Listing this fish as endangered and possibly being almost extinct is the only way any protection will be given the species. As a native fish in the Clearlake Basin, this fish serves as the beginning of our food chain.

The hitch have to spawn in low water, undisturbed but running. This sort of condition can only occur if farmers and ranchers are not been drawing off excess water for frost protection or irrigation. That has been the great source of the problem, as more and more vineyards and ranches/farms move into the area. As people exploit the resources, they will go away if protections and rules are not put into place. Local farmers and ranchers have been seen running irrigation to the creeks to alter the flow in order to water their crops or keep them from freezing. Some of the local supposedly upstanding citizens (one a judge) have been seen doing this.

Please continue the effort to get this species listed. The millions that were once seen in the creeks are now dwindling down to a dozen or so, if we are lucky.

I appreciate you taking the time to read my letter. The hitch can only survive if they are given protection because people have been altering the environment. They are known as "chi" to the natives and were often clubbed because they were blocking up the creek flow; that is how numerous they once were. We need to manage the remaining fish wisely.

Sincerely,
Ellen Karnowski

Ellen Karnowski

5591 Konocti Terrace Drive

Kelseyville, CA 95451

707-591-6708

Thomas, Kevin@Wildlife

From: Paul Kolb <paulkolb@netzero.net>
Sent: Friday, June 14, 2013 10:07 PM
To: Clear Lake Hitch
Subject: Hitch Endangered Species Comments

I have owned property with 600 feet of frontage on Middle Creek for the past 33 years. For many years, the hitch would spawn so heavily that many would be pushed up onto the shores of Middle 'Creek because the creek was commpletely full and colored black with densely packed 1 lb, 12" long hitch. For the past ten years, very few, maybe 100-300 fish were all that appeared all spring. This year, I saw no adult hitch, and some, maybe 1,000, unidentified 1" baby fish that are not likely hitch.The hitch are almost gone from Middle and nearby Clover creeks.

The few Hitch that remain must be protected with all the force of the California and Federal Endangered Spoecies Acts. Thke data from observations is obvious; drastilc action is needed.

See all the studies done by U. C., DR. Moyle, Fish and Game, the Chi Council, and others.
TAKE ACTION NOW! SAVE THE HITCH!

Now, the Clover Creek channel thru downtown Upper Lake is completely overgrown with Himalayan Blackberry, and is impassable by any fish. This may be a result of the recent clearing of the channel for fllod control, and the resulting quick recovery and domination by the blackberry. Himalayan blackberry is very usable and productive, but it overgrows and smothers native areas all over Lake County; a program should be started to try to remove it selectively.

For Clover Creek, it is an emergency now. I have been observing my part of Middle Creek for the past many years, and it appears to me that the Clover Creek strain of Hitch, which must pass thru the Middle Creek channel to get to clover creek, has always shown up under the First Street bridge, and there is no way they could get there now. i believe that the Clover Creek strain is still alive and stronger than the rest of the Hitch which continue up Middle Creek. il don't think that very many Hitch are still going up Middle Creek, so i believe it is very important to preserve and help the remaining Clover Creek strain.
Also, for the past 2 years, I haven't seen any adult Hitch, but have observed up to one hundred baby 1" fish in May which I believe are Hitch fry. Others have observed Hitch under the First Street bridge.
Please try to get the Clover Creek channel cleared; it's on private property, and may be difficult to clear.

I'm personally disgusted with our Board of Supervisors, voting unanimously to delay the Endangerred Species listing; I'm glad that they were overruled. Their token actions to protect the Lake are ineffective, and they would let the Hitch and the whole lake die. . My only hope is the program the Tribes are doing to captively breed the hitch; that WILL preserve them. I have transplanted hitch fry into a local private Upper Lake vernal pool a few years ago, and I hope they survive there too.
I intended to transplant some of the fry from either Kelsey or Adobe Creek into Highland Springs Reservoir also in hopes of them surviving after the others are extinct. The Chi Council should seek and encourage others to find private reservoirs for the strain from the creek nearest their reservoir. Three cheers for the Tribes "Hatch a Hitch" program!

PROTECT THE HITCH NOW!

Thank you.
Paul J. Kolb

LAKE COUNTY FARM BUREAU
CALIFORNIA

Marc Hooper - President
David Rosenthal - 1st Vice President
Glenn Benjamin - 2nd Vice President
Claudia Street - Executive Director

February 26, 2013

California Fish and Game Commission
1416 Ninth Street, Room 1320
Sacramento, CA 95814

RE: Agenda Item #8 – Consideration of petition, department's report and comments received on whether listing Clear Lake Hitch as a threatened species may be warranted

Dear Commissioners,

The Lake County Farm Bureau (LCFB) represents over 550 family farms in Lake County. LCFB works closely with farmers to address issues of importance that pertain to the agricultural industry at the local, regional and state levels. As a voice for local agriculture, we respectfully submit the following position paper to the California Fish and Game Commission (Commission).

This letter is to provide comments to the "Petition to List the Clear Lake Hitch as Endangered or Threatened Under the Endangered Species Act" (Petition), prepared by the Center for Biological Diversity. LCFB supports the use of sound, peer-reviewed science in the development of any and all programs designed to protect our natural resources. Towards this end, we oppose the Petition as presented due to a lack of scientific data and inconsistencies in the general data found within the Petition. In addition, we acknowledge the significance of the Department's statement noting "the limited quantitative and qualitative information available regarding historical and current population numbers and information on the best scientific approach to enhance the existing population." It is our intent to provide additional information on the following points for consideration in the spirit of providing a more accurate assessment of current conditions, as well as supporting sound, peer-reviewed science.

A. Agriculture

Agriculture is presented as a major factor contributing to the reduced hitch population. In implicating agriculture, the petitioner fails to include current scientific evidence that documents significant advances to local agriculture practices that focus on conservation methods and sustainability programs. Such practices have been scientifically developed to minimize impacts to our natural resources and environment.

1. The use of organophosphates has decreased significantly over the past 25 years. Due to the establishment of a pheromone-based mating disruption program developed for the pear industry which replaces the prior dependency on organophosphates, increased government regulations and reduced pear acreages, the trend to reduce organophosphates is dramatic. From 1990 to 1992, pesticide use reports (PURs) report the annual average of organophosphate use was 46,771 pounds per year. The most recent 3 years of data, 2008 to 2010, document the annual average per year was only 651 pounds per year. This represents a 98.6% reduction in organophosphate applications during that period.

2. The Irrigated Lands Regulatory Program (Program) was initiated in 2003 to prevent agricultural runoff from impairing surface waters. Mandated and regulated by the Regional Water Quality Control (Board), monitoring results in Lake County have never exceeded pesticide limits set forth by the Board. In addition to claims made in the Petition regarding excessive nutrient loading, the Program is required to comply with appropriate TMDL monitoring protocol for nutrients. To date, no exceedances for nutrients have occurred. This data completely negates references in the Petition to pesticides found "in surface waters in many areas".

3. According to PURs, in the 1990's Lake County averaged approximately 1,014,832 pounds of pesticides used each year. In the 2000's this average dropped dramatically to 662,629 pounds per year, resulting in a 35% drop in total pounds of pesticides used. Again, this reduction is a direct result of widespread adoption of proven conservation methods and sustainability programs. In addition, the use of Integrated Pest Management Practices (IPM) has been effective in a reduction in pesticide use. IPM is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

4. According to Natural Resources Conservation Service (NRCS), in 2012 approximately 1,000 acres of irrigation efficiency projects were implemented. These projects are developed to reduce the amount of water used during irrigation as well as reducing the amount of water runoff associated with irrigation. Numbers are not available for producers who have implemented such practices on their own.

5. According to NRCS, in 2012 approximately 1,000 acres of soil quality projects were implemented. These projects include the use of cover crops which have proven to reduce the amount of water runoff associated with irrigation or storm events. Numbers are not available for producers who have implemented such practices on their own.

6. According to NRCS, additional projects include installation of bird/bat/owl boxes to increase wildlife habitat; work with UCCE to install water monitoring sensors in pears and walnuts to increase irrigation efficiency, reduce the amount of water used in irrigation and reduce the amount of water runoff associated with irrigation; fencing to protect riparian areas; development of off-stream water storage capacity; planting of native hedgerows to increase pollinator habitat; establishment of cover crops to reduce erosion; establishment of conservation cover to provide natural insectaries; farm road improvements to reduce erosion; implementation of soil and tissue testing to better manage the amount and timing of nutrients; and the use of IPM to better manage the applications of pesticides. Numbers are not available for producers who have implemented such practices on their own.

B. Water

On the following points regarding water, the Petition lacks virtually any scientific evidence and is embellished with conjecture intended to advance the petitioner's cause.

1. There is no scientific evidence to support that "some of the tributary streams that used to run perennially now flow only after heavy rains".

2. The statement "Aquifers in the Clear Lake Basin are lower than they were even 25 years ago" is inconsistent with the scientific data that the County of Lake has collected over that period. In fact, scientific evidence documented in the CASGEM Monitoring Plan actually shows no significant changes in groundwater levels.

3. The statement by Gichuki and Garibay (2012) noted "very many illegal connections for agriculture and there seemed to be a competition among farmers to extract as much water from the creeks…Farmers do not seem to be inclined to use groundwater from wells…, but

instead preferred to pump water from creeks" lacks evidence, is defamatory and does not have any place or purpose in this Petition. According to information from the Lake County Water Resources Department, 83% of irrigation in Lake County is attributed to groundwater usage. An overall trend supports a decline in water used for irrigation as the conversion continues from pear orchards that require more irrigation to winegrapes that use considerably less irrigation.

C. Hitch Populations

The use of unscientific surveys fails to document a significant decrease in hitch populations and spawning activities since 2005.

1. While the petition estimates the spawning hitch population in the early 2000's to have dwindled to only a few thousand fish, using citizen science methodology, Chi Council surveys as late as 2010 showed 10,000+ fish in Kelsey Creek alone on a single viewing. Also in 2010, Manning Creek's spawning run was described as "the best run in 30 years".
2. Presence/Absence surveys from year to year fail to take into account weather conditions and specifically spring rainfall data that directly impact stream flows. Seasonal variations, including rainfall totals, should be overlayed with scientific hitch count surveys of spawning fish. This information would provide data necessary to support the statement made in the Petition, "water quantity was the most important factor in sustaining young hitch".
3. The use of citizen science methodology is the sole basis for estimating hitch populations provided in the Petition. To make the best, informed decision, the use of sound, peer-reviewed science should be utilized.
4. The Petition asserts historical hitch runs going back to the 1960's through the early 1990's have decreased. However, no effort has been made to establish what constitutes a viable population of hitch. The Chi Council reports large numbers of spawning hitch every year with the recent spawning years of 2010 and 2012 being two of the strongest in several years.

D. Predation and competition from introduced species

The petition minimizes the unquestionably primary contributor of decreasing hitch populations - predation and competition from introduced species of fish.

1. The introduction of the Threadfin Shad in 1985, the Mississippi Silverside in 1967 and Florida strain of Largemouth Bass in the 1970's have all had a major impact on all fish species in Clear Lake.
2. This petition refers to decreased numbers Carp and Blackfish to the point where commercial fishing is no longer practical. Other fish species that were once extremely abundant in Clear Lake, including Crappie and Bluegill have also shown steep declines in populations. It is generally believed that all of these fish species population declines are primarily a result of predation and competition from the recently introduced species of Largemouth Bass, Threadfin Shad, and Mississippi Silverside. While other fish populations have been considerably reduced, these three species have thrived.

E. Current, local efforts

Substantial efforts to improve hitch habitat are currently underway in Lake County.

1. Lake County private landowners who have barriers to spawning on their property are working to remove or modify these barriers to allow free migration of the hitch.
2. As noted in the petition, The California Department of Fish and Game, the County of Lake and the California Department of Transportation are working on correcting barriers to hitch migration on public property and surrounding public bridges.
3. Commercial gravel mining of creeks has been curtailed as a result of countywide plans.
4. Lake County has established and implemented an effective grading ordinance that reduces erosion issues associated with agricultural developments.

5. The County of Lake has adopted a General Plan that has numerous components, as outlined in the Petition, which will protect hitch habitat.
6. The ILRP continues to monitor surface water for the presence of agricultural pesticides and nutrients. Beginning in 2014, the program will be required to include monitoring of ground water.

F. Suggested measures to reduce threats to hitch population

Immediate threats to the hitch population could be reduced by implementing the following suggestions.

1. Ban commercial harvesting of both adults and juvenile Clear Lake hitch.
2. Ban recreational harvest of Clear Lake Hitch.
3. Enforce existing Fish and Game streambed management regulations.
4. Continue to work with the private landowners and municipalities on removing or modifying both public and private stream migration barriers and improving habitat for the Clear Lake Hitch.

To conclude, LCFB sincerely appreciates the Commission's review of the comments and information provided in this letter as you consider whether listing the Clear Lake Hitch may be warranted. The information we have provided and the comments included herein are intended to provide accurate data for you to analyze. We also stand ready to assist you in providing any additional information on local conditions and best management practices that support the conservation of our local natural resources.

Sincerely,

Marc Hooper
President

Ray Mostin, 81, Kelseyville resident and farmer

It is my experience that every 10 years there is a major flood in our area. There have been erratic hitch runs ever since the 1930s; the migration runs go up and down. Our creeks used to be shallow, wandering creeks. Now the creek depth is 20 feet from creek bank to creek bottom. The main contributor to the deepening of creeks has been gravel extraction. I am a graduate of UC Berkeley with a degree in geology. The historic, early 1900 photo everyone sees is not typical of every hitch run. Originally, the historic, shallow creek levels allowed the creeks to wander and meander.

The farmers were concerned about the way creeks were deepening as a result of gravel mining and we ended up signing a petition that we presented to the Lake County Board of Supervisors with the threat of a lawsuit if mining was not stopped. As a result of our concerns, mining was stopped. Years ago, Kelsey Creek meandered all the way to where it entered Clear Lake. Our State Park system changed that point of entry when they engineered a straight approach of Kelsey Creek in to Clear Lake. I estimate a loss of 14 million cubic yards of gravel that has been extracted or removed from Kelsey Creek. The farmers in this area want to protect the gravel and we know the gravel protects hitch spawning habitat.

The straightening of Kelsey Creek has increased the velocity at which the creek flows and has increased the carrying capacity of waters to move gravel. Gravel extraction has caused more erosion than any other activity in the creek. Over time, the State Park did improve some areas for habitat and Lake County has provided some rip-rap projects to prevent further erosion. The farming community has worked hard, as noted in the ground water recharge study, to improve creek habitat.

There have been fish kills documented and this can be attributed to occasional rising temperatures in the lake, and a reduced food source. The competition for food in the lake has been severely impacted by the increased population of introduced bass. The report titled "Human Influences to Clear Lake, a 20th Century History"[1], written in 2009 by Greg Giusti is an important document to read (http://celake.ucanr.edu/files/164054.pdf). Giusti names 12 native fish species and numerous non-native, introduced fish. The increased competition of non-native species is directly responsible for killing off hitch populations.

[1]See attached scanned pdf

From Human influences to Clear Lake Calif. by Greg Giusti March 2009

control carp. The sea lions remained in Lake Merced until the fish supply became exhausted and they simply walked back to the ocean. The idea was finally abandoned because "It was thought, however, that the swamp and tule land surrounding [Clear Lake] would harbor the carp and furnish them with areas that the sea lions would not reach (California Fish Commission Report for 1897–98, p. 33).

Unfortunately, not all accounts are so nonsensical. Historical accounts tell us "Clear Lake once swarmed with countless thousands of native minnows. Not only did these fish cause Livingston Stone difficulty in fording some of its tributary streams by horse when they ran upstream to spawn, but in more recent years they died in such quantities that the stench was almost intolerable to the lakeshore residents. Every year large quantities of dead fish had to be buried, but according to Capt. J.D. Dondero of the Division of Fish and Game, the establishment of white catfish in Clear Lake, which he said occurred in the 1920s, "... solved this problem." The population of non-game fish diminished, and the windrows of dead fish were a thing of the past (pers. comm.)". [Source: Fish Bulletin 178]

Fish have and continue to play an important economic and social role for Clear Lake residents and visitors. Commercial, sport and recreational utilization of fish have long been important aspects of the natural system. Clear Lake's pre-settlement fish fauna was dominated by species found naturally occurring in both the Russian and Sacramento River systems; as a result of the Lake's connection to both systems over geologic times. Native fish include: Pacific lamprey* (*Lampetra tridentate),* Sacramento perch* *(Archoplites interruptus)*, hitch (*Lavinia exilicauda),* Clear Lake split tail* *(Pogonichthys ciscoides),* Sacramento blackfish (*Orthodon microleptidotus)*, Sacramento pikeminnow (*Ptychocheilus grandis)*, Sacramento sucker (*Catostomus cocidentlis)*, prickly sculpin (*Cottus gulosus)*, tule perch (*Hysterocarpus traski)*, rainbow trout (*Oncorhyrnchus mykis)*, three-spined stickleback (*Gasterosteeus aculeatus)*, and thick-tailed chub* (*Gila crassicauda*). Those fish marked with an asterisk are considered extirpated from the Lake.

Commercial fishing for live-fish export to San Francisco's Asian markets continued from the early part of the 20th century until the first decade of the 21st century.

resulting in quarantine and eradication efforts. A list of introduced non-native species and the year of their introduction is presented in Fig. 6.

FIG. 6. NON-NATIVE SPECIES INTRODUCTIONS TO CLEAR LAKE:

- whitefish (*Coregonus clupeaformis*), 1875, failed;
- brown bullhead (*Ameiurus nebulosus*), 1875;
- white catfish (*Ameiurus catus*), 1875;
- smallmouth bass (*Micropterus dolomieu*), 1875;
- common carp (*Cyprinus carpio*), 1880;
- grass pickerel (*Esox americanus*), 1896, failed;
- golden shiner (*Notemigonnus crysolencus*), 1896 & 1950, failed;
- northern largemouth bass (*Micropterus salmoides*), 1897;
- bluegill (*Lepomis macrochirus*), 1906;
- black crappie (*Pomoxis nigromaculatus*), 1906;
- channel catfish (*Ictalurus punctatus*), 1908;
- lake trout (*Salvelinus namaycush*), 1923 & 1924, failed;
- pumpkinseed (*Lepomis gibbosus*), 1942;
- white crappie (*Pomoxis annularis*), 1945;
- inland silversides (*Menidia beryllina*), 1962;
- Florida-strain largemouth bass (*Micropterus salmoides*), 1967;
- Florida-strain black crappie (*Pomoxis nigromaculatus*), 1984;
- threadfin shad (*Dorosoma petenense*), 1985;
- *Hydrilla veritcillata*, 1994.

The threat of more invasive species becoming established in Clear Lake persists to the present time. Recent concerns over Dressenid mussels (quagga and zebra), New Zealand mud snails, and other commercially sold aquarium fish species pose a constant threat of adding more stress to the lake's system.

SUMMARY

Early 20th century exploitation of mined resources has left a prolonged and costly legacy on Clear Lake. The resultant mercury contamination continues to exercise its influence through health advisory warnings on fish consumption and persistent evidence of its existence within the Lake's food web.

Thomas, Kevin@Wildlife

From: John McDaniel <johnmc@mcdanielmfg.com>
Sent: Wednesday, May 22, 2013 11:36 AM
To: Clear Lake Hitch
Subject: Clear Lake Hitch

Greetings,
I am not a biologist or any kind of wildlife expert. I am a fisherman. I have been fishing at Clear Lake for years. The Bass population of Bass in that lake is exceptional.
The thought of removing, relocating or killing the Bass in Clear Lake is unacceptable. Maybe the thought should be to remove the Hitch to a safer location. That won't work. The Hitch are a food source for the Bass in the lake. Maybe the better solution would be to harvest the Hitch, take them to a hatchery where there eggs can be harvested and grown to a certain size and replace the fry back into Clear Lake. Just a thought. This might be a reasonable way to save the economy in the towns and business that depend on visiting fishermen and tournaments for their livelihoods. Sometimes the easiest approach(removing the Bass) is not the best.

Thank you,

John J McDaniel
President
McDaniel Manufacturing Inc.
Phone : 530-626-6336
Fax : 530-626-6722

Daily Notes

FISH RECAP – YEAR – NUMBERS CAUGHT BY SIZE
AVERAGE # OF FISH CAUGHT PER OUTING

SIZE / YEAR	05	06	07	08	09	10	11	12
1 TO 3 LBS	2,466	2,664	2798	1761	1466	814	569	574
3+	171	282	444	275	418	484	507	449
4	53	126	142	66	122	164	164	162
5	27	24	43	39	31	59	90	59
6	7	13	13	7	17	15	35	37
7	7	7	8	6	6	1	2	10
8	7	1	7	4	2	5	7	4
9	2	2	6	3	2	1	0	1
10	4	1	1	1	0	1	0	1
11	2	1	0	0	0	0	0	0
TOTAL CAUGHT	2746	3121	3473	2162	2064	1542	1374	1370
DAYS FISHED	140	185	183	151	140	141	148	140
lb/day	42 lb/day	37.69 lb/day	43.52	32.84	35.76	29.69	27.33	27 lb/day
AVERAGE # OF FISH CAUGHT PER TRIP	19.6	16.8	18.9	14.3	13.4	10.9	9.28	9.78

07 WAS THE PEAK

010 DRAMATIC DROP IN AVERAGE #'S + IN 1 TO 3 LB FISH

010 DOES SHOW AN INCREASE OF 3, 4 + 5 LBERS

ROBINSON RANCHERIA
CITIZENS BUSINESS COUNCIL

The Robinson Rancheria of Pomo Indians would like to express our support for the California listing of the Clearlake Chi hitch (*Lavinia exilicauda chi*) as a threatened species. We believe that they should be listed as soon as possible in order to help protect them from possible extinction in the near future. The hitch species population is now under a significant amount of stress from a variety of causes, most of which are a result of human actions during the past 150 years. The Clear Lake hitch have been an abundant species in the Clearlake basin for many thousands of years and have never before had to survive in such a change of conditions.

Potential Causes of *Lavinia exilicauda chi* decline:

There are a variety of in stream structures, including dams, bridges, and other kinds of barriers to the hitch reaching their spawning habitat. The dams and detention structures have been observed to also cause eggs to build up in places and suffocate from loss of oxygen.

Changes made to the stream channels making them either too steep and fast moving, or too shallow. Gravel mining has changed the stream bottom heights by 15 feet in places and there has been vegetation canopy cover loss, which is leaving fish more susceptible to predators.

Water diversions pumped from aquifers, and directly from the streams for agriculture and domestic uses affecting surface flows in tributary streams resulting in streams drying up early and therefore allowing the hitch fry less time to make their way downstream to the lakeshore or slough, and to reach a size large enough for them to have a sufficient chance of survival. These water diversions also result in more hitch adults and fry to be trapped and perish in receding waters.

There has been a loss of fish nursery areas from lakeshore alterations whereby tulles and dead wood habitat has been cleared so it is more difficult for young fish to evade predators.

The introduction of non-native fish is also one of the primary reasons for the apparent hitch decline. The bass in particular and also the channel catfish are known to be preying on the hitch significantly and are definitely successful predators to some extent since large hitch have been found in their stomachs. Other introduced fish compete for the available food with the hitch. Threadfin shad, a zooplankton feeder, are said to eliminate daphnia, one of the principle foods of the hitch. The Mississippi silverside is another introduced zooplankton feeder which also eats some of the same food as the hitch. The Clear Lake gnat was nearly exterminated with pesticides and it was a primary food source for the hitch and the gnats numbers are still very low now likely because of the the Mississippi silverside and the threadfin shad eating them.

P.O. Box 4015 • 1545 E. Highway 20 • Nice, CA 95464
Phone: 707.275.0527 • Fax: 707.275.0235

Water chemistry and quality, intense agriculture from orchards and vineyards has resulted in effluent containing fertilizers, pesticides and sediment into the lake which has contributed to lake eutrophication and bluegreen cyanobacteria blooms.

In addition there are a variety of urbanization related impacts affecting the hitch to unknown degrees. These are things such as road building, lot clearing, logging, mining, removing wetlands, vehicle in stream crossings, increased urban and rural water needs, septic systems leaking into lake water, and boating which can add stress to fish.

There is the added effect of climate change, which is generally causing the streams to dry up sooner and again leaving the hitch less time to spawn, and for the fry to mature before making their way downstream.

Changes in the balance of aquatic algae in the lake, which may change the food supply for daphnia, rotifers and other zooplankton the hitch eat, or which the hitch may eat directly because they are omnivores. One belief is that rotifers cannot eat the lymbia, which is becoming more predominant, but can eat the anabaena.

The Clear Lake hitch has also been carrying a large parasite load of non-native anchor worms for a number of years and this is likely increasing their mortality.

The Clear Lake Hitch is a culturally significant native fish that is an important component of the traditional food gathering by Robinson Rancheria tribal members and the other Tribes of the Clear Lake basin. The protection of the Clear Lake Hitch population is a multi-Tribal effort intended to help stop the decline of Hitch populations in Clear Lake.

The Tribe provided a copy of the Hitch Adaptive Management Plan in 2011 and the 'Final Report Clear Lake Hitch Study and Recovery Project' prepared for the U.S. Fish and Wildlife Service in 2011. Please let us know if you need additional copies of these documents or clarification pertaining to any of the information or data contained in these or other Robinson Rancheria documents. I can be reached at the Robinson Rancheria Environmental Center at 1645 E. Hwy 20, Nice, California.

Ph. 707-275-0205
Fax 707-275-0470
drogers@robinsonrancheria.org

Sincerely, *Dean Rogers*

Dean Rogers, Water Resource Manager, Mailing address, P.O. Box 1580, Nice, CA 95464

Seely Orchard

PO Box 218
Upper Lake CA 95485
(707) 275-2353

To Whom It May Concern,

In 1954, the Seely family purchased a pear ranch in Upper Lake which borders Middle Creek on both sides. In those days, the Hitch population was so plentiful that you couldn't walk across the creek without stepping on them. We were pumping irrigation water out of the creek and had two creek crossings for equipment as was the practice of the former owner. Many other pear farmers upstream were also pumping out of Middle Creek. The levee system was new and the levee district eradicated all plant growth bank to bank. The fire protection district burned the grass on the levees every summer. This was the "normal" until the mid 1990's.

The Middle Creek of today is much different than that of the 1950's. A wide of variety of vegetation covers both banks supporting a wide variety of wildlife. What hasn't changed, is the way our family uses the creek and its water resources.

For those of us who have lived and worked in this ecosystem for 60 years, we don't feel that our agricultural practices have been the cause of the hitch decline. With the sharp decline of the pear farming industry in this county since the 1990's, there are fewer farmers using the Middle Creek watershed to irrigate their crops as much of that acreage is now fallow. Agriculture in our area is not drawing the water it once did and yet agriculture is the industry that seems to take the blame for most environmental issues.

Currently, our farm pumps water from Middle Creek for frost protection and spring irrigation. Water is the only method used for crop frost protection since the industry moved away from burning fossil fuels. This county is made up of small farms. When presented with the threat of government limiting or completely taking away the water rights which it has enjoyed for the entire farming history of Lake County, the local family farms will become the endangered species along with its contributions to our local economy.

No Farms, No Food.

Sincerely,

The Seely Family
Edward E. Seely, Jeff Seely, Eric Seely, Colleen Rentsch
Upper Lake, CA

Sierra Club Lake Group

PO Box 27 Lakeport, CA 95453

June 12, 2013

Kevin Thomas
California Department Fish and Wildlife
701 Nimbus Road
Rancho Cordova, CA 95670.

via email to *CLH@wildlife.ca.gov*

RE: CESA listing for the Clear Lake hitch: SUPPORT

Dear Mr. Thomas:

The Sierra Club Lake Group represents some 400 Sierra Club members living in Lake County, and is a branch of the 9,000-member Redwood Chapter. Preservation of biological diversity is, as it has always been, central to the Club's core mission to "Enjoy, Explore, and Protect the Planet," and we therefore strongly support the listing of the Clear Lake hitch (*lavinia exilicauda chi*) under the California Endangered Species Act (CESA).

Lake Group has been actively involved in local efforts to preserve this endemic fish since 2004, when an informal group of Sierra Club volunteers began monitoring the annual spawning migration. This effort led to the creation of the Chi Council later that year. Subsequently we have played an important role in the recruitment of volunteers, and have done a great deal to spread awareness of the plight of the hitch and the activities of the Chi Council, local tribes, and other stakeholders to halt or reverse their population decline.

Alas, it appears that these well-intended local actions have been inadequate to the task. It was already obvious in 2004 that hitch populations were dramatically reduced from their historic levels, but at that time substantial spawning runs were nonetheless still observed in Clear Lake tributaries far distant from the creeks in the Big Valley watershed. In particular, viable spawning cohorts numbering in the thousands were regularly seen in the Middle, Scotts, and Clover creek complex at the north end of the lake. Aside from a few scattered sightings, this population seems to have completely disappeared subsequent to 2006. This distressing loss has taken place *despite* investment of considerable monetary and human resources by the County of Lake in habitat improvements, especially the installation of a series of weirs to allow fish passage at a barrier at the Rancheria Road bridge that prevented the hitch from accessing some ten miles of their historic spawning grounds on Middle Creek.

Additionally, fish capture during the course of tribal tagging projects has revealed that the remaining spawning adults are heavily infested with parasites and nearly universally subject to skin lesions of unknown origin—indications that the species is under extreme stress.

The causes of hitch population decline are not definitively understood: indeed, one of the significant advantages of CESA listing would be potential access to the funding sources needed for authoritative scientific studies of their biology and their position in the ecology of Clear Lake. Nonetheless, a number of contributing factors seem obvious. Barriers to migration that artificially restrict spawning territory—barriers present on every major Clear Lake tributary to a greater or lesser extent—have received the most public attention, though they are probably not the most important limiting factor. Dramatic loss of wetland habitat, especially the tule marshes that shelter juvenile fish, food competition from introduced fish such as silversides and threadfin shad, predation from other introduced fish such as largemouth bass, especially the voracious Florida strain, and impairments to water quality from heavy metal pollution and excessive sedimentation all are likely to have played a role in hitch decline.

On top of this diverse array of longstanding stressors the last few years have been characterized by anomalous weather patterns, sparse spring rains, and dramatically reduced stream flows during the migration season. In the winter of 2013, removal of riparian vegetation along a key segment of Adobe Creek—along with Kelsey, one of the two creeks where hitch have been known to spawn in substantial numbers in recent years—may also have had a dramatically negative effect on adult survival and reproductive success.

The consequence of this perfect storm has been a sparse spawning run in 2012 and a nearly nonexistent spawning run in 2013. Adverse climatic conditions and absence of normal spawning behavior have been known in the past without apparently causing irreversible harm, but that was when Clear Lake's hitch population was abundant and thriving, a description that certainly does not apply today.

This fish is under extreme stress, and may indeed have already passed the point of possible recovery. But according to the mandate expressed by both the state and federal Endangered Species Act, it is our responsibility as citizens to use every means in our power to prevent extinction, because every extinction impoverishes us all, and impoverishes the planet as a whole. Listing the hitch under CESA cannot guarantee its long term survival, but listing is the only plausible means available to provide the resources needed to support a good faith effort to restore the population of this iconic fish to a viable level. As an additional benefit, the improvements likely to improve the longterm survival chances of the hitch—wetland restoration in particular—will also benefit the entire ecosystem of Clear Lake and the communities that surround it.

The evidence clearly demonstrates that after barely surviving for a number of years this species is now declining with terrifying rapidity. Its plight is dire, and the need for action urgent, with CESA listing offering its only hope of survival. The Sierra Club therefore urges the staff of the California Department of Fish and Wildlife to recommend listing to the Fish and Game Commission in the most strenuous terms possible.

Yours sincerely,

Victoria Brandon
Conservation Chair, Sierra Club Lake Group

Thomas, Kevin@Wildlife

From: CADILLAC PAT <cadillacpat71@gmail.com>
Sent: Thursday, June 13, 2013 6:30 AM
To: Clear Lake Hitch
Subject: HITCH

LOOKS FARLEY SIMPLE TO US. EVER SINCE THE LARGE MOUTH BASS HAVE BEEN PUT INTO THE LAKE MANY YEARS AGO THE CRAPPIE, BLUE GILL AND HITCH ARE JUST SCOOPED UP BY THESE LARGE MOUTH PREDATORS. LARGE IS A UNDERSTATEMENT, THERE MOUTH IS BIGGER THEN THE GIRTH OF THERE BODY WHEN IT'S OPEN. IT DOESN'T TAKE MUCH TO SEE WHEN YOU LOOK AT THE BASS TO TELL WHAT THEY DO 24 HOURS A DAY, EAT EVERY THING IN SIGHT. THANK YOU, PAT SPERLING IN LAKEPORT. 60 YEARS IN LAKEPORT.

Thomas, Kevin@Wildlife

From: rkwnch@pacific.net
Sent: Tuesday, May 14, 2013 10:57 AM
To: Clear Lake Hitch
Cc: ceo@lakecochamber.com
Subject: Hitch

I grew up on a watercourse leading from Hopland Mountain to Clear Lake. In the late 40's to the late 60's, when weather was more consistent, it seemed like we could depend on a run of Hitch annually which was in such numbers as to boggle the mind. Even folks from the nearby Reservation came to catch sacksfull for drying.

But lately, there have been years when not one Hitch attempted the run. In my opinion, this may be the result of:

1.Large and inconsistent variations in air/water temperature, which may have been one of the signals to the fish to migrate.

2.Early drying-up of the seasonal creeks, sometimes in consecutive years. This might reduce the population memory of which creek is "home".

3.Increased residential and industrial development on or near the watercourses. There is the alarming tendency of some less-evolved humans to view waterways as garbage disposals and the stuff thrown into them is more and more toxic.

4.More competition for water and less leadership to conserve, budget and share it. Private dams are usually undiscovered which could have the same effect as a shortened streamflow Every year.

5.Pandering to the profitability of bass contests which probably gives the bass a serious evolutionary advantage over the Hitch.

Government will want to study the Hitch issue to death, and will continue to buy more studies until the species has passed into oblivion. But enlightened leadership might be found for mitigation of #s 3-5 above. If I might be indulged for a suggestion re #2 above, it might provide an inexpensive remedy. Some years ago, someone constructed "Gravel movement barriers" on the Lake County side of the streams around Hwy 20 in the mountains East of The Oaks.
The goal seemed to be gravel retention. A concrete dam was built across the smaller parts of the stream, but only as high as the elevation of the gravel. Thus it did not appear to and did in fact NOT dam up the water permanently, in the act of keeping gravel in place. It DID extend the flow of the stream to a later date in the Spring by holding water (that ran thru subsurface gravel) longer.

Now the Resource Conservation Districts in this county do not have a tax base from which to draw funds to test a plan such as the above to mitigate the effect of global warming weather upset on creekflow. But if money could be found to have them select a watercourse that is currently in danger of losing its Hitch run due to intermittency, place gravel movement barriers in the region of previous Hitch spawning, make and protect gravel streamfloors to encourage spawning, and then observe the results, it might be an inexpensive entre' to what direction the county could take as protection.

Someone of course would have to defend against the overzealous effort of the Yolo Water Company, which would see this from a differing
perspective. Kent Wooldridge

Appendix E. Comments from peer reviewers on the Status Review report

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Fisheries Branch
830 S Street
Sacramento, CA 95811
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

January 13, 2014

Camm Swift
Retired, Natural History Museum of Los Angeles County
6465 Elmo Road
Cumming, GA 30028-4720

Dear Dr. Swift

CLEAR LAKE HITCH (*LAVINIA EXILICAUDA CHI*); DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW STATUS REPORT

Thank you for agreeing to serve as a scientific peer reviewer for the Department of Fish and Wildlife (Department) Draft Status Report of the Clear Lake hitch (*Lavinia exilicauda chi*). A copy of the Department's peer review draft status report, dated January 2014, is enclosed for your use in that review. The Department seeks your expert analysis and input regarding the scientific validity of the report and its assessment of the status of Clear Lake hitch in California based on the best scientific information currently available. The Department is interested in and respectfully requests that you focus your peer review effort on the body of relevant scientific information and the Department's assessment of the required population and life history elements prescribed in the California Endangered Species Act (CESA). The Department would appreciate receiving your peer review input on or before February 10, 2014.

The Department seeks your review as part of formal proceedings pending before the California Fish and Game Commission under CESA. As you may know, the Commission is a constitutionally established entity distinct from the Department, exercising exclusive statutory authority under CESA to list species as endangered or threatened. The Department serves in an advisory capacity during listing proceedings, charged by the Fish and Game Code to focus on the best scientific information available to make related recommendations to the Commission.

The Commission first received the petition to list Clear Lake hitch as threatened on September 25, 2012. The Commission accepted the petition for further consideration and the species was formally designated as a candidate species on March 22, 2013 following publication of regulatory notice by the Office of Administrative Law. The Clear Lake hitch is currently protected under CESA in California in that capacity.

The peer review Status Report forwarded to you today reflects the Department's effort over the past year to identify and analyze the best scientific information available regarding the status of Clear Lake hitch in California. Headed into peer review, the Department believes the best available science indicates that listing the species as threatened under CESA is warranted at this time. To be clear, we ask that you focus your review on the scientific information and the Department's related assessment of

your review on the scientific information and the Department's related assessment of the required population and life history elements prescribed in CESA rather than focusing on the tentative conclusion we share as a matter of professional courtesy. We underscore, however, that scientific peer review plays a critical role in the Department's effort to develop and finalize its recommendation to the Commission as required by the Fish and Game Code.

Again, because of the importance of your effort, we ask you to focus your review on the best scientific information available regarding the status of Clear Lake hitch in California. As with our own effort to date, your peer review of the science and analysis regarding each of the population and life history categories prescribed in CESA (*i.e.*, present or threatened habitat modification, overexploitation, predation, competition, disease, and other natural occurrences or human-related activities that could affect the species) are particularly important as well as whether they indicate, in your opinion, that Clear Lake hitch is likely to become, in the foreseeable future, at serious risk of becoming extinct throughout all or a significant portion of its range in California.

We ask that you assess our work for quality and conduct a thorough and proper review. As with all peer review processes, the reviewer is not the final arbiter, but your comments will inform our final decision-making. Also, please note that the Department releases this peer review report to you solely as part of the peer review process, and it is not yet public.

For ease of review, I invite you to use "track changes" in WORD, or provide comments in list form by page and line number of the report. Please submit your comments electronically to Kevin Thomas at kevin.thomas@wildlife.ca.gov, or he may be reached by telephone at (916) 358-2845.

If there is anything the Department can do to facilitate your review, please let me know. Thank you again for your contribution to the status review effort and the important input it provides during the Commission's related proceedings.

Sincerely,

Stafford Lehr
Chief, Fisheries Branch

Enclosure(s)

cc: Tina Bartlett
CDFW-NCR

CDFW-OGC

Katherine Hill
CDFW-NCR

Kevin Thomas
CDFW-NCR

Peer Review of: Preliminary Draft of "Status Review of Clear Lake Hitch (*Lavinia exilicauda chi*), January, 2014, Report to the Fish and Game Commission by Charlton H. Bonham, Director, California Fish and Wildlife

By Camm C. Swift, Ph.D., 10 February 2014

This report provides exhaustive support for the severe decline and justifies threatened or endangered status for the Clear Lake Hitch (CLH). Comments on the details of the report are given first, followed by more general discussion. References cited are given at the end only when referring to papers not cited in the Draft Report.

For a broader audience, I think the title should include the trailer "…a native minnow (Pisces, Cyprinidae) of California." The title of my early paper on the embryological development in this species left out the "…minnow (Pisces, Cyrinidae)…", and many times I have been asked, "What is a hitch, anyhow?"

p. 7, line 12-13, CLH can be separated from native minnows by having a higher anal ray count, which is technically accurate, but in my experience a mistake sometimes made in rapid field identifications is to confuse hitch with the non-native golden shiner because it also has a long anal fin. Apparently golden shiners were only in Clear Lake briefly in the late 1800s. But since they are widely sold as bait since becoming legal to raise and use for bait in California in 1955 (Moyle 2002), it would be surprising if they did not turn up in Clear Lake once in a while and maybe even frequently. The rise of bass fishing would have made these larger bait minnows popular. It makes me wonder whether some of the hitch records taken by commercial fishermen and the Vector Control surveys may have been golden shiners. In both cases the hitch were secondary to the objectives of the studies and less attention may have been paid to them as they were field identified and released. This would mean that the hitch themselves were even less common than the records indicate. However, apparently no records of golden shiner exist since 1896 (Thompson et al. 2013) which seems surprising.

It also seems surprising in retrospect that golden shiners did not "take" in Clear Lake since they like clear vegetated waters which were prevalent back then.

Page 7, line 27-32, Aguilar et al. 2009 and Hopkirk (1973) are credited with molecular (microsatellite) and morphological data, respectively, to support subspecific recognition. It is stated that mtDNA do not support it but no reference is given and such is needed here to support this statement. It is well known that microsatellite (nuclear) DNA provides stronger evidence of systematic differences than mitochondrial data.

P. 11, lines 21-33

Commercial data is given as catch (number of fish) per days [fished?] or times "operations occurred." Presumably the effort was not, or cannot be, better quantified, such as time fished, or hauls or net sets made, or some other indication. Did the commercial fishermen do more or less the same thing every time?

Similarly the observational data is apparently number of fish observed [in spawning creeks] by number of observation periods. Do we have any indication of length of these periods, or how much stream was observed on each occasion? Without moreinformation on how this data "looks" or was taken its hard to assess its value. (also on page 13, line 27-28).

Finally some similar questions about the LCVCDD is given as number of fish caught by year. It would seem that this effort may have been more quantified since they were after abundance data on silversides and shad. Like the number of hauls, or meters of shoreline seined, or something similar. No indication is given that this was the case, and perhaps it is not available, but would be valuable if it exists to make the estimates more quantitative. Although I guess they were staggered to be mostly after the hitch would have been in the areas targeted.

p. 12, Figure 2, is interesting, as noted in the text, in that the peaks and valleys of the various methods correspond which strengthens their validity as trends. Even the commercial peaks are delayed a year or so behind the LCVCDD ones as expected since the former would be adults from the younger cohorts sampled by the latter.

p. 13, lines 25-43, Good discussion of spawning tributaries and documentation of dramatic drop in tributaries utilized in the last 10 years or so, including a shift of the primary spawning from Kelsey to Adobe Creeks. This would seem to be a major change since Kelsey Creek is considered to have been the most, or nearly most, important stream for over 100 years. How does the amount and quality of habitat compare between the two systems? Also the drop from 12-13 tributaries to two or three in the last 10-15 years would seem to be a major reduction but is not quantified nor emphasized. Adobe Creek is a somewhat smaller drainage on the map but how do they compare in flow or water supply? What about the largest system (drainage coming in from the northwest? It is much larger than any of the others as illustrated on Figure 1. It would seem to have been a great loss if formerly utilized to the extent its size suggests. It seems like the number of tributaries lost could be strengthened by adding up the meters or kilometers of spawning/nursery habitat lost or something similar.

p. 14, line 1 onward, it is not clear to me why or how water quality conditions and lake depth influenced or make the LCVCD beach seine data less useful. Since they were designed (design not included here) to get at abundance of threadfin shad and Mississippi silversides, it would seem they would provide trend data for CLH also. Despite the fact they may not have been in the ideal season, habitat, or time of year, they did get CLH and if somehow regularly and consistently done should provide trends. The discussion suggests this latter may not be the case but does not exactly explain why, giving the impression that this possibly good source of data is being under-utilized. The fact that it corresponds, or is consistent with trends in the other catch data indicate it may be more useful than indicated.

p. 15, Fig. 4, catches by LCVCD mostly low, as expected from above, but peaks seem in or near particularly wet years, like 97-98, 2005-2006 but others not so much. There seems to be continued higher numbers after the 2005 wet year, possibly due to the end of commercial fishing. But the adults in spawning stream declined tremendously without corresponding data for the juveniles via LCVCD. Peaks in the commercial catch seem widely scattered and without correspondence to any data given.

One lack here is the data on other fish which may shed more light on trends. We are told that the numbers of shad and silversides parallels those of juvenile hitch somewhat, but also that non-native fish overwhelmingly dominated all three sources of catch data. Particularly the change in abundance of piscivores like black crappie, largemouth bass, channel catfish, sunfish might be instructive. Several observations in southern California have shown large numbers of YOY largemouth bass at the upper end of reservoirs as juvenile minnows and suckers are drifting or dispersing downstream and adults of these prey species being non-existent or very rare in those areas. This coincides with much more detailed work in the Colorado River (Arizona,Nevada, California) showing that non-native centrarchids strongly and negatively impact recruitment of native cyprinids and catostomids there by preying on larvae and small juveniles as they move into slow-moving marginal nursery areas. As (and if) they get larger and move into flowing water, they then become vulnerable to nocturnal catfish predators. See Minckley and Marsh (2009).

Data on these would shed more light on the possibility of these phenomena in Clear Lake.

p. 16, line 6, the sentence reads as if CDFW (called CDFG in many places in this report?) began sampling Clear Lake fishes in a regular way, but later we see that it is referring to four separate and disparate sampling events with purposes unrelated to CLH. In fact they were designed to avoid CLH as were the LCVCD samplings but with different methods. But they do document the relative rarity of CLH and overwhelming dominance of non-native species, but not what the other species are. The rarity is very significant for the purposes of this report since on line 28, CLH and other non-game fish were documented to be "…the bulk of the Clear Lake fishes…" up to 1972 and on p. 17 "…CLH [was] the third most common fish in the lake…" at that time, 1961-63.

p. 17, 19, clearly the fish has been highly impacted both by the lake being allowed to vary several feet (7.56) after building some kind of dam at the outlet, and stream changes, dams, etc. led to the loss of 92% of the spawning habitat. More information could be provided about the nature of the fluctuation related to historical fluctuations, apparently slight because of a permanent sill of some sort at the outlet. Unless evaporation exceeded inflow and allowed the lake to actually drop and dry up Putah Creek? These fluctuations may have impacted spawning success on gravel shores which perhaps was, or had become, more important as streams were compromised?

p. 24, line 42, it would seem clear and could be better emphasized that lead (Hg) levels are high enough to adversely impact hitch since they are documented to be at dangerous levels in fathead minnows. Fathead minnows are hardy (more tolerant to pollutants like lead), shorter-lived, and smaller fish than CLH. Thus CLH being longer-lived and larger would be expected to concentrate more Hg and also to be more sensitive to it as well.

p. 25, line 5, The outlawing of commercial catch for catfish may well have increased their ability to prey on other fish in the lake. Aggressive control of invasive catfishes in other systems has increased native sport fish populations. As noted (p. 26, lines 18,19) the lake has already lost Sacramento perch, splittail, and thicktail chub, and pikeminnow are greatly diminished in the lake (Thompson et al. 2013), undoubtedly for many of the same reasons proposed here for CLH. It is particularly surprising that blackfish have been extirpated since they are one of the few native fishes seemingly surviving in the southern San Joaquin Valley in face of large numbers of non-native game and forage fish. In Clear Lake, catfish could be preying on both sunfishes and larger hitch and the sunfish and juvenile bass prey on the smaller hitch.

p. 28, it was surprise to see that a 1988 creel census found CLH to be 2% of the sport catch, indicating they were still fairly common. Possibly local papers or newletters have some hunting and fishing columnists that might have some kind of continuing record of catches? Or local anglers?

p. 33 onward, Present or threatened modifications or destruction of habitat: This has been very well and convincingly covered. Only the possible effects of fluctuating lake levels might be slighted as noted above.

Overexploitation, seems an unlikely effect since the only evidence of major take of the species was back when it was very abundant. Even the only likely current exploiters, the local native Americans, seem to have largely reduced their take to just a few for ceremonial purposes. The 1988 creel survey indicated some exploitation and in the absence of golden shiners, they may be targeted as large bait for largemouth bass.

Predation, while this is entertained, lack of a smoking gun leaves predation by non-native fish under-appreciated for this species and place in this report. The effect of introduced centrarchids and ictalurids on native minnows and suckers has been well documented in analogous systems like the Colorado River (Minckley and Marsh 2009) and certainly must have had an effect here. This report makes them seem less important by restricting discussion to this one species, and only slightly noting the splittail, blackfish, and Sacramento Perch have all already been completely lost. It would be important to know how and why the hitch is able to hang on, perhaps like the pikeminnow, by residing partly in the streams? In any case given the history here and elsewhere with other species, survival may depend on actually fencing off some rearing areas for the juveniles to allow them to reach sufficient size to reduce predation. Largemouth bass breed relatively early and many juveniles could congregate near the stream mouths for the larvae and juvenile hitch coming downstream. This is in addition to larger bass feeding on the adults massing near the stream mouths during spring spawning migrations.

Competition also seems very likely since the food of silversides and gizzard shad are somewhat similar, but presumably little chance exists for limiting these two species at this point. No mention is made of zebra or other invasive mussels except for the mention of quagga mussel inspections. They seem virtually certain to show up, if not already, and could affect the dynamic of pelagic feeding species with their filtering effects on water quality. I did not see this addressed. I also did not note any mention of non-native crayfish or molluscs which infest many of California's waters. They could have an effect on egg survival if they prey on them, or by feeding the exotic predators that otherwise might not be as abundant.

Diseases, I do not know of any other disease factors that should be considered, but the introduction of other non-natives always has the potential of brining in other parasites and diseases. There must be pressure to bring in things like hybrid striped bass, etc that are being brought into other lakes at least in southern California.

Undoubtedly climate change will affect the lake, but parceling out effects specific to CLH is probably very conjectural and less likely to accomplish much compared to addressing the more direct known effects of habitat change and the mix of non-native species.

Page 37, Management recommendations are comprehensive and seem to cover all the things that need to be done to recover the species. Since it might be hard to do all of these soon, some prioritization could be in order. Adequate monitoring to establish population trends is a very important thing to establish as soon as possible. Improving habitat and managing predators are close behind as the most important adverse aspects affecting the species according to all the evidence. Given how dire the situation seems to be, identifying local refuges free of exotic predators could be a high priority also. Presumably two to four of these with several hundred fish each would maintain genetic diversity.

Overall this is a very comprehensive and detailed account that more than justifies special conservation status for the CLH. Hopefully many of the recommendations made here can be implemented to save the last few remnants of what was once a diverse native fish fauna.

Minckley, W. L. and P. Marsh. 2009. Inland fishes of the greater southwest. Chronicle of a vanishing biota.

Page	Line	Reviewer Comment	Department Response
1	Title	For a broader audience, I think the title should include the trailer "…a native minnow (Pisces, Cyprinidae) of California." The title of my early paper on the embryological development in this species left out the "…minnow (Pisces, Cyrinidae)…", and many times I have been asked, "What is a hitch, anyhow?"	No Change- The title is consistent with other species status reviews.
7	12-13	CLH can be separated from native minnows by having a higher anal ray count, which is technically accurate, but in my experience a mistake sometimes made in rapid field identifications is to confuse hitch with the non-native golden shiner because it also has a long anal fin. Apparently golden shiners were only in Clear Lake briefly in the late 1800s. But since they are widely sold as bait since becoming legal to raise and use for bait in California in 1955 (Moyle 2002), it would be surprising if they did not turn up in Clear Lake. It also seems surprising in retrospect that golden shiners did not "take" in Clear Lake since they like clear vegetated waters which were prevalent back then. once in a while and maybe even frequently. The rise of bass fishing would have made these larger bait minnows popular. It makes me wonder whether some of the hitch records taken by commercial fishermen and the Vector Control surveys may have been golden shiners. In both cases the hitch were secondary to the objectives of the studies and less attention may have been paid to them as they were field identified and released. This would mean that the hitch themselves were even less common than the records indicate. However, apparently no records of golden shiner exist since 1896 (Thompson et al. 2013) which seems surprising.	Noted- There is no indication that golden shiner would occur any more frequently in the commercial or seine records than they do in our standard survey efforts. Golden shiner are encountered every year in very small numbers and do not seem to be well established in the lake. Even if the were collected and incorrectly-identified based on other survey efforts they would not make up a large portion of the catch.
7	27-32	Aguilar et al. 2009 and Hopkirk (1973) are credited with molecular (microsatellite) and morphological data, respectively, to support subspecific recognition. It is stated that mtDNA do not support it but no reference is given and such is needed here to support this statement. It is well known that microsatellite (nuclear) DNA provides stronger evidence of systematic differences than mitochondrial data.	Accepted- reference added to document.
11	21-33	Commercial data is given as catch (number of fish) per days [fished?] or times "operations occurred." Presumably the effort was not, or cannot be, better quantified, such as time fished, or hauls or net sets made, or some other indication. Did the commercial fishermen do more or less the same thing every time?	Noted- All commercial data was recorded on data sheets that only required the date, location, and number of CLH captured.
11	21-33	Similarly the observational data is apparently number of fish observed [in spawning creeks] by number of observation periods. Do we have any indication of length of these periods, or how much stream was observed on each occasion? Without more information on how this data "looks" or was taken its hard to assess its value. (also on page 13, line 27-28).	Noted- Limitations of the observation data are discussed in the document. No data on duration of survey or survey reach length is available.
11	21-33	Finally some similar questions about the LCVCDD is given as number of fish caught by year. It would seem that this effort may have been more quantified since they were after abundance data on silversides and shad. Like the number of hauls, or meters of shoreline seined, or something similar. No indication is given that this was the case, and perhaps it is not available, but would be valuable if it exists to make the estimates more quantitative. Although I guess they were staggered to be mostly after the hitch would have been in the areas targeted.	Noted- Data was used in the format provided to the Department, additional information was not made available.
12	Figure 2	is interesting, as noted in the text, in that the peaks and valleys of the various methods correspond which strengthens their validity as trends. Even the commercial peaks are delayed a year or so behind the LCVCDD ones as expected since the former would be adults from the younger cohorts sampled by the latter.	Noted- This is what we would assume from the sampling methods, however no lengths were given with either the commercial or seine data to determine if juvenile or adult fish were captured.

13	25-43	Good discussion of spawning tributaries and documentation of dramatic drop in tributaries utilized in the last 10 years or so, including a shift of the primary spawning from Kelsey to Adobe Creeks. This would seem to be a major change since Kelsey Creek is considered to have been the most, or nearly most, important stream for over 100 years. How does the amount and quality of habitat compare between the two systems? Also the drop from 12-13 tributaries to two or three in the last 10-15 years would seem to be a major reduction but is not quantified nor emphasized. Adobe Creek is a somewhat smaller drainage on the map but how do they compare in flow or water supply? What about the largest system (drainage coming in from the northwest? It is much larger than any of the others as illustrated on Figure 1. It would seem to have been a great loss if formerly utilized to the extent its size suggests. It seems like the number of tributaries lost could be strengthened by adding up the meters or kilometers of spawning/nursery habitat lost or something similar.	Noted- A complete habitat assessment of all the spawning tributaries has not been completed. It is discussed ho the primary spawning tributary has switch from Kelsey to Adobe creek. The number of spawning tributaries has not dropped over the last ten years but rather fluctuated. The second lowest number was recorded in 2007 followed by several years of increased use until another drop in 2013. Additional information on spawning tributaries has been added to the document. Amount of lost spawning habitat is discussed in the Dams, Barriers, and Diversions section.
14	1 onward	it is not clear to me why or how water quality conditions and lake depth influenced or make the LCVCD beach seine data less useful. Since they were designed (design not included here) to get at abundance of threadfin shad and Mississippi silversides, it would seem they would provide trend data for CLH also. Despite the fact they may not have been in the ideal season, habitat, or time of year, they did get CLH and if somehow regularly and consistently done should provide trends. The discussion suggests this latter may not be the case but does not exactly explain why, giving the impression that this possibly good source of data is being under-utilized. The fact that it corresponds, or is consistent with trends in the other catch data indicate it may be more useful than indicated.	Accepted- the sentence has been reworded to reflect the desired intent of the original sentence.
15	Figure 4	catches by LCVCD mostly low, as expected from above, but peaks seem in or near particularly wet years, like 97-98, 2005-2006 but others not so much. There seems to be continued higher numbers after the 2005 wet year, possibly due to the end of commercial fishing. But the adults in spawning stream declined tremendously without corresponding data for the juveniles via LCVCD. Peaks in the commercial catch seem widely scattered and without correspondence to any data given.	Noted- the data sets available for the status review do not provide clear estimates of CLH populations. The only provide an glimpse into the fluctuating nature of the population.
15	Figure 4	One lack here is the data on other fish which may shed more light on trends. We are told that the numbers of shad and silversides parallels those of juvenile hitch somewhat, but also that non-native fish overwhelmingly dominated all three sources of catch data. Particularly the change in abundance of piscivores like black crappie, largemouth bass, channel catfish, sunfish might be instructive. Several observations in southern California have shown large numbers of YOY largemouth bass at the upper end of reservoirs as juvenile minnows and suckers are drifting or dispersing downstream and adults of these prey species being non-existent or very rare in those areas. This coincides with much more detailed work in the Colorado River (Arizona, Nevada, California) showing that non-native centrarchids strongly and negatively impact recruitment of native cyprinids and catostomids there by preying on larvae and small juveniles as they move into slow-moving marginal nursery areas. As (and if) they get larger and move into flowing water, they then become vulnerable to nocturnal catfish predators. See Minckley and Marsh (2009). Data on these would shed more light on the possibility of these phenomena in Clear Lake.	Noted- A comprehensive paper on the fish distribution as seen during the Department's general fish surveys conducted over the last ten years or so is currently being compiled.
16	6	the sentence reads as if CDFW (called CDFG in many places in this report?) began sampling Clear Lake fishes in a regular way, but later we see that it is referring to four separate and disparate sampling events with purposes unrelated to CLH. In fact they were designed to avoid CLH as were the LCVCD samplings but with different methods. But they do document the relative rarity of CLH and overwhelming dominance of non-native species, but not what the other species are. The rarity is very significant for the purposes of this report since on line 28, CLH and other non-game fish were documented to be "…the bulk of the Clear Lake fishes…" up to 1972 and on p. 17 "…CLH [was] the third most common fish in the lake…" at that time, 1961-63.	Noted- CDFG refers to references that were titled as the California Department of Fish and Game prior to the name change to the California Department of Fish and Wildlife. The paragraph was reworded to clarify the sampling regularity in question. The goal of the status review is to evaluate all existing data on CLH. Not all data allows for a specific conclusion to be drawn.

17,19	all	clearly the fish has been highly impacted both by the lake being allowed to vary several feet (7.56) after building some kind of dam at the outlet, and stream changes, dams, etc. led to the loss of 92% of the spawning habitat. More information could be provided about the nature of the fluctuation related to historical fluctuations, apparently slight because of a permanent sill of some sort at the outlet. Unless evaporation exceeded inflow and allowed the lake to actually drop and dry up Putah Creek? These fluctuations may have impacted spawning success on gravel shores which perhaps was, or had become, more important as streams were compromised?	Accepted- Additional information provided on lake levels.
24	42	it would seem clear and could be better emphasized that lead (Hg) levels are high enough to adversely impact hitch since they are documented to be at dangerous levels in fathead minnows. Fathead minnows are hardy (more tolerant to pollutants like lead), shorter-lived, and smaller fish than CLH. Thus CLH being longer-lived and larger would be expected to concentrate more Hg and also to be more sensitive to it as well.	Noted- without actual mercury contamination numbers for CLH the Department is satisfied with listing the possible biological impacts from mercury contamination. The paragraph concludes by saying it is reasonable to suspect CLH are experiencing effects of mercury contamination.
25	5	The outlawing of commercial catch for catfish may well have increased their ability to prey on other fish in the lake. Aggressive control of invasive catfishes in other systems has increased native sport fish populations. As noted (p. 26, lines 18,19) the lake has already lost Sacramento perch, splittail, and thicktail chub, and pikeminnow are greatly diminished in the lake (Thompson et al. 2013), undoubtedly for many of the same reasons proposed here for CLH. It is particularly surprising that blackfish have been extirpated since they are one of the few native fishes seemingly surviving in the southern San Joaquin Valley in face of large numbers of non-native game and forage fish. In Clear Lake, catfish could be preying on both sunfishes and larger hitch and the sunfish and juvenile bass prey on the smaller hitch.	Noted- There is no specific data to suggest that stopping catfish harvest resulted in a decrease in CLH numbers. However, it is reasonable to assume that commercial harvest of catfish could have beneficial impacts on CLH populations.
28	44	it was surprise to see that a 1988 creel census found CLH to be 2% of the sport catch, indicating they were still fairly common. Possibly local papers or newsletters have some hunting and fishing columnists that might have some kind of continuing record of catches? Or local anglers?	Noted- The Department receives incidental reports of CLH being captured by anglers. As noted in the management actions section the Department seeks to conduct more creel surveys to better understand the capture rates for all Clear Lake fishes.
33	onward	Present or threatened modifications or destruction of habitat: This has been very well and convincingly covered. Only the possible effects of fluctuating lake levels might be slighted as noted above.	Accepted- Additional information provided on lake levels.
33	onward	Overexploitation, seems an unlikely effect since the only evidence of major take of the species was back when it was very abundant. Even the only likely current exploiters, the local native Americans, seem to have largely reduced their take to just a few for ceremonial purposes. The 1988 creel survey indicated some exploitation and in the absence of golden shiners, they may be targeted as large bait for largemouth bass.	Noted- The Department does not feel that overexploitation is threatening the continued existence of CLH.
33	onward	Predation, while this is entertained, lack of a smoking gun leaves predation by non-native fish under-appreciated for this species and place in this report. The effect of introduced centrarchids and ictalurids on native minnows and suckers has been well documented in analogous systems like the Colorado River (Minckley and Marsh 2009) and certainly must have had an effect here. This report makes them seem less important by restricting discussion to this one species, and only slightly noting the splittail, blackfish, and Sacramento Perch have all already been completely lost. It would be important to know how and why the hitch is able to hang on, perhaps like the pikeminnow, by residing partly in the streams? In any case given the history here and elsewhere with other species, survival may depend on actually fencing off some rearing areas for the juveniles to allow them to reach sufficient size to reduce predation. Largemouth bass breed relatively early and many juveniles could congregate near the stream mouths for the larvae and juvenile hitch coming downstream. This is in addition to larger bass feeding on the adults massing near the stream mouths during spring spawning migrations.	Noted- This section provides a summary of the Predation section earlier in the document. There is little known about the predation rates of CLH by any species in Clear Lake. It will take further actions to determine the extent and possible actions to address this issue.

33	onward	Competition also seems very likely since the food of silversides and gizzard shad are somewhat similar, but presumably little chance exists for limiting these two species at this point. No mention is made of zebra or other invasive mussels except for the mention of quagga mussel inspections. They seem virtually certain to show up, if not already, and could affect the dynamic of pelagic feeding species with their filtering effects on water quality. I did not see this addressed. I also did not note any mention of non-native crayfish or molluscs which infest many of California's waters. They could have an effect on egg survival if they prey on them, or by feeding the exotic predators that otherwise might not be as abundant.	Noted- Competition from introduced fishes is impacting CLH. There is a need to understand the interactions for resources in the lake. Management actions are proposed to help address these issues.
33	onward	Diseases, I do not know of any other disease factors that should be considered, but the introduction of other non-natives always has the potential of brining in other parasites and diseases. There must be pressure to bring in things like hybrid striped bass, etc that are being brought into other lakes at least in southern California.	Noted- The Department has not received any requests for additional species to be added to Clear Lake.
33	onward	Undoubtedly climate change will affect the lake, but parceling out effects specific to CLH is probably very conjectural and less likely to accomplish much compared to addressing the more direct known effects of habitat change and the mix of non-native species.	Noted- Climate change impacts are based on models for climate change in California. Any impacts would need to be studied as climate change occurs in the coming years.
37	onward	Management recommendations are comprehensive and seem to cover all the things that need to be done to recover the species. Since it might be hard to do all of these soon, some prioritization could be in order. Adequate monitoring to establish population trends is a very important thing to establish as soon as possible. Improving habitat and managing predators are close behind as the most important adverse aspects affecting the species according to all the evidence. Given how dire the situation seems to be, identifying local refuges free of exotic predators could be a high priority also. Presumably two to four of these with several hundred fish each would maintain genetic diversity.	Noted- The Department will prioritize implementation of management actions based on available resources.

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Fisheries Branch
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EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

January 13, 2014

Gregory Giusti
Forest and Wildlands Ecology Advisor
University of California, Davis – Cooperative Extension
883 Lakeport Blvd
Lakeport, CA 95453

Dear Mr. Giusti

CLEAR LAKE HITCH (*LAVINIA EXILICAUDA CHI*); DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW STATUS REPORT

Thank you for agreeing to serve as a scientific peer reviewer for the Department of Fish and Wildlife (Department) Draft Status Report of the Clear Lake hitch (*Lavinia exilicauda chi*). A copy of the Department's peer review draft status report, dated January 2014, is enclosed for your use in that review. The Department seeks your expert analysis and input regarding the scientific validity of the report and its assessment of the status of Clear Lake hitch in California based on the best scientific information currently available. The Department is interested in and respectfully requests that you focus your peer review effort on the body of relevant scientific information and the Department's assessment of the required population and life history elements prescribed in the California Endangered Species Act (CESA). The Department would appreciate receiving your peer review input on or before February 10, 2014.

The Department seeks your review as part of formal proceedings pending before the California Fish and Game Commission under CESA. As you may know, the Commission is a constitutionally established entity distinct from the Department, exercising exclusive statutory authority under CESA to list species as endangered or threatened. The Department serves in an advisory capacity during listing proceedings, charged by the Fish and Game Code to focus on the best scientific information available to make related recommendations to the Commission.

The Commission first received the petition to list Clear Lake hitch as threatened on September 25, 2012. The Commission accepted the petition for further consideration and the species was formally designated as a candidate species on March 22, 2013 following publication of regulatory notice by the Office of Administrative Law. The Clear Lake hitch is currently protected under CESA in California in that capacity.

The peer review Status Report forwarded to you today reflects the Department's effort over the past year to identify and analyze the best scientific information available regarding the status of Clear Lake hitch in California. Headed into peer review, the Department believes the best available science indicates that listing the species as threatened under CESA is warranted at this time. To be clear, we ask that you focus

your review on the scientific information and the Department's related assessment of the required population and life history elements prescribed in CESA rather than focusing on the tentative conclusion we share as a matter of professional courtesy. We underscore, however, that scientific peer review plays a critical role in the Department's effort to develop and finalize its recommendation to the Commission as required by the Fish and Game Code.

Again, because of the importance of your effort, we ask you to focus your review on the best scientific information available regarding the status of Clear Lake hitch in California. As with our own effort to date, your peer review of the science and analysis regarding each of the population and life history categories prescribed in CESA (*i.e.*, present or threatened habitat modification, overexploitation, predation, competition, disease, and other natural occurrences or human-related activities that could affect the species) are particularly important as well as whether they indicate, in your opinion, that Clear Lake hitch is likely to become, in the foreseeable future, at serious risk of becoming extinct throughout all or a significant portion of its range in California.

We ask that you assess our work for quality and conduct a thorough and proper review. As with all peer review processes, the reviewer is not the final arbiter, but your comments will inform our final decision-making. Also, please note that the Department releases this peer review report to you solely as part of the peer review process, and it is not yet public.

For ease of review, I invite you to use "track changes" in WORD, or provide comments in list form by page and line number of the report. Please submit your comments electronically to Kevin Thomas at kevin.thomas@wildlife.ca.gov, or he may be reached by telephone at (916) 358-2845.

If there is anything the Department can do to facilitate your review, please let me know. Thank you again for your contribution to the status review effort and the important input it provides during the Commission's related proceedings.

Sincerely,

Stafford Lehr
Chief, Fisheries Branch

Enclosure(s)

cc: Tina Bartlett
CDFW-NCR

Thomas Gibson
CDFW-OGC

Katherine Hill
CDFW-NCR

Kevin Thomas
CDFW-NCR

State of California
Natural Resources Agency
Department of Fish and Wildlife

REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF CLEAR LAKE HITCH (*Lavinia exilicauda chi*)

January 2014 Preliminary Draft for Peer Review

Clear Lake hitch adult. Photo courtesy of Rick Macedo

Charlton H. Bonham, Director
Department of Fish and Wildlife

Report to the Fish and Game Commission

A STATUS REVIEW OF CLEAR LAKE HITCH

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EXECUTIVE SUMMARY

This status review report describes the current status of Clear Lake hitch (*Lavinia exilicauda chi*) (CLH) in California as informed by the scientific information available to the California Department of Fish and Wildlife (Department, CDFW, CDFG).

Background

- September 25, 2012: The Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity to list CLH as threatened under the California Endangered Species Act (CESA) (Center for Biological Diversity 2012).
- September 26, 2012: The Commission sent a memorandum to the Department, referring the petition to the Department for its evaluation.
- October 12, 2012: The Commission provided notice of the received petition from the Center for Biological Diversity to list CLH as threatened under CESA (Cal. Reg. Notice Register 2012, Vol. 41-Z, p.1502).
- December 12, 2012 the Commission granted a 30-day extension on the submission date for the Department's Initial Review of Petition to List the Clear Lake Hitch as threatened under CESA.
- January 31, 2013: The Department provided the Commission with an Initial Review of Petition to List the Clear Lake Hitch as Threatened under the California Endangered Species Act pursuant to Fish and Game Code, section 2073.5. The Department's review recommended that the petition provided sufficient information to indicate the petitioned action may be warranted, and the petition should be accepted and considered (CDFW 2013).
- March 6, 2013: At its scheduled public meeting in Mt. Shasta, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received by the Commission and found that the petition provided sufficient information to indicate the petitioned action may be warranted.
- March 22, 2013: The Commission published its Notice of Findings in the California Regulatory Notice Register (CA Reg. Notice Register 2013, Vol. 12-Z p. 488), stating the petition was accepted for consideration, and designated CLH as a candidate species.

Summary of Findings

Note to Reviewer: This Summary of Findings will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

Status

Threats

Petitioned Action

Management and Recovery Recommendations

INTRODUCTION

This status review report addresses the Clear Lake hitch (*Lavinia exilicauda chi*) (CLH), the subject of a petition to list the species as threatened under the California Endangered Species Act (CESA) (Fish & G. Code § 2050 *et seq*.).

Petition History

On September 25, 2012, the Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity (Petitioner) to list the CLH as a threatened species under CESA.

On September 26, 2012 the Commission sent a memorandum to the California Department of Fish and Wildlife (Department, CDFW, and CDFG) referring the petition to the Department for its evaluation.

On October 12, 2012, as required by Fish and Game Code, section 2073.3, notice of the petition was published in the California Notice Register (Cal. Reg. Notice Register 2012, Vol. 41-Z, p.1502).

On December 12, 2012 the Commission granted a 30-day extension on the submission date for the Department's Initial Review of Petition to List the CLH as threatened under CESA.

On January 31, 2013, the Department provided the Commission with its Initial Review of Petition to List the CLH as threatened under CESA. Pursuant to Fish and Game Code, section 2073.5, subdivision (a) (2), the Department recommended that the petition provided sufficient information to indicate the petitioned action may be warranted.

On March 6, 2013 at its scheduled public meeting in Mt. Shasta, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received, and found that sufficient information existed to indicate the petition may be warranted and accepted the petition for consideration.

Subsequently, on March 22, 2013 the Commission published its Notice of Findings for CLH in the California Regulatory Notice Register, designating the CLH as a candidate species (CA Reg. Notice Register 2013, Vol. 12-Z p. 488).

Department Review

Following the Commission's action to designate CLH as a candidate species, the Department notified affected and interested parties and solicited data and comments on the petitioned action, pursuant to Fish and Game Code, section 2074.4 (see also Cal. Code Regs., Title 14, § 670.1(f)(2)) (CDFW 2013). All comments received are included in Appendix D to this report. The Department commenced its review of the status of the species as required by Fish and Game Code section 2074.6.

This report reflects the Department's scientific assessment to date of the status of CLH in California. At this point, the report will undergo independent and competent peer review by scientists with acknowledged expertise relevant to the status of CLH. Once peer review is completed Appendix E will contain the specific input provided to the Department by the individual peer reviewers (Cal. Code Regs., Title 14, § 670.1(f) (2)).

BIOLOGY

Species Description

Clear Lake hitch is a member of the cyprinid family (Cyprinidae), growing to 35 centimeters (cm) standard length (SL), and with laterally compressed bodies, small heads and upward pointing mouths (Moyle et al. 1995). They are separated from other California minnows by their long anal fin consisting of 11 to 14 rays. The dorsal fin (10 to 12 rays) originates behind the origin of the pelvic fins. Juvenile CLH have a silver coloration with a black spot at the base of the tail. As CLH grow older the spot is lost and they appear yellow-brown to silvery-white on the back. The body becomes deeper in color as the length increases (Hopkirk 1973; Moyle 2002). CLH show little change in pigmentation during the breeding season (Hopkirk 1973). The deep, compressed body, small upturned mouth, and numerous long slender gill rakers (26 to 32) reflect the zooplankton-feeding strategy of a limnetic forager (Moyle 2002). This lake adapted subspecies also has larger eyes and larger scales than other hitch subspecies.

Comment [GG1]: Hopkirk felt that the compressed body differentiated the lake ssp. from riverine ssp. You may want to identify that point as well.

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Taxonomy

Hopkirk (1973) described CLH as a lake-adapted subspecies based primarily on the greater number of fine gill rakers. CLH are distinguished from other subspecies of hitch by their deeper body, larger eyes, larger scales and more gill rakers (Hopkirk 1973). Recent research on 10 microsatellite loci supports Hopkirk's description of CLH as a distinct subspecies (Aguilar et al. 2009). However, mitochondrial DNA analysis has not been able to distinguish CLH as a distinct subspecies from other hitch in California. Yet, based upon the morphological and microsatellite analysis there is sufficient evidence to warrant the designation of CLH as a distinct subspecies of hitch (Hopkirk 1973; Moyle et al. 1995; Aguilar et al. 2009).

Comment [GG2]: You just addressed my previous point.

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Comment [GG3]: Do you have a citation for this?

CLH can hybridize with other Cyprinidae species and hybridization is known to occur with the genetically similar California roach (*Lavinia symmetricus*) (Miller 1945b; Avise and Ayala 1976; Moyle and Massingill 1981; Moyle et al. *in review*). However, there is no documentation of these hybrids in Clear Lake. CLH were known to hybridize in Clear Lake with the now extinct thicktail chub (*Gila crassicauda*) (Moyle et al. *in review*).

Range and Distribution

The entire CLH population is confined to Clear Lake, Lake County, California, and to associated lakes and ponds within the Clear Lake watershed such as Thurston Lake and Lampson Pond (Figure 1). Populations previously identified in the Blue Lakes, west of Clear Lake, have apparently been extirpated (Macedo 1994).

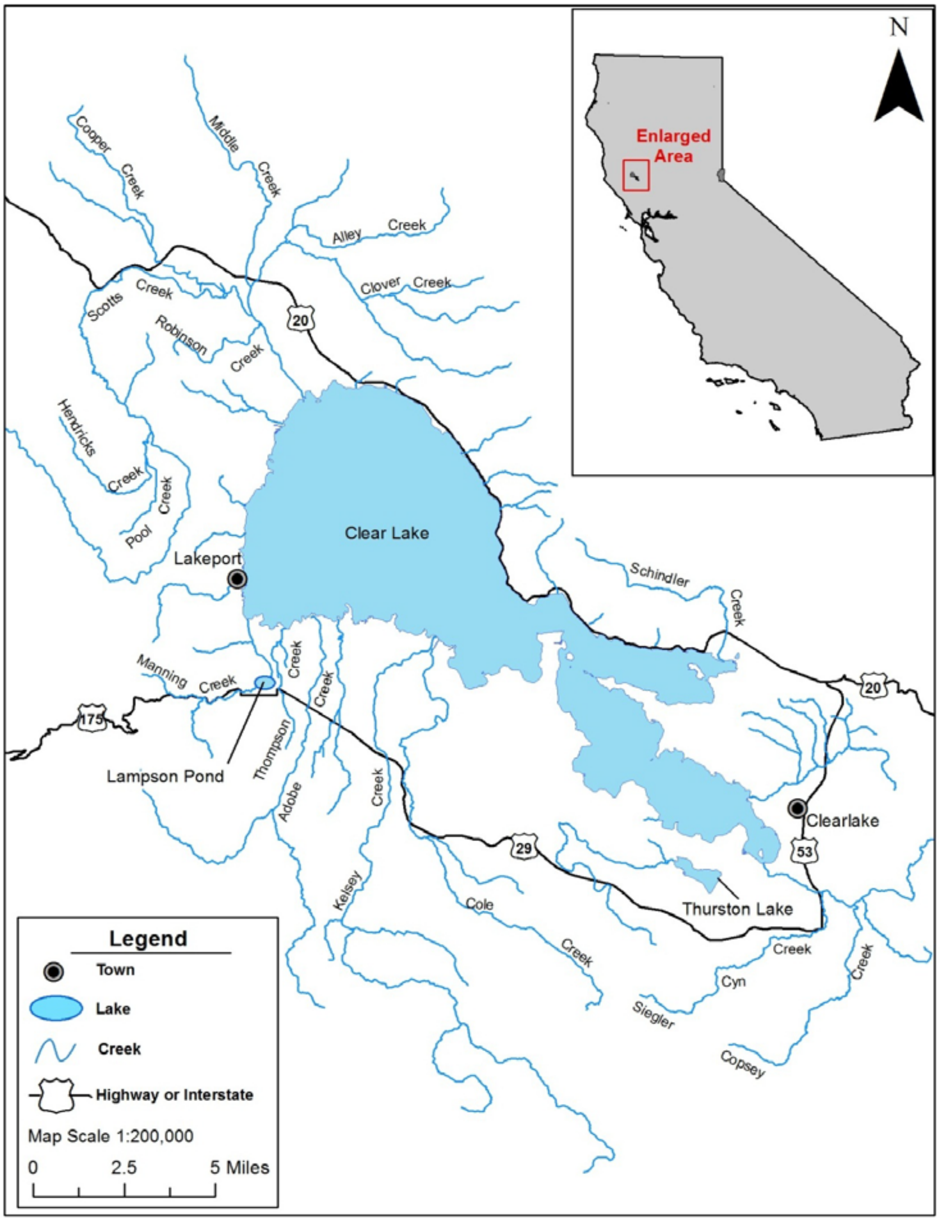

Figure 1. Map depicting the Clear Lake watershed.

Life History

Physical adaptations to lake conditions allow CLH greater than 50 millimeters (mm) SL to feed almost exclusively on water fleas (*Daphnia* spp.) (Geary 1978; Geary and Moyle 1980; Moyle 2002). Stomach analysis indicates that CLH feed primarily in the day rather than at night (Geary 1978). Juveniles less than 50 mm SL are found in shallow, littoral zone (near-shore) waters and feed primarily on the larvae and pupae of chironomidae; planktonic crustaceans including the genera *Bosnia* and *Daphnia*; and historically on the eggs, larvae, and adults of Clear Lake gnat (*Chaoborus astictopus*) (Lindquist et al. 1943; Geary 1978; Geary and Moyle 1980). Growth in CLH is faster and total size greater than that of other hitch subspecies (Nicola 1974). By three months CLH have reached 44 mm SL and will continue to grow to between 80 to 120 mm by the end of their first year (Geary and Moyle 1980). Females become mature by their second or third year, whereas males tend to mature in their first or second year (Kimsey 1960). Females grow faster and are larger at maturity than males (Hopkirk 1973; Geary 1978; Ringelberg and McGinnis 2009). The larger size of CLH in comparison to hitch from other locations translates to greater fecundity. Accordingly, spawning females in Clear Lake average 36,000 eggs each year (Geary and Moyle 1980) compared to an average of 26,000 eggs for hitch in Beardsley Reservoir (Nicola 1974).

Clear Lake tributaries are numerous and located around the lake basin (Figure 1). Most streams have headwaters at higher elevations in the surrounding foothills; others have headwaters in lower elevations of the basin, and nearly all have of low gradients prior to entering the lake. Some streams are more substantial than others with flowing water year round. Most are seasonal with remnant pools occurring by late spring, and subsequently dry during summer months. Those that retain water year round often have long stream reaches that are ephemeral. CLH spawn in these low-gradient tributary streams and form spawning migrations that resemble salmonid ~~small scale salmon~~ runs. Spawning migrations usually occur in response to heavy spring rains, from mid-February through May and occasionally into June (Murphy 1948b; Kimsey 1960; Swift 1965; Chi Council for Clear Lake Hitch (CCCLH) 2013 (unpublished data)). During wet years, CLH spawning migrations may also opportunistically extend into the upper reaches of various small tributaries, drainage ditches, and even flooded meadows (Moyle et al. *in review*). CLH have also been observed spawning along the shores of Clear Lake, over clean gravel in water 1 to 10 cm deep where wave action cleans the gravel of silt (Kimsey 1960). The success of these atypical spawning areas is not clearly understood and may be limited due to losses from egg desiccation and juvenile predation (Kimsey 1960; Rowan, J. personal communication, October 10, 2013, unreferenced).

CLH spawn at water temperatures of 14 to 18°C in the lower reaches of tributaries. Egg deposition occurs along the margins of streams in very shallow riffles over clean, fine-to-medium sized gravel (Murphy 1948b; Kimsey 1960). Eggs are fertilized by one to five males as they are released from the females (Murphy 1948b; Moyle 2002). Eggs are non-adhesive and sink to the bottom after fertilization, where they become lodged among the interstices in the gravel. The eggs immediately begin to absorb water and swell to more than double their original size. This rapid expansion provides a protective

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Comment [GG4]: I'm not sure about this. This may be true in the headwater regions of Kelsey Creek, Cole Creek and possibility others, but I believe surface water is found beyond the reach of hitch.

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cushion of water between the outer membrane and the developing embryo (Swift 1965) and may help to secure eggs in gravel interstices. The embryos hatch after approximately 7 days, and larvae become free-swimming after another 7 days (Swift 1965). Larvae must then move downstream to the lake before stream flows become ephemeral (Moyle 2002).

Within Clear Lake, larvae remain near shore and are thought to depend upon stands of tules (*Schoenoplectus acutus*) and submerged weeds for cover until they assume a limnetic lifestyle (CDFG 2012). Juvenile CLH require rearing habitat with water temperatures of 15° C or greater for survival (Moyle 2002; Franson 2012 and 2013). Juveniles are found in littoral shallow-water habitats and move into deeper offshore areas after approximately 80 days, when they are between 40 to 50 mm SL (Geary 1978; CDFG 2012). Adult CLH are usually found in the limnetic zone (well-lit, surface waters away from shore) of Clear Lake. The limnetic feeding behavior of adult fish is supported by stomach analysis of CLH where very little content of benthic midges was found, even though the fish were collected in the profundal (deep-water) habitat during the survey (Cook et al. 1964). Additional data collected by the Department during the early 1980s indicates CLH are present in the littoral zone from April to July and are absent from this habitat during other months (Week 1982).

Adult CLH are vulnerable to predation during their spawning migration by mergansers (*Mergus* spp.), herons (*Ardea* spp.), bald eagles (*Haliaeetus leucocephalus*), and other birds, river otter (*Lontra canadensis*), northern raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*) (Bairrington 1999). In addition, CLH have been recovered from the stomachs of black bass (*Micropterus* spp.) caught in the lake (Bairrington 1999). Most predation by black bass likely occurs during spring staging periods as CLH congregate and begin to ascend tributaries to spawn (Rowan, J. personal communication, October 10, 2013, unreferenced).

Comment [GG5]: Should we list other fish species e.g. catfish, other centrarchids?

Habitat that May be Essential to the Continued Existence of the Species

At various life stages CLH utilize stream and lacustrine (lake) habitat present in the watershed (Figure 1). Adult fish spawn in the tributaries of the lake during the spring and juvenile fish emerge from the tributaries and utilize near shore habitats to continue growth and seek refuge from predators. As juveniles mature into adults they move to the main body of the lake and assume a limnetic lifestyle until returning to spawn in the tributaries the following spring.

SPECIES STATUS AND POPULATION TRENDS

An assessment of the status of CLH should include statistically valid population estimates conducted over time, to provide population data and trends. CLH studies to date have consisted primarily of qualitative sampling and are not suitable for deriving population estimates; however, these study results can provide insight into the current status of the species.

The population trends for this status review focus on three sets of data available to the Department for analysis. First, commercial catch records, submitted to the department by operators on Clear Lake, contain incidental catch information on CLH dating back to 1961. Operators were required to keep records of CLH caught incidentally while operations focused on other species in the lake. Second, the Lake County Vector Control District (LCVCD) has been conducting sampling efforts along the shoreline of Clear Lake since 1987. Although sampling efforts are not specific to CLH, LCVCD recorded incidental data on CLH captured during each sampling. Third, spawning observation data have been collected by volunteers with the CCCLH since 2005. Spawning observation data provide an estimate of the number of CLH in any given spawning tributary during the observation period. Results are summarized by the CCCLH each year following the completion of the spawning season. Information on population trends prior to 1961 is focused on small sampling efforts, published articles, and traditional ecological knowledge from tribal members. Although not quantifiable, this data provides an idea of the status and distribution of CLH prior to larger qualitative sampling efforts.

Comment [GG6]: I think you should spell this out the first time.

Environmental conditions required for successful spawning and biological impacts to the survivorship of CLH are highly variable from year to year and often result in multiple years with reduced spawning success or reduced recruitment into the population. The information presented in Figure 2 comes from the three qualitative sampling efforts conducted at Clear Lake and measured rainfall totals during the past 52 years in the watershed. Trend data in commercial catch records were represented for a given year by totaling the number of CLH captured per year and dividing by the number of days commercial operations occurred. Commercial catch data are comprised primarily of adult CLH. The CLH spawning trend data were calculated by totaling the number of CLH observed and dividing by the number of observation periods. LCVCD data on CLH captures represent the total number of CLH captured per year. LCVCD data is comprised primarily of juvenile CLH. The data represented from Table 6 of CDFG (1999) were calculated by using 20,000 as a total catch baseline for percent of total catch for CLH. Total rainfall data for January to June of each year was measured at the Clear Lake Highlands and U.S. Geological Survey rainfall gauges. Figure 2 does not reflect population numbers but rather trends in the abundance of CLH in any given year. As a proxy for changes in an established population size, biologists often use qualitative information as an indicator of population trends.

Comment [GG7]: I know what your intention is here but we really don't have "spawning success" data i.e. fecundity numbers. Maybe "reduced number of adults observed" or something similar. None of the counts include night time observations.

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Comment [GG8]: You might want to consider a line that identifies turbidity following a rain can affect observation data collection. Simply to identify another variable.

The trends of all data show a highly variable population that responds both positively and negatively to environmental parameters and varies significantly from year to year. Rainfall totals do not appear to be significantly correlated to the abundance of CLH during the timeframe. It is likely that a combination of environmental factors is impacting the CLH population. The fluctuating abundance trend has continued throughout the duration of the qualitative sampling efforts and indicates CLH populations have at times been extremely low and at other times relatively robust.

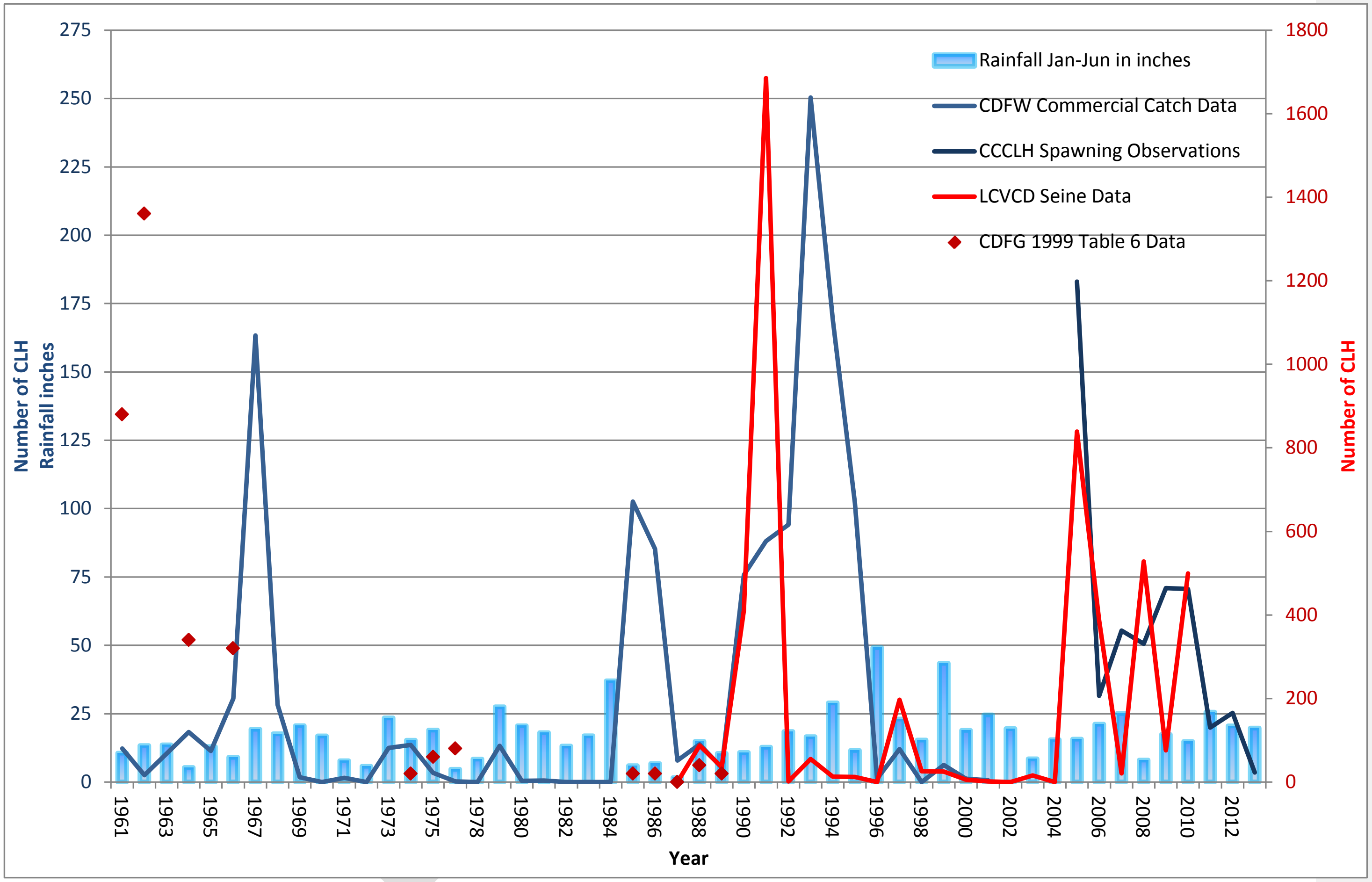

Figure 2. Clear Lake hitch population trends over the past 52 years as measured by three methods of qualitative sampling and spawning season rainfall totals as recorded at the Clear Lake Highlands and U.S. Geological Survey 385525122335501 rainfall gauges. Data in blue tones corresponds to the primary y axis and data in red tones corresponds to the secondary y axis.

In 2013 the Department conducted a mark-and-recapture study to gain a better understanding of the CLH spawning population in Cole and Kelsey creeks. Unfortunately, too few individuals were marked and recaptured to give a statistically valid population estimate (Ewing 2013). Electrofishing surveys in June 2012 identified thousands of young of year CLH in near shore habitats along the southwestern shoreline of Clear Lake (CDFG 2012). Volunteers with the CCCLH conducted direct observations of CLH in spawning tributaries of Clear Lake in 2013, and spawning observations identified less than 500 CLH present (CCCLH 2013). Of those fish, 300 to 400 were found below the Kelsey Creek detention dam. No single day count totaled more than 70 fish in any spawning tributary in 2013 (CCCLH 2013).

CCCLH qualitative spawning observations between 2005 and 2013 indicated peak single day CLH spawning runs of 1,000 to 5,000 fish (CCCLH 2013), and daily observation averages ranged from 3.5 to 183.1 fish (Figure 2). However, these observations make no distinction between previously counted fish, and it may be more prudent to look at fixed location single day counts from this time period. The highest number of CLH observations recorded was approximately 5,000 during 2005; concurring with beach seine data that demonstrate a higher than average number of CLH caught in 2005 as well (CCCLH 2013; LCVCD 2013). The increased number of juvenile CLH captured in the 2005 beach seine sampling is the likely reason for the increase in adult spawning observations between 2007 and 2009. Appendix A contains summary graphs and figures, prepared by CCCLH, for observations made between 2005 and 2013.

Comment [GG9]: Good point.

There is sufficient information from these spawning observations to suggest the number of spawning tributaries being used by CLH decreased in 2013 compared to the average from 2005 to 2012 (Figure 3) (CCCLH 2013). However, the data limitations do not allow for quantification of observation time on each creek (survey effort) compared with the number of fish observed to aid in understanding the extent of use in each tributary. Appendix B contains figures depicting the decline in annual spawning runs in Clear Lake tributaries between 2005 and 2013 (CCCLH 2013). Historic accounts and habitat suitability predications suggest that CLH originally spawned, to some degree, in all the tributaries to Clear Lake (Robinson Rancheria Ecological Center (RREC) 2011). However, reports on Pomo geography speak of Pomo tribes in the area travelling to Kelsey Creek to capture CLH and even of war when a tribe tried to divert Kelsey Creek to gain control of the important CLH supply (Barrett 1906; Kniffen 1939). Based on the reports it is unclear to what extent CLH spawned in other tributaries to Clear Lake. It can be surmised the majority of CLH spawning occurred in Kelsey Creek during this period. Over the past eight years the number of occupied spawning tributaries has decreased from a high of 12 in 2006 to three in 2013 (CCCLH 2013). Currently, Adobe Creek seems to have the largest spawning run in the Clear Lake watershed while Kelsey and Cole creeks support smaller spawning runs. Based on historical accounts the primary spawning tributary has shifted from Kelsey Creek to Adobe Creek (Kniffen 1939; CCCLH 2013).

Comment [GG10]: More than fish numbers, I think this is a salient point. Trend analysis is more important that a single year data point due to the lack of flow in many historic spawning tribs in 2013.

Comment [GG11]: Does this identify a need to better quantify and standardize a protocol to estimate annual fish migration numbers?

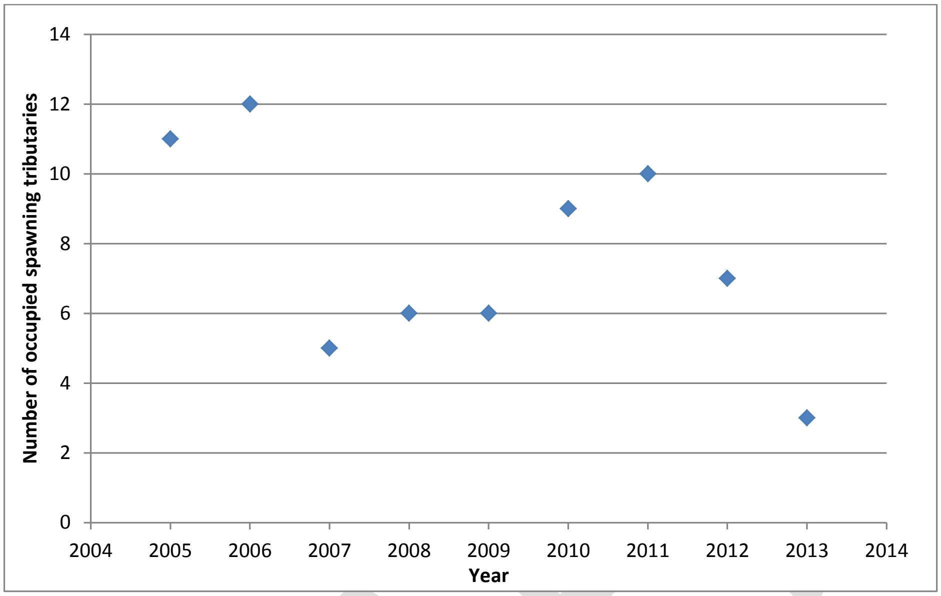

Figure 3. Number of occupied Clear Lake hitch spawning tributaries documented by CCCLH observers between 2005 and 2013.

LCVCD has been collecting beach seine data at various sites around the lake for more than two decades. The sampling is designed to measure abundance of threadfin shad (*Dorosoma petenense*) and inland silversides (*Menidia beryllina*) as part of a Clear Lake gnat (*Chaoborus astictopus*) surveillance program. Incidental captures of CLH are recorded during these surveys; however, the data collected are not appropriate for a statistically valid evaluation of CLH populations as the sample design varies significantly in timing, water quality conditions, and lake depth during surveys. Additionally, sample locations are in areas that contain open unvegetated beaches that are not preferred habitat for CLH. Although surveys were not conducted to assess CLH, capture data for these surveys is consistent with other data sources in demonstrating a population that has poor recruitment in many years interspersed with few years of high levels of recruitment (Figure 4) (LCVCD 2013). In most years less than 100 CLH are captured during the surveys (17 of 24 years). Four of the six years when more than 100 CLH were captured were between 2005 and 2010. The greatest numbers of CLH were captured in 1991, a year that was described by the Department as a boom for juvenile fish in the lake (Bairrington 1999). Commercial fisheries data from 1991 also indicate an increase in CLH numbers captured during operations; over 6,000 CLH were captured and released by commercial fishery operators between March and May in 1991 (CDFW Commercial Fisheries Data). Data from the early 1990s also indicate an increase in zooplankton and macroinvertebrate numbers resulting in increased available forage for CLH (Winder et al. 2010).

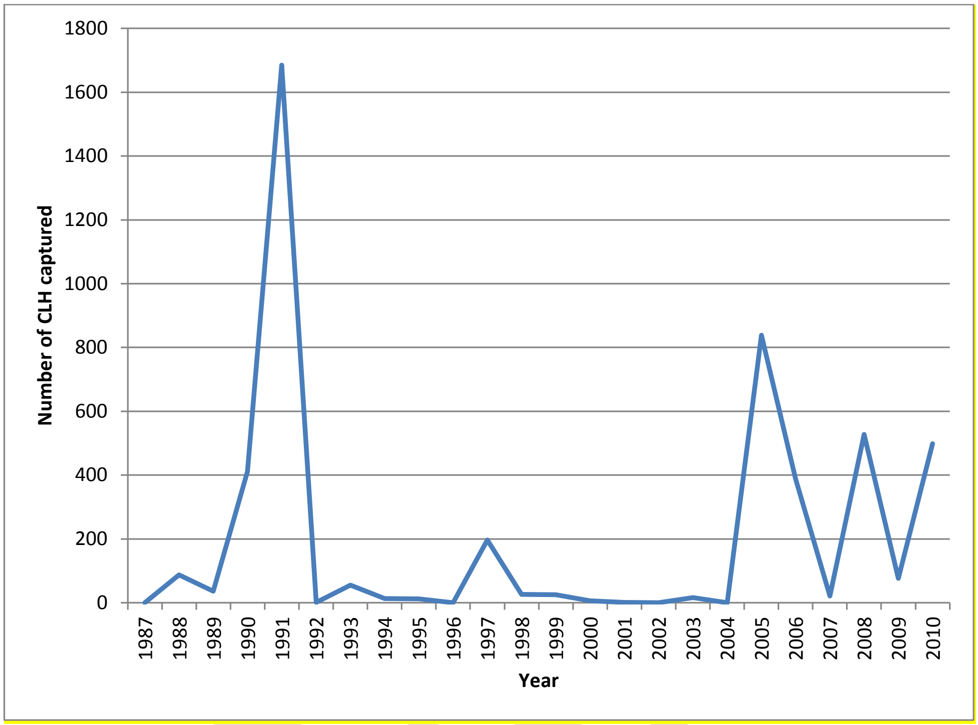

Figure 4. Summary of Clear Lake hitch captured during Lake County Vector Control District beach seine surveys conducted from 1987 to 2010.

The data available to the Department that cover the greatest timeframe come from commercial harvest records for Clear Lake. These data, 1961 to 2001, provide estimates of CLH numbers captured incidentally during operations (Figure 5). Multiple times throughout the past 50 years the number of CLH captured has surpassed 10,000 fish. There are also several years where CLH were almost or entirely absent from sample collections. These data suggest that CLH can sustain a population through multiple years of suppressed spawning or recruitment or both.

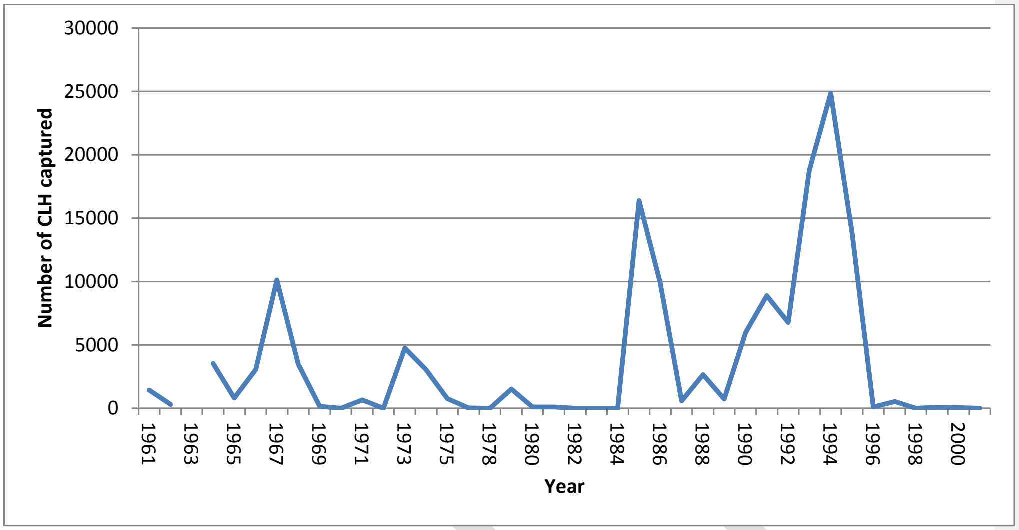

Figure 5. Number of Clear Lake hitch captured incidentally during commercial harvest operations between 1961 and 2001.

In the 1980s, the Department began sampling Clear Lake fishes to assess native and sport fish populations in the lake. Surveys found CLH occupying littoral habitats between April and July each year (Week 1982). The surveys were directed towards littoral zone use and provide no information on CLH outside of those months (Week 1982). An electrofishing survey was completed in April of 1987, and CLH was the most abundant fish sampled at locations around Rattlesnake Island and Clearlake Oaks subdivision; however, only a total of 52 CLH were captured during the survey (CDFG 1988). It must be noted that this sampling was on a very small scale, targeted black crappie (*Pomoxis nigromaculatus*), and occurred in habitats where CLH would likely be found during this time period. Additional spring and fall sampling between 1995 and 2006 found CLH to be the most abundant native fish, but the overall capture numbers were relatively low with a peak catch per unit effort (CPUE) of only 0.087 for juvenile fish in the fall of 2000 and 0.169 for adult fish in the spring of 1999. CPUE's were based on the number of fish caught per minute of electrofishing (Cox 2007). Electrofishing surveys conducted during late June 2007 reported low numbers of CLH recorded during the survey (Rowan 2008). The low numbers of CLH may be attributed to the sampling timeframe in late June. As noted in Cook et al. 1964, CLH were absent from littoral zone sampling following the start of summer. In an effort to reduce impacts to CLH while sampling, the Department's Clear Lake surveys between 2008 and 2012 were all confined to the timeframe of late June and July when CLH numbers are greatly reduced in the littoral zone.

Comment [GG12]: I know this is the information that is available but each anecdotal point is qualified that CLH would have been incidental to the effort. What is one to deduce from this?

As late as 1972, CLH and other nongame fish were described as comprising the bulk of the Clear Lake fishery (Puckett 1972). The Lake County Mosquito Abatement District conducted surveys between 1961 and 1963 examining the relationship between fish and midges. These surveys identified CLH as the third most abundant fish in the lake.

The majority of CLH were captured in the littoral and profundal zones using gill nets. However, the limnetic zone was not sampled since midges do not occur in this area. A total of 1,229 fish was taken during these surveys (Cook et al. 1964).

Comment [GG13]: This last paragraph is good information.

Field notes from CDFG biologists in 1955 note CLH runs with large numbers in Kelsey Creek (CDFG 1955). Similar notes from 1956 indicate spawning CLH in Kelsey Creek as numbering in the hundreds and Seigler Creek containing 400 CLH for every 100 feet of stream above the Anderson Brothers ford (CDFG 1956). CLH were the second most abundant fish caught during various gill net surveys in the lake at that time (Lindquist et al. 1943). Surveys conducted between 1938 and 1941, for examination of fish and gnat interactions, describe the runs of Sacramento splittail (*Ptychocheilus grandis*) and CLH as numbering in the tens of thousands (Lindquist et al. 1943). A photograph from 1890 depicts a spawning run so thick that CLH formed a blanket across the creek (Figure 6). Early stories from the area describe fish runs so thick that streams were difficult to ford by horses and wagons, and residents shoveled spawning fish to bring home for hog feed (Rideout 1899). The volume of dead fish found during spawning runs on Clear Lake tributaries created a stench that was intolerable to lakeshore residents (Dill and Cordone 1997). It is not entirely clear if spawning runs such as those depicted in Figure 6 occurred every year or fluctuated based on tributary flows, but it is likely they fluctuated in a similar fashion to what was observed during the past decade of CCCLH spawning surveys. Regardless, the body of evidence lends support for claims of CLH as common and the most abundant fish in Clear Lake during the late nineteenth and early twentieth centuries (Coleman 1930; Jordan and Gilbert 1894).

Comment [GG14]: There is some local discrepancy about this picture. The image is certainly of cyprinids, but there is some dispute as to the species.

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Comment [GG15]: This is all good information. It strikes me as out of place. Might it be better placed earlier in the document to provide a historical perspective followed by the information provided by Chi Council and Vector Control?

Figure 6. Photo from 1890s depicting spawning CLH being stranded in Kelsey Creek.

FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE

Present or Threatened Modification or Destruction of Habitat

Wetland Habitat Loss

Wetlands provide critical rearing habitat for juvenile fishes native to Clear Lake (Geary 1978; CDFG 2012). Prior to the arrival of European settlers in the mid-1800s, Clear Lake was surrounded by large tracts of wetlands. Throughout the expansion of European settlements around the lake, the wetland habitat was drained and filled to provide urban and agricultural lands. Currently, the Clear Lake watershed contains over 16,000 acres of land dedicated to agricultural production (Lake County Department of Agriculture 2011; Forsgen Associates Inc. 2012). Comparisons of historical versus current wetland habitat reveal a loss of approximately 85%, from 9,000 acres in 1840 to 1,500 acres by 1977 (Week 1982; Bairrington 1999; Suchanek et al. 2002; ; Lake County Department of Public Works 2003; Giusti 2009; CEPA 2012). Loss of wetland habitat coupled with competition for existing habitat with introduced fishes has led to a decline in available rearing habitat for juvenile CLH (Week 1982).

Comment [GG16]: Not all of these acres represent converted wetlands, though some operations could potentially impact "wetland function".

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Spawning Habitat Exclusion and Loss

Dams, Barriers, and Diversions

Cache Creek Dam was constructed at the outlet of Clear Lake in 1915, and Yolo County Flood Control and Water Conservation District (YCFCWCD) manipulates the lake water level several feet seasonally to allow for diversions for irrigation (CDWR 1975). Clear Lake is allowed to fluctuate on a yearly basis, a maximum of 7.56 feet above a mean level plane referred to as the "Rumsey gage" (CDWR 1975). The effects of lake water manipulations on CLH populations have not been quantified. Manipulation of water levels in the Clear Lake watershed likely results in decreased water quality, a reduction in spawning and rearing habitat, and increased risk of predation (Converse et al. 1998; Wetzel 2001; Gafny et al. 2006; Cott et al. 2008; Hudon et al 2009). All of these impacts can lead to the extinction of native species that evolved in lakes free of habitat modifications resulting from impoundment structures (Wetzel 2001). Impounded systems also tend to be dominated by non-native species (Moyle and Light 1996).

CLH spawn in low-gradient tributary streams to Clear Lake. All of the tributary streams to Clear Lake have been altered (Appendix C) to various degrees by dams, barriers, and diversions. Stream alterations can block migratory routes and decrease stream flows necessary for spawning. The result can be loss of spawning and rearing habitat, loss of nursery areas, increases in predation, competition from non-native aquatic species, and decreased water quality (Murphy 1948 and 1951; Moyle 2002;). A limited physical habitat analysis survey was conducted in 2013 on Adobe, Kelsey, Manning, Middle, and Scotts creeks. Results of the survey indicate all of the creeks had low Index of Biological Integrity (IBI) scores and are either partially or not supportive of aquatic life (Mosley 2013). Examples of alterations to Clear Lake tributaries that have impacted CLH include agricultural irrigation pumps and diversions, aggregate mining activity, flood control structures, road crossings, bridge aprons, and off-highway vehicle (OHV) use (McGinnis and Ringelberg 2008).

Adobe Creek, Highland Creek, Middle Creek, Clover Creek, and Kelsey Creek have experienced a reduction in fish spawning habitat since the installation of dams and increased irrigation (Murphy 1951; Macedo 1994; McGinnis and Ringelberg 2006). A barrier assessment was completed in 2006 for Middle Creek and the Kelsey Creek fish ladder (McGinnis and Ringelberg 2006). The assessment found physical barriers to fish migration were associated with bridge aprons and weirs as well as habitat barriers from historical gravel operations (McGinnis and Ringelberg 2006). The Kelsey Creek fish ladder was found unsuitable for passage of CLH. The jump heights and velocities at the ladder were determined to be too great for CLH (McGinnis and Ringelberg 2006). Spawning observations by CCCLH from 2005 to 2013 witnessed fish stranded below multiple barriers within the watershed (CCCLH 2013).

Many Clear Lake tributaries are no longer used for spawning or have reduced spawning runs as a result of artificial structures that continue to impede spawning migrations (Figure 7). While some operational and physical modifications to these structures have been implemented over the years, they continue to adversely impact spawning CLH, especially during dry years when spring stream flows are low.

In preparation of this report, the Department estimated the loss of CLH spawning and rearing habitat due to constructed barriers and impediments within the tributaries to Clear Lake (Figure 7). The barrier assessment determined the approximate locations of barriers and estimated miles of stream habitat as determined from the California Native Diversity Database, CDFW Geographic Information System, CDFW Fish Passage Assessment Database, California GIS street layer, and Google Earth Maps. Using that data, the Department estimated 180 river miles were historically available to spawning CLH and that barriers have eliminated or reduced access to greater than 92% of the historically available spawning habitat. Physical barriers, such as the footings of bridges, low water crossings, dams, pipes, culverts, and water diversions in Kelsey, Scotts, Middle, Clover, and other creeks interrupt or eliminate migration to spawning areas (McGinnis and Ringelberg 2008). Appendix C contains a list of several tributaries and some of their associated barriers.

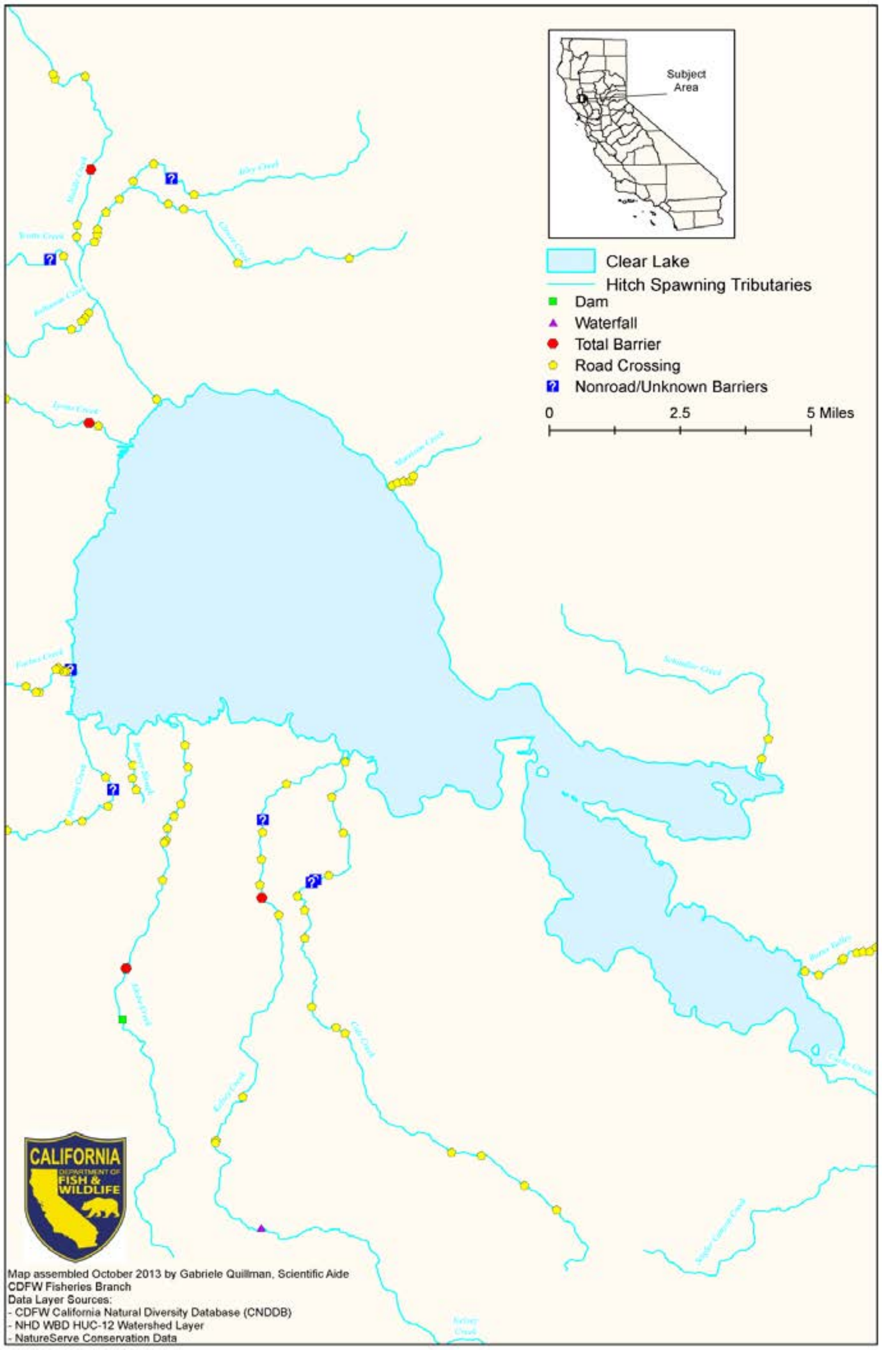

Figure 7. Clear Lake hitch spawning barriers located on tributaries throughout the watershed.

Water is frequently diverted from Clear Lake tributaries, during the CLH spawning season, under riparian rights associated with land ownership in the watershed. These water diversions consist of direct diversion from surface water intake pumps and from shallow off-channel wells that capture groundwater flows. The primary purpose of water diversions from Clear Lake tributaries is for agricultural production and frost protection. Water diversions for frost protection have been shown to temporarily reduce in-stream flow by as much as 95% (Deitch et al. 2009). Natural flow regimes are thought to favor the success of native fishes over non-native fishes (Marchetti and Moyle 2001). The impact of diversion on CLH spawning tributaries is poorly understood. In some tributaries, water diversion has contributed to early drying of stream reaches and desiccation of CLH eggs masses and newly hatched juveniles (Macedo, R., personal communication, November 25, 2013, unreferenced). Additionally, significant flow reductions can lead to increased water temperatures, reduced available aquatic habitat, altered or decreased biodiversity, increases in non-native species, and alterations to fish assemblages (Marchetti and Moyle 2001; Bunn and Arthington 2002; Bellucci et al. 2011).

Comment [GG17]: The County of Lake Special Districts diverts water from Kelsey Creek as the primary source of water for the town of Kelseyville. I think this statement may not identify all of the diversions equally. I know that ball field irrigation has caused a complete draw down on Cole Creek…..more than once.

The impacts of spawning habitat alterations to CLH may be inferred by the fate of another native Clear Lake fish that required tributaries for spawning; the Clear Lake splittail was last recorded in 1972 (Puckett 1972). The Clear Lake splittail formerly spawned later in the season than did CLH, and the drying up of tributaries contributed to their demise (Moyle 2002). All stream spawners had "declined precipitously" by 1944 (Murphy 1951). Therefore, earlier drying of tributaries by both natural and anthropogenic processes likely impacts the CLH population.

Dredging and Mining

Since the first European settlers arrived at Clear Lake and began gravel mining and dredging operations, there have been documented deleterious effects on the watershed (Suchanek et al. 2002). Field notes from CDFG personnel conducting stocking assessments documented Kelsey Creek so loaded with silt from gravel operations that creek visibility was zero (CDFG 1955). Smaller scale mining and dredging in tributary streams has occurred since early settlement and has altered the amount and distribution of stream gravels (Thompson et al. 2013). In some tributaries, gravel extraction has resulted in the incising and channelizing of the streams and stream level changes by as much as 15 feet (Suchanek et al. 2002; Eutenier, D. April 17, 2013 comment letter). After 1965 about one million metric tons of gravel products per year were removed from the watershed until the partial moratorium on aggregate mining in 1981 (Richerson et al. 1994). Gravel was removed from Clear Lake tributaries to provide road base for new roads created to accommodate the expanding population of the area (Suchanek et al. 2002). Currently, approximately 58 acres in the Clear Lake watershed are used for mining purposes (Forsgren Associates Inc. 2012).

Many areas along the tributaries to Clear Lake were channelized in response to frequent flooding during the late winter and early spring (Maclanahan et al. 1972; U.S. Army Corps of Engineers 1974). As a result of gravel extraction and channelization, some areas were covered with riprap or confined by levees to prevent further erosion and flooding. Erosion problems have contributed to sediment entering Clear Lake and providing increased phosphorous loads that impair water quality (Richerson et al. 1994). Gravel extraction results in channelization and down cutting of the stream bank, a decrease in suitable spawning habitat, and increasing flow velocity and amount of coarse material that passes through the system (Brown et al. 1998).

Water Quality Impacts

The Clear Lake watershed has seen a significant increase in the amount of contaminants entering the lake over the past 75 years (Richerson et al. 1994). An increase in agriculture and mining, and a shift to an urban environment, has resulted in adverse water quality impacts in the lake (Mioni et al. 2011; California Environmental Protection Agency [CEPA] 2012).

Erosion from construction, dredging, mining, agriculture, OHV use, grazing, residential development and urbanization has resulted in increased sediment loads to the Clear Lake watershed (Forsgren Associates Inc. 2012). Increased sediment loads transport nutrient rich soil, particularly phosphorous, into Clear Lake and reduce spawning habitat by increasing substrate "embeddedness" (Mosley 2013). During the late 1990s and early 2000s soil erosion and sedimentation became an increasing problem as existing agricultural lands were converted to vineyards (Forsgren Associates Inc. 2012). From 2002 to 2011 vineyard acreage in the Clear Lake watershed increased from approximately 5,500 acres to 8,000 acres (Lake County Department of Agriculture 2011).

Development and expansion of extensive and intensive agriculture in the Clear Lake watershed during the late 1890s until present day reclaimed the lake's natural wetland filtration system for agricultural use. An increase in agricultural production and a decrease in wetland filtration increased nutrient flows into Clear Lake. Wetland reclamation projects altered the transport of sediment and nutrients, particularly phosphorous, into Clear Lake, resulting in an increase in noxious cyanobacteria blooms that cover the lake in warmer months (Suchanek et al. 2002). As a result of continued water quality issues, Clear Lake was added to the Clean Water Act Section 303(d) list of impaired water bodies in 1988 (CEPA 2010 and 2012). In recent years, noxious cyanobacteria blooms have at a minimum remained constant and may have increased (CEPA 2012).

Cyanobacteria blooms have occurred at Clear Lake since the mid-1900s. Studies indicate an increase in phosphorous was the driver behind water quality impairments and noxious cyanobacteria blooms (Horne 1975; Richerson et al. 1994; CEPA 2012). The blooms originally consisted primarily of *Microcystis*, but in recent years the blooms have been attributed to both *Microcystis* and *Lyngbya.* These taxa represent both non-nitrogen fixing (*Microcystis*) and nitrogen fixing (*Lyngbya*) cyanobacteria and raise concerns that both phosphorous and nitrogen entering the lake need to be controlled (Mioni et al. 2011; CEPA 2012). Cyanobacteria blooms have the ability to both directly and indirectly impact CLH by direct interference with the growth of *Daphnia*, a limnetic organism that is a food source for adult CLH, and interference with food web efficiency.

No studies have been conducted at Clear Lake to quantify the impact of cyanobacteria blooms on the ecosystem, but studies conducted at other water bodies with varying degrees of cyanobacteria blooms provide information on their impacts to the aquatic environment. Cyanobacteria blooms reduce the amount of light penetration in the water column and cause a reduction in producers that are unable to reposition themselves to gain more light (Havens 2008). Organisms such as epiphyton, benthic algae, and rooted vascular plants have a reduced ability to function in the ecosystem as a result of cyanobacteria blooms. As the bacteria alter the nutrient cycle of the lake they replace the producers in space and mass. The expanding bacteria begin to deplete CO_2 from the water body, which increases pH and reduces growth of other producers (Havens 2008). The decreased CO_2 and increased pH can create surface scums and result in mortality of fishes, including CLH. In the summer of 1969, a large fish die off, due to heavy cyanobacteria growth and low oxygen levels, was reported at Clear Lake. An estimated 170,000 fish died, consisting primarily of carp, CLH, and blackfish (CDFG News Release 1969). Sub lethal and lethal effects of toxins released during cyanobacteria blooms are also seen in fish and their associated food web (Havens 2008).

Comment [GG18]: This is true but in the case of CL the Lyngbya blooms have been attributed to the clarity of the water, and rooted vegetation has become problematic in the past ten years. Water clarity has been steadily increasing since 1969.

Comment [GG19]: Again, this is very old data, I'm not sure it accurately reflects the current water quality conditions of the lake and I'm not sure of its relevance here.

On September 19, 2007, the U.S. Environmental Protection Agency (EPA) approved a control program as a nutrient Total Maximum Daily Load (TMDL) for Clear Lake with the goal of reducing point and non-point source phosphorous entering the lake (CEPA 2012). Sources for phosphorous entering the lake include agricultural and urban runoff, timber harvest, road maintenance, construction, gravel mining, dredging, and fire. Additional amounts of nutrients from home fertilizers, marijuana grows, sewer, and septic systems cannot be quantified.

To allow for increased yields on agricultural land and to prevent nuisance insect species around the lake, pesticides became commonplace during the early and mid-1900s. For many decades the Clear Lake gnat, a primary food source for CLH and CL splittail, was targeted with pesticides to reduce its population. Between 1949 and 1957, the Clear Lake gnat was targeted with the pesticide dichlorodiphenyldichloroethane (DDD). During these years it is estimated that 99 percent of the gnat larvae in the lake were killed. Concentrations of DDD were magnitudes higher in invertebrates, fish, and birds than in the surrounding water in which they were found (Lindquist and Roth 1950; Rudd 1964). Sampling conducted during the late 1950s identified CLH, as well as other fish species, contaminated with DDD (Hunt and Bischoff 1960). Contamination levels ranged from 5.27 to 115 parts per million (ppm) for edible flesh of sampled fishes (Hunt and Bischoff 1960). CLH were at the lower level of DDD contamination for Clear Lake fishes at 10.9 to 28.1 ppm for edible flesh content (Hunt and Bischoff 1960). The results of DDD in the Clear Lake watershed resulted in the first major ecological disaster at the lake and the first records of pesticide bioaccumulation in the wildlife of the lake (Suchanek et al. 2002).

Following the resurgence of gnat populations in response to growing resistance to DDD, two additional measures were taken to reduce the gnat population. Gnat eggs were targeted with a petroleum product, and adult gnats were targeted at roosting locations with Malathion. Additional applications of methyl parathion were also made in 1962 (Suchanek et al. 2002). Clear Lake gnats are still present at the lake, but populations are significantly reduced from historical levels. The likely cause of the reduced population of gnats is introduced fishes, primarily inland silversides (Suchanek et al. 2002). In 2010 and 2012 Clear Lake gnat populations reached levels not seen in decades. These gnat population booms appeared to coincide with years of low population levels of inland silversides (Scott, J. 2013 personal communication, Aug 1, 2013, unreferenced). Qualitative sampling data on CLH does not allow for a direct comparison of CLH numbers in years with increases in the gnat population.

In recent years, two herbicides, Komeen™ (copper sulfate) and SONAR™ (fluridone), have been used ~~extensively~~ to manage the *Hydrilla verticillata* infestation at the lake. Applied concentrations of Komeen™ do not kill fish directly; however, the impacts to macroinvertebrates may indirectly impact CLH populations (Bairrington 1999). These systemic herbicides also pose a threat to non-target vascular aquatic plants, such as tules and submerged vegetation, which juvenile CLH require for rearing habitat. As noted previously, there has already been a significant reduction in wetland habitat around the lake, and any additional reductions would further limit the amount of habitat available for CLH. Initial studies indicate a reduction in tule habitat following SONAR™ applications (Bairrington 1999). Environmental monitoring of eradication activities in 1996 and 1997 found that invertebrate species declined within the treatment area but rebounded quickly following the toxicity decay of the herbicide (Bairrington 1999). Post-treatment electrofishing surveys noted an increase in the number and abundance of fish species (Bairrington 1999).

Comment [GG20]: I removed the word "extensively" as it is valued laden and subjective. It does not add to the discussion.

Comment [GG21]: I believe Komeen is a contact herbicide…check me on this.

Comment [GG22]: This is subjective. I know of no examples of tules being impacted. You need to include a reference if possible…at least in recent times.

Mining operations within the watershed contributed to sulphur and mercury contamination in Clear Lake. The Sulphur Bank Mercury Mine began operations in 1865 and ended in 1957 (Osleger et al. 2008; Giusti 2009) Originally the mine focused on extracting sulphur, but as operations continued into the late 1920s and the sulphur was found to be contaminated with mercury sulfide, operations switched to extracting mercury from the large-scale open-pit mine (Giusti 2009). As a result of contamination, the mine was classified as an EPA Superfund Site in 1990 (Suchanek et al. 1993). The mine is thought to have contaminated the lake with both mercury and arsenic (Suchanek et al. 1993). Studies have found the mercury concentrations in sediment to be high (over 400 ppm) in the vicinity of the mine, decreasing as distance from the mine increases (Suchanek et al. 2002). The mine continues to produce low pH acid mine drainage that delivers sulfate to the lake. Over the past decade, the EPA has taken several actions to remediate contamination from the mine. These include erosion control measures, removal of contaminated soil, storm water diversion, and well capping (U.S. Environmental Protection Agency 2012).

During the 1970s, elevated concentrations of mercury were found in the fish of the lake (Curtis 1977). Mercury contamination can lead to significant impacts to the reproductive success of fishes and can result in reduced brain function, altered size and function of gonads and reduced gamete production (Sandheinrich and Miller 2006; Crump and Trudeau 2009). In 2003, a mercury TMDL was developed for Clear Lake to reduce methylmercury in fish by reducing overall mercury loads to Clear Lake (CEPA 2010). Levels of mercury found in fish, including CLH, are between 0.06 and 0.32 µg/g (CEPA 2002). Concentrations of mercury present in Clear Lake fishes have resulted in health advisories on their consumption, but are below acute toxicity thresholds (Harnly et al.

1997). Mercury levels are close to or within the effect thresholds for reproduction and growth for fathead minnow (0.32 to 0.62 µg/g) and rainbow trout (National Oceanic and Atmospheric Administration [NOAA] 2011). Concentrations with no effect on rainbow trout growth and development are 0.02 to 0.09 µg/g (NOAA 2011). Lacking specific studies on CLH, based on surrogate effect levels for fathead minnows and rainbow trout, it is reasonable to suspect that CLH may be experiencing sub lethal chronic and reproductive effects from mercury contamination.

Overexploitation

Commercial Harvest

Commercial fish harvest at Clear Lake has been occurring since the early 1900s. Harvested fish were distributed to fish markets in California for sale for human consumption and animal feed. Prior to 1941, the majority of commercial operations centered on harvesting catfish (*Ictalurus* or *Ameiurus* spp.) from the lake. Although exact numbers are unavailable, it is likely that large numbers of catfish were taken during this period (Bairrington 1999). In 1942 commercial harvest of catfish was banned at Clear Lake. Beginning in the 1930s commercial harvest focused on Sacramento blackfish (*Orthodon microlepidotus*), a native species, and common carp (*Cyprinus carpio*), a non-native species. From 1932 to 1962 the annual average catch rate was 295,000 pounds for the commercial fishery (Bairrington 1999). A ratio of 1.33:1 for blackfish to carp was the average during commercial fishing operations (Bairrington 1999). In 1976 the only recorded capture and sale of CLH for commercial purposes was submitted to the Department, a total of 1,550 pounds was reported captured and sold at market that year (CDFW Commercial Fisheries Data). This is the only instance in the records of CLH being captured for commercial sale, primarily due to lack of interest and low sale price for the species (CDFW Commercial Fisheries Data). By 1960 commercial fishing operators were required to count and release all by-catch from commercial operations. CLH were found in large numbers some years and were recorded and returned to the lake when captured (Figure 5; CDFW Commercial Fisheries Data). The Department has received no commercial permit applications for operations on Clear Lake over the past several years. The lack of permit applications indicates that at this time commercial fishing operations at Clear Lake have ceased (CDFW Commercial Fishing Permit Data).

Cultural Harvest

Clear Lake hitch are culturally significant to several Pomo tribes that inhabit the Clear Lake watershed. Two Pomo tribes fought a war over Kelsey Creek and its important CLH supply (Barrett 1906; Kniffen 1939). Historically, large runs of CLH provided a staple food source for the local tribes (RREC 2011). During spawning runs, CLH were captured by constructing a series of dams in the creeks from which the fish were then scooped with baskets. The fish were cured to provide a food source throughout the year (Kniffen 1939). Historical accounts from tribal members speak of CLH being easy to find as they spawned in large numbers in the tributaries to the lake (Scotts Valley Band of Pomo Indians historical accounts 2013). There are no estimates of the number of CLH that were taken for cultural harvest during any specific timeframe. However, an account from a tribal member indicates that, historically, a single family may have taken a couple thousand fish during the spawning runs (Big Valley EPA 2013). Tribal accounts indicate the harvest of CLH continued until the decline in spawning runs in the mid-1980s (Big Valley EPA 2013). Prior to designation of CLH as a candidate species for listing, regulations in the Clear Lake watershed allowed for the harvest of CLH in spawning tributaries by hand or hand-held dip net. In 2013 the Department issued CESA Memoranda of Understanding (Fish and Game Code, § 2081(a)) to three tribes to authorize collection of CLH for scientific research and public education (Kratville, D. personal communication, October 7, 2013, unreferenced).

Predation and Competition

Non-native fish introductions into Clear Lake date back as far as the late 1800s (Dill and Cordone 1997). Prior to the introduction of non-native fish species, between 12 and 14 native fish species occupied Clear Lake (Bairrington 1999; Moyle 2002; Thompson et al. 2013). Currently, approximately ten native species and 20 non-native species inhabit the lake (Bairrington1999; Thompson et al. 2013). Over the past 100 years one native species, thicktail chub (*Gila crassicauda*), has gone extinct and two native species, hardhead (*Mylopharodon concephalus*), and Clear Lake splittail, have been extirpated from the lake. Sacramento perch (*Archoplites interruptus*), has not been captured in sampling efforts since 1996 (Bairrington 1999; CDFW Commercial Fisheries Data; Thompson et al. 2013). Tule perch (*Hysterocarpus traski*) are accidentally caught or incidentally observed as recently as 2014 (Giusti, pers. communication) but quantified estimates of their populations do not exist. The majority of non-native species introductions have been conducted by the Department, various local agencies, and angling groups in an effort to increase sport fishing opportunities. Introductions of fish at Clear Lake have been warm water sport fish (black bass, sunfish (*Lepomis* spp.), catfish, etc.) or forage species for piscivorous sport fish. The Department has not stocked fish in Clear Lake in the past decade. The four fish species listed below were introduced without authorization from the Department (Bairrington 1999; Rowan J. personal communication, October 10, 2013, unreferenced). Inland silverside, threadfin shad, smallmouth bass (*Micropterus dolomieu*), and pumpkinseed (*Lepomis gibbosus*) were introduced to provide forage for other game fishes, provide Clear Lake gnat control, or as part of a new sport fishery (Anderson et al. 1986; Dill and Cordone 1997; Bairrington 1999). Non-native game fishes comprise nearly 100 percent of the sport catch from the lake. Incidental captures of native species occur infrequently and are rarely recorded during creel and tournament surveys (Rowan J. personal communication, October 10, 2013, unreferenced).

Non-native fish introductions can have significant impacts on native fish species. Inland silverside and threadfin shad are thought to compete directly with CLH for food resources (Geary and Moyle 1980; Anderson et al. 1986; Bairrington 1999). All three species are limnetic foragers that rely on macroinvertebrates for food. There are no direct comparisons, but years with declines in threadfin shad and inland silverside are thought to coincide with increases in CLH numbers, and years with decreased threadfin

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Comment [GG23]: Introduced yes, but I'm not sure if the introduction was successful.

Comment [GG24]: Is this the reference were Moyle goes so far to suggest that silverside may have played a role in the final demise of CL splittail?

shad and inland silverside result in increased young of year recruitment for other native and non-native species (Rowan J. personal communication, October 10, 2013, unreferenced). Competition for juvenile rearing habitat has increased with the reduction in wetland habitat and increase in non-native fish species. Rearing habitat is essential for CLH recruitment to any year class. A reduction in recruitment leads to a decrease in spawning adults in the following years. A species with highly fluctuating population trends, such as CLH, is particularly vulnerable to population level impacts in years with reduced recruitment. Piscivorous fish species such as largemouth bass (*Micropterus salmoides*) prey directly on both juvenile and adult CLH. Although no comprehensive diet studies have been done, incidental data indicate that CLH are found in the stomachs of piscivorous species in the lake (Moyle et al. in progress). Omnivorous species such as catfish (*Ameiurus* spp.) are known to prey on various life stages of native fishes. It is suggested that the introduction of catfish to Clear Lake may have played a role in the decline of native fish species (Dill and Cordone 1997). The introduction of catfish was described, by Captain J.D. Dondero of the Division of Fish and Game, as having solved the problem of large spawning runs of fish dying in tributaries to Clear Lake and that the population of nongame fish diminished following their introduction (Dill and Cordone 1997). Jordan and Gilbert (1894) also describe catfish as being destructive to the spawn of other species. The rates at which CLH are consumed in relation to other prey species and the amount of CLH consumed are unknown. It is likely that during years when alternative prey abundance is low, CLH predation increases (Eagles-Smith et al. 2008).

Disease and Parasites

Disease outbreaks in fishes have been known to occur at Clear Lake. The outbreaks are primarily koi herpes virus (KHV) and it affects introduced carp and goldfish. Native minnows, including CLH, show no effects from KHV. Fish fungi (*Saprolegnia* spp.) have been observed on fishes captured in Clear Lake and results from physical injury or infection. CLH are susceptible to fish fungi but it is not readily observed in captured fish. All fish in Clear Lake are susceptible to anchor worms (*Lernaea* spp.) and heavy infestations can lead to mortality. No CLH with heavy anchor worm infestations have been observed during CDFW fishery surveys at Clear Lake (Rowan J. personal communication, October 10, 2013, unreferenced). The Big Valley Rancheria Band of Pomo Indians has documented light loads of anchor worms occurring on CLH (Big Valley Rancheria 2012 and 2013).

Other Natural Occurrences or Human Related Activities

Climate Change

It is likely that native fishes in California will be vulnerable to physical and chemical changes as a result of climate change (Moyle et al. 2012). Research has shown that the annual mean temperature in North America has increased between 1955 and 2005 and is predicted to continue increasing in the future (Field et al. 1999; Hayhoe et al. 2004); however, it varies across North America, is more pronounced in spring and winter, and has affected daily minimum temperatures more than daily maximum temperatures (Field et al. 2007). In general, climate change models for California indicate an increase in overall air temperature, decreased and warmer rainfall, and an increase in overall water temperatures (California Climate Change Center [CCCC] 2012). Cold storms are expected to decrease, giving way to warmer storms that create earlier run-off and less water storage capabilities (Field et al. 1999; Hayhoe et al. 2004; CCCC 2012). Climate change in the Clear Lake watershed is likely to cause some changes to the interannual variability in rainfall. The change in rainfall variability would likely increase the occurrence of drought and flood years (Clear Lake Integrated Watershed Management Plan [CLIWMP] 2010). Expected climate change impacts to California and the Clear Lake watershed will be significant during annual CLH spawning cycles. CLH require winter and spring storms that provide suitable spawning flows in the tributaries of Clear Lake. A shift in timing, temperature, and amount of runoff could significantly impact the ability of CLH to successfully spawn. A climate driven change in the Clear Lake watershed could result in the loss of spawning habitat, reduced access to spawning habitat, stranding of spawning and juvenile fish, and egg desiccation.

A report on the projected effects of climate on California freshwater fishes, prepared for the California Energy Commission's California Climate Change Center, determined CLH to be critically vulnerable to impacts from climate change (Moyle et al. 2012). The report evaluated criteria such as population size, population trends, range, lifespan, and vulnerability to stochastic events to identify the degree of vulnerability of each fish species. The Intergovernmental Panel on Climate Change has stated that of all ecosystems, freshwater ecosystems will have the highest proportion of species threatened with extinction due to climate change (Kundzewicz et al. 2007). Freshwater lake species are more susceptible to extirpation because they are unable to emigrate should habitat changes occur (CA Natural Resources Agency 2009).

Recreational Activities

The natural resources of the Clear Lake watershed are a tremendous recreational resource for residents and visitors to Lake County. As the largest freshwater lake wholly in California, with opportunities for multiple aquatic recreational activities, the lake receives tens thousands of visitors per year. According to 2008 data acquired from Lake County quagga mussel (*Dreissena rostriformis*) inspection sticker application forms; there were 11,230 boats that visited the lake that year. Jet skis and pleasure boats accounted for 41 percent of the boating activity at the lake (CLIWMP 2010).

Permanent structures, associated with boat docks, boat ramps, and swimming beaches, have reduced littoral zone habitat around the lake. These structures require clearing of littoral zone habitat to maintain access for recreational boaters and swimmers. It is estimated that there are over 600 private boat docks and boat ramps on the lake shoreline. In addition to reducing littoral zone habitat these structures provide additional habitat for non-native sport fish, such as largemouth bass, that prey on CLH.

Recreational and tournament angling generate a significant amount of the activity in the Clear Lake aquatic environment. In 2008, 18 percent of all boats entering the lake identified their recreational activity as angling (CLIWMP 2010). In a single year creel survey conducted in 1988 by the Department, CLH comprised two percent of the recreational sport catch (Macedo 1991).

Comment [GG25]: I would like to encourage the Dept to re-engage with anglers and conduct annual or even bi-annual creel surveys to address this data gap.

The number of angling tournaments, primarily targeting largemouth bass, has drastically increased over the last three decades in response to Clear Lake's reputation as a premiere sport fishery. Between 2001 and 2008 the number of angling tournaments increased from 98 to 208 per year (Rowan J. personal communication, October 10, 2013, unreferenced). The number of tournaments per year is a function of the economy and has decreased since the recession that began in 2008. It is generally anticipated tournament numbers will increase again as the economy continues to improve. It is believed that recreational and tournament anglers' capture CLH incidentally while angling. The impact to CLH from the increase in angling tournaments is unknown, but is likely negligible because tournament anglers do not target CLH and by-catch would be an inadvertent snagging on an artificial lure, a rare occurrence.

REGULATORY AND LISTING STATUS

Federal

On September 25, 2012 the Center for Biological Diversity petitioned the U.S. Fish and Wildlife Service (USFWS) to list CLH as endangered or threatened under the federal Endangered Species Act (ESA). As of the publication of this status review there has been no action taken on the petition by USFWS.

The U.S. Forest Service (USFS) lists CLH as a sensitive species. USFS sensitive species are those plant and animal species identified by a regional forester that are not listed or proposed for listing under the federal ESA for which population viability is a concern.

State

The Department designated CLH as a Species of Special Concern (SSC) in 1994. A SSC is a species, subspecies, or distinct population of an animal native to California that currently satisfies one or more of the following (not necessarily mutually exclusive) criteria:

- Is extirpated from the State or, in the case of birds, in its primary seasonal or breeding role;
- Is listed as Federally, but not State, threatened or endangered;
- Is experiencing, or formerly experienced, serious (noncyclical) population declines or range restrictions (not reversed) that, if continued or resumed, could qualify it for State threatened or endangered status;
- Has naturally small populations exhibiting high susceptibility to risk from any factor(s) that if realized, could lead to declines that would qualify it for State threatened or endangered status.

The intent of designating a species as a SSC is to:

- Focus attention on animals at conservation risk by the Department, other State, local and Federal government entities, regulators, land managers, planners, consulting biologists, and others;
- Stimulate research on poorly known species;
- Achieve conservation and recovery of these animals before they meet California Endangered Species Act criteria for listing as threatened or endangered.

There are no provisions in the Fish and Game Code that specifically prohibit take of CLH or protect its habitat.

Other Rankings

The American Fisheries Society ranks CLH as vulnerable, meaning the taxon is in imminent danger of becoming threatened throughout all or a significant portion of its range (Jelks et al. 2011).

EXISTING MANAGEMENT EFFORTS

Resource Management Plans

An increase in resource management efforts throughout the Clear Lake watershed has benefitted CLH, and several plans and strategies are in place to assist in reducing the threats to CLH.

The Clear Lake Integrated Watershed Management Plan (2010) was prepared by two resource conservation districts and provides details of past and current resource management within the Clear Lake watershed. The plan seeks to identify opportunities to improve and protect the health and function of the watershed and identifies specific implementation actions to improve and protect watershed resources. Recommended actions are prioritized on a timeline. As funding allows, implementation of these actions will be undertaken by various non-governmental organizations (NGO) and local, state, and federal agencies that share an interest in promoting the health and function of the watershed. Multiple action items listed in the plan would benefit CLH and their habitats. Several tributaries to Clear Lake have completed Watershed Assessment plans as well. These include Kelsey Creek Watershed Assessment (2010), Middle Creek Watershed Assessment (2010), and Scotts Creek Watershed Assessment (2010). These plans were all completed by Lake County Water Resources Division for West and East Lake Resource Conservation Districts.

Comment [GG26]: Should the tribes be included here?

With adoption of the TMDL for Clear Lake, several projects are in process or have been completed to reduce the amount of phosphorous entering the lake. Specifically, the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project seeks to reduce the amount of phosphorous entering the lake by 40 percent (CEPA 2012). Lake County and the California Department of Transportation have implemented several best management practices (BMPs) for managing storm water runoff to reduce the amount of phosphorous and other contaminants that enter the lake. Both the USFS and Bureau of Land Management (BLM) have undertaken projects to reduce nutrients entering the lake as a result of off-highway vehicles and other land uses. BLM, in coordination with Scotts Valley Band of Pomo Indians, received a grant to implement the Eightmile Valley Sediment Reduction and Habitat Enhancement Project Design. Controlling sediment from Eightmile Valley is crucial to controlling the amount of nutrients entering the lake. Many of these projects are still in design or early implementation and it will be several years before changes in nutrient loads within the lake can be observed and studied.

The adverse effects from an increase in sedimentation as a result of conversion of various types of agricultural land to vineyard resulted in the formation of the Erosion Prevention and Education Committee (EPEC). The EPEC was ~~is~~ a group of county agencies and private entities that provide educational outreach regarding erosion control and water quality protection. In addition, the Lake County Grading Ordinance was approved in 2007 and requires grading permits and Erosion Control and Sediment Detention Plans for projects with the probability of resulting in increased sedimentation (Forsgren Associates, Inc. 2012).

Comment [GG27]: "was" past tense as the committee is no longer functioning as the mass increase of vineyard expansion has waned.

Concerns over the reduction in habitat quality resulting from gravel mining prompted Lake County to adopt an Aggregate Resources Management Plan in 1994. The plan called for a moratorium on gravel mining in several tributaries to Clear Lake. The implementation of gravel mining regulations has resulted in reduced in-stream and bank erosion and increased riparian habitat along the creeks (CEPA 2008).

To prevent further destruction of wetland habitat along the lake shoreline, in 2000 and 2003 amendments, Lake County adopted Section 23-15 of the Clear Lake Shoreline Ordinance that prohibits the destruction of woody species and tules. In addition to the ordinance, there is a no net-loss requirement for commercial, resort, and public properties that seek to clear vegetation from areas along the shoreline (CLIWMP 2010).

RREC produced an Adaptive Management Plan (HAMP) for the Clear Lake Hitch, *Lavinia exilicauda chi* (RREC 2011). The HAMP describes the current status of CLH habitat and problems for habitat recovery. The habitat assessments are included in a management plan that identifies action items, issues of uncertainty, stakeholder involvement, sustainability, and plan amendment procedures. The RREC is currently in the process of revising the HAMP.

Comment [GG28]: ???? What is this?

Comment [GG29]: What does the "H" stand for?

The Department has created or approved two Conceptual Area Protection Plans (CAPP) for the Clear Lake Watershed. The creation of a CAPP for an area allows the Department, as well as local and federal agencies, and NGOs, to apply for land acquisition funding from the Wildlife Conservation Board. The first, the Clear Lake CAPP, was approved in 2002 and addresses land acquisition needs in the area of Middle Creek. The plan focuses on protecting wetland and riparian habitat for the benefit of natural resources. The second CAPP, Big Valley Wetlands, is currently in development with possible approval in 2014. The Big Valley Wetlands CAPP focuses on land acquisitions in the western portion of the Clear Lake watershed for the purpose of protecting wetland and riparian habitat. Both CAPP's will benefit CLH in the protection of riparian and wetland habitat critical for spawning and rearing CLH. Land acquisitions that seek to protect and restore existing CLH habitat should create a stable environment for CLH populations.

The Department published a Clear Lake Fishery Management Plan in 1999 (Bairrington 1999). The plan provides a review of past and present biological information for Clear Lake. The primary focus of the plan is to maintain fishery resources of the lake and enhance recreational fishing opportunities. The plan identifies areas of controversy between various stakeholder groups in the watershed, and states that “adapting to the biological and social settings at Clear Lake involves a variety of compromises between these groups and the non-angling groups who wish to ensure the well-being of Clear Lake’s native fish species.” The plan identifies the decline in native fish species at Clear Lake as being detrimental both socially and biologically. No specific guidelines are given for addressing impacts to native species, but restoration of spawning habitat and natural flow regimes are discussed as critical for native species survival.

Monitoring and Research

In 2013 the Department attempted to conduct a status assessment of the CLH population present in Cole and Kelsey creeks. Sampling produced too few fish to facilitate a statistically valid mark and recapture study. As a result, a population estimate was not completed. The Department has proposed additional funding in 2014 to begin a multi-year mark-recapture study to determine a statistically valid population estimate or index of CLH.

The CCCLH has been conducting annual spawning observations since 2005. A simple protocol is followed that identifies the time, observer, and number of CLH observed. Volunteers have put in hundreds of hours monitoring CLH spawning runs during this time period. Although not quantitative, the surveys provide a glimpse into the number of spawning CLH and how successful spawning is in a particular season. Results of these surveys are included in Appendices A and B and summarized in Section 4.1 and 4.2 above.

Habitat Restoration Projects

In recent years, local, state, and federal agencies have begun implementing actions to aid in the protection and restoration of Clear Lake wetland habitat. The Middle Creek Flood Damage Reduction and Ecosystem Restoration Project will restore up to 1,400 acres of wetland habitat around Middle Creek and Rodman Slough, essentially doubling the amount of existing wetland habitat in the watershed (CLIWMP 2010).

Comment [GG30]: Just so that you know, this “idea” has been in the works the entire time I have been in Lake County. Nearly 25 years.

Impacts of Existing Management Efforts

To date, existing management efforts have focused on CLH habitat restoration in the watershed. Wetland restoration projects that would significantly benefit CLH have been proposed and have been or will be implemented through the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project and the two CAPPs that cover portions of the watershed. Wetland restoration is expected to aid in increasing spawning success and juvenile recruitment into the population. Increased wetland acreage would enhance filtration of tributary waters resulting in decreased amounts of nutrients entering the lake and an increase in the water table. The increased water table will help maintain surface flow in tributaries, resulting in suitable spawning habitat being maintained throughout the spawning season. The Clear Lake Shoreline Ordinance has resulted in a "no net loss" of shoreline wetland habitat around the lake since its enactment. However, because these wetland restoration projects are either recent or yet to be implemented, a thorough assessment of direct and indirect impacts to CLH populations cannot be included in this status review.

Establishment of TMDLs for mercury and nutrients has led to a reduction in inputs and an increase in monitoring efforts in the Clear Lake watershed. Past and future steps by the federal government will reduce mercury contamination resulting from the Sulphur Bank Mercury Mine. Most of the identified initial actions for cleanup have been implemented. The focus will now be on two long-term projects to address waste pile and lake sediment cleanup, which should result in significant reductions in mercury contamination in the watershed. Nutrient loads entering Clear Lake have been addressed by several measures including wetland restoration, BMPs for storm water runoff, and erosion control measures. Many of these projects are in the early stages of implementation, and a thorough assessment of impacts to CLH is yet to be been completed. It is likely that reduced mercury and nutrient loads in Clear Lake will result in a ~~significant~~ benefit to CLH.

Comment [GG31]: We can hope the results would be "significant" but I think it is speculative at this time. I would omit this adjective.

SCIENTIFIC DETERMINATIONS REGARDING THE STATUS OF CLEAR LAKE HITCH IN CALIFORNIA

CESA directs the Department to prepare this report regarding the status of CLH based upon the best scientific information available to the Department. CESA's implementing regulations identify key factors that are relevant to the Department's analyses. Specifically, a "species shall be listed as endangered or threatened ... if the Commission determines that its continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities." (Cal. Code Regs., tit. 14, § 670.1 (i)(1)(A)).

The definitions of endangered and threatened species in the Fish and Game Code provide guidance to the Department's scientific determination. An endangered species under CESA is one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, over exploitation, predation, competition, or disease." (Fish & G. Code, § 2062). A threatened species under CESA is one "that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [CESA]." (*Id.*, § 2067).

The preceding sections of this status review report describe the best scientific information available to the Department, with respect to the key factors identified in the regulations. The Department's scientific determinations regarding these factors as peer review begins are summarized below.

Present or Threatened Modification or Destruction of Habitat

Beginning with the arrival of European settlers in the mid-1800s, alterations to habitats in the watershed have directly impacted the ability of CLH to survive. Habitats necessary for both spawning and rearing have been reduced or severely decreased in suitability in the past century resulting in an observable decrease in the overall abundance of CLH and its habitat. Spawning tributaries have been physically altered by a combination of dams, diversions, and mining operations that have altered the course and timing of spring flows and the amount and quality of spawning habitat available for CLH. Dams create barriers to CLH passage that reduce the amount of available spawning habitat while altering the natural flow regime of tributaries. Water diversions in tributaries have resulted in decreased flows during critical spawning migrations for CLH. Loss of eggs, juvenile, and adult fish due to desiccation and stranding from water diversions are likely a significant impact on CLH populations. Gravel mining removed large amounts of spawning substrate during peak operations in the mid-1900s. Spawning substrate has been restored slowly after gravel mining was discontinued in the majority of the watershed. Water quality impacts to the watershed have resulted in Clear Lake being listed as an impaired water body and led to the establishment of TMDLs for both mercury and nutrients for the lake. It is unclear to what extent the water quality impacts are affecting CLH populations. The Department considers modification and destruction of habitat a significant threat to the continued existence of CLH.

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Overexploitation

Harvest of CLH has occurred by both Pomo tribes and commercial fishery operators at Clear Lake. Historic accounts from tribal members indicate that significant amounts of CLH were harvested during spawning runs. In recent years, the amount of harvest by the Pomo has been minimal, and the CLH are used strictly for educational and cultural reasons. Since the early 1990s commercial fishery operations have been required to return all CLH captured to the lake. Prior to that, CLH had not been regularly harvested for sale. It is likely that incidental catch during commercial harvest operations resulted in mortality of some CLH. However, there is no information indicating that overexploitation threatens the continued existence of CLH.

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Predation

Direct predation of CLH by fish, birds, and mammals is known to occur in suitable habitats within the watershed. Spawning runs are vulnerable to predation from birds and mammals as fish migrate upstream and become stranded at various locations. Stranding occurs both naturally and as a result of habitat modifications described above. Non-native fishes prey directly on different life stages of CLH in all occupied habitats. CLH have been found during stomach content analyses of largemouth bass. Incidental observations indicate that largemouth bass may target CLH as the CLH stage at the entrance to ascend spawning tributaries in early spring. Other introduced fishes, such as catfish species, also prey on CLH. A detailed diet study on introduced fishes is necessary to determine the extent of predation from introduced fishes. There is scientific information suggesting that predation by introduced fishes threatens the continued existence of CLH.

Competition

The extent of impacts on CLH from competition with other aquatic species is poorly understood. Studies conducted on diet analysis of CLH indicate that there is competition between CLH and other macroinvertebrate consuming fish species, primarily inland silversides and threadfin shad. Observations by Department biologists and others indicate that CLH populations fluctuate on alternating cycles with inland silverside populations. CLH directly compete with other native and non-native fishes for juvenile rearing habitat. The majority of fishes in Clear Lake utilize near shore wetland habitat for juvenile rearing. With the decrease in wetland habitat over the past century, there is increased competition for the remaining habitat. Although no formal studies have been completed, it is likely that competition for resources threatens the continued existence of CLH.

Disease

There are no known diseases that are significant threats to the continued existence of CLH.

Other Natural Occurrences or Human-related Activities

If projected ~~Expected~~ climate change models prove to be accurate potential impacts to California and the Clear Lake watershed could ~~will~~ be significant during annual CLH spawning cycles. CLH require winter and spring storms that provide suitable spawning flows in the tributaries of Clear Lake. A shift in timing, temperature, and amount of runoff could have negative ~~significantly~~ impacts on the ability of CLH to successfully spawn. A report on the projected effects of climate on California freshwater fishes determined CLH to be critically vulnerable to impacts from climate change.

Numerous recreational activities take place in Clear Lake each year. The majority of recreational activities pose no significant threat to the survival of CLH. However, though it is believed that recreational and tournament anglers' capture CLH incidentally, the occurrence is consider rare. ~~at a low rate.~~ The extent of impacts to CLH from angling is unknown, but likely do not threaten the continued existence of CLH.

SUMMARY OF KEY FINDINGS

At present time, the species can be found in portions of its historic habitat and qualitative surveys indicate a variable interannual population. Based on qualitative survey efforts to date a population estimate or index of CLH is not attainable. Without a current population or index for CLH it is necessary to estimate impacts not based on a set baseline but rather against trends seen in abundance and distribution in sampling efforts over the past half century.

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Comment [GG32]: Though I agree with the premise, and undoubtedly predation from introductions is real, both LMB and catfish have co-existed with CLH for nearly 100 years. I'm not sure taken by themselves, we can make the argument that predation "threatens" their existence. Certainly a key factor affecting current population.

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Comment [GG33]: I think Moyle has identified silversides as a causative agent for the extirpation of splittail (last straw if you will). I think if you look at creel data pre and post introduction of SS you will see a dramatic shift in species abundance.

Comment [GG34]: Citation?

Comment [GG35]: I agree however the conclusions are speculative at this time. I wasn't comfortable with the number of time the word "significantly" was used in the paragraph. Climate change may indeed be a huge factor, but individual weather events can provide the necessary water for spawning. I know I'm playing with words here but I think it better reflects how the debate for climate is evolving.

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It will be imperative for the Department and the conservation community to study and monitor the population of CLH over the next decade. A review of the scientific determinations regarding the status of CLH indicates there are significant threats to the continued existence of the species, particularly related to historical and ongoing habitat modification, predation from introduced species, and competition. Many of these threats are currently or in the near future being addressed by existing management efforts. Monitoring impacts from existing management efforts will be imperative to assessing the future status of CLH.

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RECOMMENDATION FOR PETITIONED ACTION

CESA directs the Department to prepare this report regarding the status of CLH in California based upon the best scientific information available. CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)). The Department includes and makes its recommendation in its status report as submitted to the Commission in an advisory capacity based on the best available science.

Based on the criteria described above, the scientific information available to the Department does/does not indicate that CLH are threatened with extinction and likely to become an endangered species in the foreseeable future. The listing recommendation will be provided in this report after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

PROTECTION AFFORDED BY LISTING

It is the policy of the State to conserve, protect, restore and enhance any endangered or any threatened species and its habitat. (Fish & G. Code, § 2052.) If listed as an endangered or threatened species, unauthorized “take” of CLH will be prohibited, making the conservation, protection, and enhancement of the species and its habitat an issue of statewide concern. As noted earlier, CESA defines “take” as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill. (*Id.*, § 86.) Any person violating the take prohibition would be punishable under State law. The Fish and Game Code provides the Department with related authority to authorize “take” under certain circumstances. (*Id.*, §§ 2081, 2081.1, 2086, 2087 and 2835.) As authorized through an incidental take permit, however, impacts of the taking on CLH caused by the activity must be minimized and fully mitigated according to State standards.

Additional protection of CLH following listing would also occur with required public agency environmental review under CEQA and its federal counter-part, the National Environmental Policy Act (NEPA). CEQA and NEPA both require affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on endangered, rare, and threatened special status species. Under CEQA’s “substantive mandate,” for example, state and local agencies in California must avoid or substantially lessen significant environmental effects of their projects to the extent feasible. With that mandate and the Department’s regulatory jurisdiction generally, the Department expects related CEQA and NEPA review will likely result in increased information regarding the status of CLH in California as a result of, among other things, updated occurrence and abundance information for individual projects. Where significant impacts are identified under CEQA, the Department expects project-specific required avoidance, minimization, and mitigation measures will also benefit the species. State listing, in this respect, and required consultation with the Department during state and local agency environmental review under CEQA, is also expected to benefit the species in terms of related impacts for individual projects that might otherwise occur absent listing.

If CLH are listed under CESA, it may increase the likelihood that State and federal land and resource management agencies will allocate additional funds towards protection and recovery actions. However, funding for species recovery and management is limited, and there is a growing list of threatened and endangered species.

MANAGEMENT RECOMMENDATIONS AND RECOVERY MEASURES

Current data on CLH suffers from being largely anecdotal and qualitative in nature. Studies designed to provide quantitative data on CLH populations and the factors that affect the ability of CLH to survive and reproduce are necessary for species management. The following management recommendations were generated by Department staff with considerations from local agencies, non-profits, and interested parties.

- Derive a statistically valid population estimate or index allowing assessment of impacts to the overall population and provide a baseline to maintain a sustainable population level.
- Conduct a thorough assessment of barriers to fish movement on primary spawning streams and provide recommendations for restoration actions on substantial barriers.
- Complete a detailed analysis of spawning habitat in primary spawning streams and provide recommendations for restoration actions.
- Implement identified restoration activities to increase available spawning habitat for CLH.
- Conduct a review of reservoir operations at Highland Springs, Adobe Creek, and Kelsey Creek detention dams to assess water release operations that may be impacting CLH, development and implementation of guidelines for minimizing impacts.
- Conduct an in stream flow analysis of primary spawning tributaries to determine impacts of water diversions on stream flows, particularly during spawning season.
- Coordinate with landowners, stakeholders, and permitting agencies on developing strategies for reducing in stream diversions during spawning season.
- Determine the value of wetland habitat in the watershed pertaining to survivorship of juvenile CLH and make appropriate recommendations on restoration or modification.

- Analyze food web interactions of CLH and non-native fish to determine potential impacts to CLH.
- Conduct a diet analysis of predatory fish species to determine the extent of their impact on CLH.
- Conduct creel surveys to gain a better understanding of CLH capture rates during both recreational and tournament angling.
- Develop a comprehensive monitoring program to assess both native and non-native fish populations and their distribution in the watershed.
- Identify habitats within the watershed that may be suitable for CLH translocations.
- Coordinate the above research and restoration efforts with interested stakeholders in the watershed.
- Develop an outreach program to provide updates to stakeholders on recovery and management efforts.

PUBLIC RESPONSE

Note to Reviewer: Public response will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

PEER REVIEW

Note to Reviewer: Peer review will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

LITERATURE CITED

Aguilar, A. and J. Jones. 2009. Nuclear and Mitochondrial Diversification in two Native California Minnows: Insights into Taxonomic Identity and Regional Phylogeography. Molecular Phylogenetics and Evolution 51 (2): 373-381.

Anderson, N.L., D.L. Woodward and A.E. Colwell. 1986. Pestiferous dipterans and two recently introduced aquatic species at Clear Lake. Proceedings of the California Mosquito Vector Control Association. 54:163-167.

Anderson, N.L., 1989. Letter to Rick Macedo containing notes and data from LCVCD sampling efforts.

Avise, J.C. and F.J. Ayala. 1976. Genetic differentiation in speciose versus depauperate phylads: Evidence from the California minnows. Evolution 30:46-58.

Barrett, S.A., 1906. The Ethno-Geography of the Pomo and Neighboring Indians. University of California Publications in American Archeology and Ethnology. Vol 6 No. 1.

Bairrington, P., 1999. CDFG Clear Lake Fishery Management Plan.

Bellucci, C. J., Becker, M., & Beauchene, M. (2011). Characteristics of macroinvertebrate and fish communities from 30 least disturbed small streams in Connecticut. *Northeastern Naturalist, 18*(4), 411-444.

Big Valley EPA, 2013. Hitch interview notes with families of Big Valley Rancheria and Elem Indian Colony.

Big Valley Rancheria, 2012. Hitch *Lavinia exilicauda* Chi Hopkirk ecology and water quality studies in Big Valley sub-basin creeks in 2012.

Big Valley Rancheria, 2013. Big Valley sub-basin creek water quality, quantity, and Hitch *Lavinia exilicauda* Chi Hopkirk ecology program. Spring, 2013.

Brown, A.V., M.M. Little, and K.B. Brown, 1998. Impacts of gravel mining on gravel bed streams. *Transactions of the American Fisheries Society*. 127:979-994.

Bunn, S.E., and A.H. Arthington, 2002. Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity. *Environmental Management*. Vol. 30:4. Pp 492-507.

California Climate Change Center, 2012. Our Changing Climate 2012 Vulnerability and Adaptation to the Increasing Risks from Climate Change in California.

California Department of Fish and Game, 1955-1956. Field notes on Kelsey and Seigler Creeks.

California Department of Fish and Game, 1961-2001. Commercial Catch data for Clear Lake

California Department of Fish and Game, 1969. News Release on Fish Dieoffs at Clear Lake.

California Department of Fish and Game, 1988. Clear Lake Electrofishing Survey, April 2, 1987 Memorandum.

California Department of Fish and Game, 2012. Electrofishing data, Memorandum in progress.

California Department of Fish and Wildlife, 2013. Report to the Fish and Game Commission Evaluation of the Petition from the Center for Biological Diversity to List Clear Lake Hitch (*Lavinia exilicauda chi*) as a Threatened Species under the California Endangered Species Act.

California Department of Fish and Wildlife, 2013. Commercial Fisheries Data from catch records.

California Department of Fish and Wildlife, 2013. Commercial Operators permit applications.

California Department of Fish and Wildlife, April 24, 2013. Press Release – CDFW Seeks Public Comment and Data Regarding Clear Lake Hitch.

California Department of Water Resources. 1975. Clear Lake Water Quality Data.

California Natural Resources Agency, 2009. California Climate Adaptation Strategy Discussion Draft.

California Environmental Protection Agency RWQCBCVR, 2002. Clear Lake TMDL for Mercury Staff Report.

California Environmental Protection Agency RWQCBCVR, 2008, Monitoring and Implementation Plan Clear Lake Mercury and Nutrient TMDL's.

California Environmental Protection Agency RWQCBCVR, 2010. Clear Lake Mercury Total Maximum Daily Load Update.

California Environmental Protection Agency RWQCBCVR, 2012. Clear Lake Nutrient Total Maximum Daily Load Control Program 5-year Update.

California Regulatory Notice Register, 2012. No. 41-Z. p.1501

California Regulatory Notice Register, 2013. No. 12-Z. p.488

Center for Biological Diversity, 2012. Petition to List Clear Lake Hitch (*Lavinia exilicauda chi*) as Threatened under the California Endangered Species Act. 58 pp.

Chi Council for the Clear Lake Hitch (CCCLH). 2013. Hitch spawning survey results, 2005-2013. Available at http://lakelive.info/chicouncil/

Clear Lake Integrated Watershed Management Plan, February 2010. Prepared for West Lake and East Lake Resource Conservation Districts.

Coleman, G.A. 1930. A biological survey of Clear Lake, Lake County. *Calif. Fish and Game* 16: 221-227.

Converse,Y.A., C.P. Hawkins and R. A. VALDEZ, 1998. Habitat Relationships of Subadult Humpback Chub in the Colorado River through Grand Canyon: Spatial Variability and Implications of Flow Regulation. *REGULATED RIVERS: RESEARCH & MANAGEMENT* **14**: 267–284

Cook, S. F., Jr., J. D. Connors, and R. L. Moore, 1964. The impact of the fishery on the midges of Clear Lake, Lake County, CA, *Annals of the Entomological Society of America*, Vol. 57, pp. 701-707.

Cott, P. A., Sibley, P. K., Somers, W. M., Lilly, M. R., & Gordon, A. M. (2008). A REVIEW OF WATER LEVEL FLUCTUATIONS ON AQUATIC BIOTA WITH AN EMPHASIS ON FISHES IN ICE-COVERED LAKES1. *Journal of the American Water Resources Association, 44*(2), 343-359.

Cox, B., 2007. CDFG Clear Lake Fishery Surveys Summary Report.

Curtis T.C. 1977. Pesticide Laboratory report. California Department of Fish and Game, E.P. No. P-133. 3pp.

Crump, KL and VL Trudeau, 2009. Mercury-induced reproductive impairment in fish. *Environmental Toxicology and Chemistry*. 28(5):895-907.

Deitch, M.J., G.M. Kondolf, and A.M. Merenlender. 2009. Hydrologic impacts of smallscale instream diversions for frost and heat protection in the California wine country. River Research and Applications, Volume 25, Issue 2, pages 118-134.

Dill, W. A., and A. J. Cordone. 1997. Fish Bulletin 178. History and Status of Introduced Fishes in California 1871-1996. California. Fish and Game. 414 pp.

Eagles-Smith, C.A., T.H. Suchanek, A.E. Colwell, N.L. Anderson, and P.B. Moyle. 2008. Changes in fish diets and food web mercury bioaccumulation induced by an invasive planktivorous fish. Ecological Applications 18(Supplement): A213–A226.

Ewing, B., 2013. Summary of the Clear Lake Hitch Population Estimate for Cole and Kelsey Creeks, Lake County.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller, 1999. *Confronting Climate Change in California: Ecological Impacts on the Golden State.* Union of Concerned Scientists, Cambridge, MA and Ecological Society of America, Washington, DC.

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

Forsgren Associates Inc, 2012. Clear Lake Watershed Sanitary Survey 2012 Update Final.

Franson, S. 2013. Summary of Spring 20-13 Field Monitoring with Locations chosen for observing egg and larval development of Clear Lake Hitch (*Lavinia exilicauda chi*).

Gafny, S., A. Gasith, and M. Goren 2006. Effect of water level fluctuation on shore spawning of *Mirogrex terraesanctae* (Steinitz), (Cyprinidae) in Lake Kinneret, Israel. Journal of Fish Biology vol 41:6 pages 863-871

Geary, R.E. 1978. Life history of the Clear Lake hitch *(Lavinia exilicauda chi).* Unpublished Master's Thesis, University of California, Davis. 27 pp.

Geary, R.E. and P.B. Moyle. 1980. Aspects of the ecology of the hitch, *Lavinia exilicauda* (Cyprinidae), a persistent native cyprinid in Clear Lake, California. Southwest. Nat. 25:385-390.

Giusti, G. 2009. Human Influences to Clear Lake, California A 20th Century History.

Harnly, M., S. Seidel, P. Rojas, R. Fornes, P. Flessel, D. Smith, R. Kreutzer, and L. Goldman. 1996. Biological monitoring for mercury within a community with soil and fish contamination. *Environmental Health Perspectives*, Vol. 105:4, 424-429.

Havens, K.E. 2008. Cyanobaterial Harmful Algal Blooms: State of the Science and Research Needs. Chapter 33: Cyanobacteria blooms: effects on aquatic ecosystems.
Hayhoe, K., D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider,K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S. Kalkstein, J. Lenihan, C.K.Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Science 101:12422-12427.

Hopkirk, J.D. 1973. Endemism in fishes of the Clear Lake region of central California. University of California Publications in Zoology 96: 160 pp.

Horne, A.J. 1975. The Effects of Copper, Major and Minor Nutrient Element Additions, and Lake Water Movements on Blue-Green Algal Bloom Development in Clear Lake.

Hudon, C., Armellin, A., Gagnon, P., & Patoine, A. (2010). Variations in water temperatures and levels in the St. Lawrence River (quebec, canada) and potential implications for three common fish species. *Hydrobiologia, 647*(1), 145-161.

Hunt, E.G. and A.I. Bischoff. 1960. Inimical effects on wildlife or periodic DDD applications to Clear Lake. California Fish and Game 46:91-106.

Jelks, H L., Stephen J. Walsh, Noel M. Burkhead, Salvador Contreras-Balderas, Edmundo Diaz-Pardo, Dean A. Hendrickson, John Lyons, Nicholas E. Mandrak, Frank McCormick, Joseph S. Nelson, Steven P. Platania, Brady A. Porter, Claude B. Renaud, Juan Jacobo Schmitter-Soto, Eric B. Taylor & Melvin L. Warren Jr. (2008): Conservation Status of Imperiled North American Freshwater and Diadromous Fishes, Fisheries, 33:8, 372-407.

Jordan, D.S., and C.H. Gilbert. 1894. List of Fishes Inhabiting Clear Lake, California. Bulletin of the United States Fish Commission, Vol. XIV.

Kelsey Creek Watershed Assessment, February 2010. Prepared for East Lake and West Lake Resource Conservation Districts.

Kimsey, J.B. and L.O. Fisk. 1960. Keys to the freshwater and anadromous fishes of California. Calif. Fish Game 46:453-79.

Kniffen, F.B. 1939. Pomo Geography. University of California Publications in American Archaeology and Ethnology. Vol. 36 No. 6 pp. 353-400.

Kratville, D. October 7, 2013. Email correspondence on CESA MOU's issued for CLH.

Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen and I.A. Shiklomanov, 2007: Freshwater resources and their management. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210.

Lake County Department of Agriculture, 2011. Crop Report

Lake County Department of Public Works Water Resources Division, 2003. Clear Lake Wetlands Geographic Information Systems Data User Manual.

Lake County Vector Control District, 2013. Copy of verified Beach Seine 1987-2010 CL Hitch with notes.

Lindquist, A.W., C.D. Deonier, and J.E. Hanley. 1943. The relationship of fish to the Clear Lake gnat, in Clear Lake, California. Calif. Fish Game 29:196-202.

Lindquist, A.W. and A.R. Roth. 1950. Effect of dichlorodiphenyl dichloroethane on larva of the Clear Lake gnat in California. *Journal of Economic Entomology* 43:328-332.

Macclanahan, J., E. W. Danley, H. F. Dewitt, and W. Wolber. 1972[app]. Flood control project maintenance and repair, 1971 inspection report. California Department of Water Resources Bulletin 149-71.

Macedo, R., 1991. Creel Survey at Clear Lake, California March – June, 1988. CDFG Administrative Report No. 91-3.

Macedo, R. 1994. Swimming Upstream Without a Hitch. Outdoor California: January/February 1994.

Marchetti, M.P. and P.B. Moyle, 2001. Effects of flow regime on fish assemblages in a regulated California stream. *Ecological Applications*. 11(2). Pp. 530-539.

McGinnis, D. and E. Ringelberg. 2006. Lake County Fish Barrier Assessment. Technical Memo.

Middle Creek Watershed Assessment, February 2010. Prepared for West Lake Resource Conservation District.

Miller, R.R. 1945. A new cyprinid fish from Southern Arizona, and Sonora, Mexico, with description of a new subgenus of *Gila* and a review of related species. Copeia 1945:104-110.

Miller, R.R. 1963. Synonymy, characters and variation of *Gila crassicauda*, a rare California minnow, with an account of its hybridization with *Lavinia exilicauda*. California Fish and Game 49 (1): 20-29.

Mioni, C., R. Kudela, and D. Baxter. 2011. Harmful cyanobacteria blooms and their toxins in Clear Lake and the Sacramento-San Joaquin delta (California). Central Valley Regional Water Quality Control Board: 10-058-150.

Moyle, P.B. and M. Massingill. 1981. Hybridization between hitch, *Lavinia exilicauda*, and Sacramento blackfish, *Orthodon microlepidotus*, in San Luis Reservoir, California. California Fish Game 67:196-198.

Moyle, P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern in California, 2nd edition.

Moyle, P.B. and T. Light, 1996. Fish Invasions in California: Do Abiotic Factors Determine Success? Ecology 77:1666-1670.

Moyle, P. B. 2002. Inland Fishes of California. Berkeley: University of California Press.

Moyle, PB., JD Kiernam, PK Crain and RM Quinones, 2012. Projected Effects of Future Climates on Freshwater Fishes of California. A White Paper from the California Energy Commission's California Climate Change Center.

Moyle P.B., J.V Katz, and R.M. Quinones. In review. Fish Species of Special Concern for California. Prepared for California Department of Fish and Game, Sacramento

Murphy, G.I. 1948. Notes on the biology of the Sacramento hitch *(Lavinia e. exilicauda)* of Clear Lake, Lake County, California. Calif. Fish Game 34:101-110.

Murphy, G.I. 1951. The fishery of Clear Lake, Lake County, California. *Calif. Fish and Game* 37: 439-484.

National Oceanic and Atmospheric Administration, 2011. Table 2. Toxicity associated with mercury in tissues (ug/g) wet weight.

Nicola, S.J. 1974. The life history of the hitch, *Lavinia exilicauda* Baird and Girard, in Beardsley Reservoir, California. Inland Fish. Admin. Rep. 74-6:1-16.

Osleger, D.A., R.A. Zierenberg, T.H. Suchanek, J.S. Stoner, S. Morgan, and D.P. Adam. 2008. Clear Lake sediments: anthropogenic changes in physical sedimentology and magnetic response. Ecological Applications 18 (Supplement): A239-A256.

Puckett, L., 1972. CDFG Memorandum-Fisheries Survey Clear Lake, Lake County.

Richerson P.J., T.H. Suchanek, and S.J. Why. 1994. The Causes and Control of Algal Blooms in Clear Lake, Clean Lakes Diagnostic/Feasibility Study for Clear Lake, California. Prepared for USEPA Region IX.

Ridout, W.L. 1899. A Fish Jam on Kelsey Creek. *Overland Monthly and Out West Magazine.* Volume 34, Issue 202. p. 333.

Robinson Rancheria Environmental Center (RREC). 2011. Draft Adaptive Management Plan for the Clear Lake Hitch, *Lavinia exilicauda chi*. Available at http://www.robinsonrancheria.org/environmental/water.htm.

Rowan, J., 2008. CDFG Clear Lake, Lake County Memorandum.

Rudd, R.L. 1964. *Pesticides and the Living Landscape*. University of Wisconsin Press, Madison, WI.

Sandheinrich, MB. And KM Miller, 2006. Effects of dietary methylmercury on reproductive behavior of fathead minnows (*Pimephales promelas*). *Environmental Toxicology and Chemistry.* 25(11):3053-3057.

Scotts Creek Watershed Assessment, February 2010. Prepared for West Lake Conservation District.

Scotts Valley Band of Pomo Indians, 2013. Historical accounts provided to CDFW by Steve Elliott and Wanda Quitiquit.

State of California Fish and Game Commission, March 11, 2013. California Fish and Game Commission Notice of Findings

State of California Fish and Game Commission, October 2, 2012. California Fish and Game Commission Notice of Receipt of Petition

Suchanek, T.H., P.J. Richerson, L.A. Woodward, D.G. Slotton, L.J. Holts and C.E. Woodmansee. 1993. Ecological Assessment of the Sulphur Bank Mercury Mine Superfund Site, Clear Lake, California: A Survey and Evaluation of Mercury In: Sediment, Water, Plankton, Periphyton, Benthic Invertebrates and Fishes Within the Aquatic Ecosystem of Clear Lake, California. Phase 1- Preliminary Lake Study Report. Prepared for EPA-Region IX, Superfund Program. 113 pp., plus 2 attachments.

Suchanek, T.H., P.J. Richerson, D.C. Nelson, C.A. Eagles-Smith, D.W. Anderson, J.J. Cech, Jr., G. Schladow, R. Zierenberg, J.F. Mount, S.C. McHatton, D.G. Slotton, L.B. Webber, A.L. Bern and B.J. Swisher. 2002. Evaluating and managing a multiply-stressed ecosystem at Clear Lake, California: A holistic ecosystem approach. "Managing For Healthy Ecosystems: Case Studies," CRC/Lewis Press. pp. 1233-1265.

Swift, C. 1965. Early development of the hitch, *Lavinia exilicauda,* of Clear Lake, California. Calif. Fish Game 51:74-80.

Thompson, L.C., G.A. Giusti, K.L. Weber, and R.F. Keiffer. 2013. The native and introduced fishes of Clear Lake: a review of the past to assist with decisions of the future. California Fish and Game 99(1):7-41.

U.S. Army Corps of Engineers. 1974[app]. Flood plain information: Big Valley streams (Manning, Adobe, Kelsey, and Cole Creeks), Kelseyville, California. Department of the Army, Sacramento District, Corps of Engineers, Sacramento, California, USA.

U.S. Environmental Protection Agency, 2012. Sulphur Bank Mercury Mine News Release – EPA to Begin Construction of Test Covers in Clear Lake.

Week, L., 1982. Habitat Selectivity of Littoral Zone Fishes at Clear Lake, CDFG California. Administrative Report No. 82-7.

Wetzel, R.G., 2001. Limnology lake and River Ecosystems, 3rd ed. Pg. 834.

Winder, M., J. Reuter and G. Schladow, 2010. Clear Lake Report: Clear Lake Historical Data Analysis.

Appendix A. Summary graphs of spawning observations between 2005 and 2013

Appendix B. Figures depicting CLH observations on spawning tributaries

Appendix C. Description of barriers associated with CLH spawning tributaries

Highland Springs Creek: There is a flood control dam on Highland Springs Creek, a tributary to Adobe Creek, which is impassable to CLH.

Adobe Creek: There is a flood control dam on Adobe Creek above Bell Hill Road that is impassable to CLH. There are two culverts on Adobe Creek that are mitigation barriers to spawning CLH when the water flows and velocity are not too great, but these culverts block CLH migration.

Alley Creek: Alley Creek has been channeled and diverted into Clover Creek. Alley Creek historically supported CLH runs. During some time and under certain conditions migrating CLH can access Alley Creek via the Clover channel bypass, but not when the diversion has silt or sand obstructing it.

Clover Creek: There was a diversion barrier on Clover Creek, a tributary of Middle Creek, which prevented fish passage into Clover Creek and Alley Creek. In 2004 the Robinson Rancheria received a Tribal Wildlife Grant to mitigate the diversion barrier. The work has been completed and the barrier has been modified and no longer obstructs fish passage. However, CLH must pass a concrete diversion structure at the junction with Alley Creek to the northwest of Upper Lake to gain the upper reaches of Clover Creek. This diversion structure usually becomes a complete barrier when filled with gravel and sediment.

Forbes Creek: Forbes Creek has a concrete storm water diversion structure that impedes and at times blocks CLH passage.

Kelsey Creek: On Kelsey Creek, the main barriers to CLH migration are a detention dam 2 to 3 miles upstream of Clear Lake, and the Main Street Bridge in Kelseyville. The rock and concrete weir constructed at the base of the Main Street Bridge is a barrier to the passage of CLH (Peter Windrem, personnel communication, 2012). The structure has a fish ladder which is nonfunctional and the site is nonetheless a total barrier to CLH (McGinnis and Ringelberg, 2008). The Kelsey Creek detention structure below Dorn Crossing has retractable gates which can be opened during the CLH spawning season. However, altered flow patterns and slight increases in the slope of the streambed have been enough to reduce the number of spawning CLH that can pass through the detention structure and move upstream. Also, rock riprap situated below the retention dam seems to have impeded the upstream migration of CLH and needs to be modified to provide a clear channel for fish transit. A number of drop-structures in Kelsey Creek intended for gravel aggradation impede migration. Some of these do not seem to impede CLH passage under current conditions, but CLH navigate them with difficulty especially on the downstream passage. Further upstream, culverts that once tended to clog with debris and block fish migration at the Merritt Road crossing have been removed and replaced by a bridge that poses no impediment to CLH passage.

Lyons Creek: A high culvert on Lyons Creek at Lakeshore Drive prevents CLH from moving upstream. Lyons Creek also has a concrete barrier at the County's Juvenile Hall facility that completely prevents fish passage.

Manning Creek: A dam upstream of known CLH spawning areas in the lower reaches of Manning Creek may prevent CLH from spawning further upstream.

Middle Creek: On Middle Creek, a rock and concrete weir at the Rancheria Road Bridge has been a total fish passage barrier for CLH. Remedial work has been done downstream, with more weirs installed in an effort to elevate the gradient so that CLH could surmount the barrier and work was done to improve their stability after high flows, but it remains to be seen if this will allow CLH passage. Similar weirs to capture and hold gravel were installed many years ago in Adobe Creek and Kelsey Creek that do not impede CLH passage, but there is concern the installed weirs on Middle Creek may be potential barriers to CLH. A downstream weir at Rancheria Road is a partial barrier and improperly sized rip rap at this location acts as partial migration barrier (McGinnis and Ringelberg 2008). CLH were seen recently at Middle Creek Bridge and Highway 20 and although there are no obvious barriers, they did not appear to be able to navigate the swift currents there due to the lack of resting pools. If CLH could surmount Rancheria Bridge, many additional miles of spawning grounds would be accessible to CLH up to areas south of Hunter Bridge, where habitat suitability ends because the channel is braided and shallow due to gravel mining.

Scotts Creek: On Scotts Creek, a rock and concrete weir at the Decker Bridge is a total barrier to the passage of CLH. As water levels have been lower, a barrier at the lower end of Tule Lake is problematic for fish passage to Tule Lake and its tributary Mendenhall Creek, Scotts Creek and tributaries, Bachelor Valley/Witter Springs area tributaries, and Blue Lakes and tributaries. There is a one-way flow gate on the Blue Lakes outlet at Scotts Creek that prevents CLH from entering Blue Lakes.

Seigler Canyon Creek: There are two barriers to CLH migration into Seigler Canyon Creek, an exposed sewer pipe and a road crossing. The sewer pipeline which crosses Seigler Canyon Creek for Anderson Marsh State Park was modified in the 1990s and completely blocks CLH access to that creek, once a major spawning tributary.

Page	Line	Reviewer Comment	Department Response
7	18	Hopkirk felt that the compressed body differentiated the lake ssp. from riverine ssp. You may want to identify that point as well.	No Change-difference is noted in next paragraph of document.
7	26	You just addressed my previous point.	Noted.
7	30	Do you have a citation for this?	No Change- sentence is referenced and the Department accepted Clear Lake hitch as a distinct subspecies in the Fish Species of Special Concern in California document from 1995.
9	24-25	suggested edit "all have of low gradients prior to entering the lake"	Accepted- sentence reworded.
9	26	I'm not sure about this. This may be true in the headwater regions of Kelsey Creek, Cole Creek and possibility others, but I believe surface water is found beyond the reach of hitch.	Accepted- sentence reworded.
9	29-30	suggested edit "resemble salmonid runs"	Accepted- sentence reworded.
10	28	Should we list other fish species e.g. catfish, other centrarchids?	Noted- sentence was removed based on other peer review comments.
11	9	I think you should spell this out the first time.	No Change- Chi Council for Clear Lake Hitch (CCCLH) is spelled out previously in the Life History section.
11	20	I know what your intention is here but we really don't have "spawning success" data i.e. fecundity numbers. Maybe "reduced number of adults observed" or something similar. None of the counts include night time observations	Accepted- sentence reworded.
11	35	You might want to consider a line that identifies turbidity following a rain can affect observation data collection. Simply to identify another variable.	Accepted- additional info added to paragraph describing Chi Council spawning observations.
13	14-16	Good point.	Noted.
13	25-27	More than fish numbers, I think this is a salient point. Trend analysis is more important that a single year data point due to the lack of flow in many historic spawning tribs in 2013.	Noted- Figure 3 Illustrates the number of spawning tributaries between 2005-2013.
13	27-29	Does this identify a need to better quantify and standardize a protocol to estimate annual fish migration numbers?	Noted- The Department is working with observers to create a more rigorous and scientifically valid survey protocol.
16	6-26	I know this is the information that is available but each anecdotal point is qualified that CLH would have been incidental to the effort. What is one to deduce from this?	Noted- The goal of the status review is to evaluate all existing data on CLH. Not all data allows for a specific conclusion to be drawn.
17	1-3	This last paragraph is good information.	Noted.
17	13	There is some local discrepancy about this picture. The image is certainly of cyprinids, but there is some dispute as to the species.	Accepted- sentence reworded.
17	5-23	This is all good information. It strikes me as out of place. Might it be better placed earlier in the document to provide a historical perspective followed by the information provided by Chi Council and Vector Control?	Noted- The format of the document is consistent with the requirements for a status review.
18	12	Not all of these acres represent converted wetlands, though some operations could potentially impact "wetland function".	Accepted- sentence reworded.
21	5	The County of Lake Special Districts diverts water from Kelsey Creek as the primary source of water for the town of Kelseyville. I think this statement may not identify all of the diversions equally. I know that ball field irrigation has caused a complete draw down on Cole Creek.....more than once	Accepted- Additional information added on diversions.
22	15-16	suggested edit "Erosion from construction, dredging, mining, agriculture, OHV use, grazing, residential development and urbanization"	No Change- This information was found in Forsgren Associates Inc. 2012. Residential development was not specifically mentioned.
22	26	suggested edit "Development and expansion of extensive and intensive agriculture in the Clear Lake"	No Change- extensive and intensive removed for lack of reference
23	4-8	This is true but in the case of CL the Lyngbya blooms have been attributed to the clarity of the water, and rooted vegetation has become problematic in the past ten years. Water clarity has been steadily increasing since 1969.	Noted- No references were cited by reviewer on increase in water clarity or rooted vegetation.
23	12-17	Again, this is very old data, I'm not sure it accurately reflects the current water quality conditions of the lake and I'm not sure of its relevance here.	No Change- The paragraph describes direct impacts to CLH resulting from water Cyanobacteria.
23	29	suggested edit "a primary food source for CLH and CL splittail"	No Change- The status review is addressing impacts to CLH.
24	10	I removed the word "extensively" as it is valued laden and subjective. It does not add to the discussion.	Accepted- sentence reworded.
24	13	I believe Komeen is a contact herbicide…check me on this.	Accepted- sentence reworded.
24	12-17	This is subjective. I know of no examples of tules being impacted. You need to include a reference if possible…at least in recent times.	No Change- The two herbicides are non selective and will impact any vascular plant they come in contact with. There is no claim that they impact a specific amount of tules just that they can.
26	24	suggested addition "Tule perch (Hysterocarpus traski) are accidentally caught or incidentally observed as recently as 2014 (Giusti, pers. communication) but quantified estimates of their populations do not exist.	No Change- The previous sentences are describing species that are extinct, extirpated, or possible extirpated from the lake. Tule perch do not fit in this group.
26	34	Introduced yes, but I'm not sure if the introduction was successful.	Noted- It is documented an introduction occurred but the species did not establish in the lake. A clarifying sentence has been added.
26	44	Is this the reference were Moyle goes so far to suggest that silverside may have played a role in the final demise of CL splittail?	Noted- Geary and Moyle 1980 does not suggest silversides played a role in the demise of Clear Lake splittail.
29	1-2	I would like to encourage the Dept to re-engage with anglers and conduct annual or even bi-annual creel surveys to address this data gap	Accepted- As part of the Management Recommendations and Recovery Measures the Department included angler surveys.
29	8	suggested edit "The number of tournaments per year is a function of the economy and has decreased since the recession that began in 2008. It is generally anticipated tournament numbers will increase again as the economy continues to improve."	Accepted premise- Information was added stating the decline in permitted tournaments between 2008-2013. Information on the function of the economy was omitted.
30	30	Should the tribes be included here?	Accepted-Sentence reworded
31	10	"was" past tense as the committee is no longer functioning as the mass increase of vineyard expansion has waned	Accepted- sentence reworded.

31	29	???? What is this?	RREC is defined in the Species Status and Population Trends section as Robinson Rancheria Ecological Center
31	29	What does the "H" stand for?	Accepted- HAMP changed to AMP throughout document.
32	32-36	Just so that you know, this "idea" has been in the works the entire time I have been in Lake County. Nearly 25 years	Noted.
33	20	We can hope the results would be "significant" but I think it is speculative at this time. I would omit this adjective.	Accepted- sentence reworded.
35	1-3	Though I agree with the premise, and undoubtedly predation from introductions is real, both LMB and catfish have co-existed with CLH for nearly 100 years. I'm not sure taken by themselves, we can make the argument that predation "threatens" their existence. Certainly a key factor affecting current population.	No Change- The language is consistent with the requirements of the status review under Fish and Game Code and Title 14.
35	6-16	I think Moyle has identified silversides as a causative agent for the extirpation of splittail (last straw if you will). I think if you look at creel data pre and post introduction of SS you will see a dramatic shift in species abundance.	Accepted- Information has been added on Mississippi silverside, threadfin shad, and CLH abundance.
35	22-24	suggested edit "If projected climate change models prove to be accurate potential impacts to California and the Clear Lake watershed could be significant during annual CLH spawning cycles.	Accepted - sentence reworded except for change to projected and from will to could be.
35	26	suggested edit "runoff could have negative impacts on the ability of CLH to successfully"	No Change- spawning impacts would be significant.
35	27-28	Citation?	No Change- These are summary sections the citations are in the more detailed impacts sections.
35	27-28	I agree however the conclusions are speculative at this time. I wasn't comfortable with the number of time the word "significantly" was used in the paragraph. Climate change may indeed be a huge factor, but individual weather events can provide the necessary water for spawning. I know I'm playing with words here but I think it better reflects how the debate for climate is evolving.	No Change- The language is consistent with the requirements of the status review under Fish and Game Code and Title 14.
35	31-33	suggested edit "However, though it is believed that recreational and tournament anglers' capture CLH incidentally, the occurrence is consider rare.	Accepted- sentence reworded.
General	none	You might want to review the Annotated Bibliography published by Weber, K. et.al. 2011 as it contains over 300 references to both Clear Lake and its fishes. Particularly you may find some useful and informative "gray literature" to assist you with historical perspectives.	Noted.

State of California – Natural Resources Agency
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January 13, 2014

Jerry J. Smith
Biological Sciences Department
San Jose State University
One Washington Square
San Jose, CA 95192

Dear Dr. Smith

CLEAR LAKE HITCH (*LAVINIA EXILICAUDA CHI*); DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW STATUS REPORT

Thank you for agreeing to serve as a scientific peer reviewer for the Department of Fish and Wildlife (Department) Draft Status Report of the Clear Lake hitch (*Lavinia exilicauda chi*). A copy of the Department's peer review draft status report, dated January 2014, is enclosed for your use in that review. The Department seeks your expert analysis and input regarding the scientific validity of the report and its assessment of the status of Clear Lake hitch in California based on the best scientific information currently available. The Department is interested in and respectfully requests that you focus your peer review effort on the body of relevant scientific information and the Department's assessment of the required population and life history elements prescribed in the California Endangered Species Act (CESA). The Department would appreciate receiving your peer review input on or before February 10, 2014.

The Department seeks your review as part of formal proceedings pending before the California Fish and Game Commission under CESA. As you may know, the Commission is a constitutionally established entity distinct from the Department, exercising exclusive statutory authority under CESA to list species as endangered or threatened. The Department serves in an advisory capacity during listing proceedings, charged by the Fish and Game Code to focus on the best scientific information available to make related recommendations to the Commission.

The Commission first received the petition to list Clear Lake hitch as threatened on September 25, 2012. The Commission accepted the petition for further consideration and the species was formally designated as a candidate species on March 22, 2013 following publication of regulatory notice by the Office of Administrative Law. The Clear Lake hitch is currently protected under CESA in California in that capacity.

The peer review Status Report forwarded to you today reflects the Department's effort over the past year to identify and analyze the best scientific information available regarding the status of Clear Lake hitch in California. Headed into peer review, the Department believes the best available science indicates that listing the species as threatened under CESA is warranted at this time. To be clear, we ask that you focus

your review on the scientific information and the Department's related assessment of the required population and life history elements prescribed in CESA rather than focusing on the tentative conclusion we share as a matter of professional courtesy. We underscore, however, that scientific peer review plays a critical role in the Department's effort to develop and finalize its recommendation to the Commission as required by the Fish and Game Code.

Again, because of the importance of your effort, we ask you to focus your review on the best scientific information available regarding the status of Clear Lake hitch in California. As with our own effort to date, your peer review of the science and analysis regarding each of the population and life history categories prescribed in CESA (*i.e.*, present or threatened habitat modification, overexploitation, predation, competition, disease, and other natural occurrences or human-related activities that could affect the species) are particularly important as well as whether they indicate, in your opinion, that Clear Lake hitch is likely to become, in the foreseeable future, at serious risk of becoming extinct throughout all or a significant portion of its range in California.

We ask that you assess our work for quality and conduct a thorough and proper review. As with all peer review processes, the reviewer is not the final arbiter, but your comments will inform our final decision-making. Also, please note that the Department releases this peer review report to you solely as part of the peer review process, and it is not yet public.

For ease of review, I invite you to use "track changes" in WORD, or provide comments in list form by page and line number of the report. Please submit your comments electronically to Kevin Thomas at kevin.thomas@wildlife.ca.gov, or he may be reached by telephone at (916) 358-2845.

If there is anything the Department can do to facilitate your review, please let me know. Thank you again for your contribution to the status review effort and the important input it provides during the Commission's related proceedings.

Sincerely,

Stafford Lehr
Chief, Fisheries Branch

Enclosure(s)

cc: Tina Bartlett
CDFW-NCR

Thomas Gibson
CDFW-OGC

Katherine Hill
CDFW-NCR

Kevin Thomas
CDFW-NCR

State of California
Natural Resources Agency
Department of Fish and Wildlife

REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF CLEAR LAKE HITCH (*Lavinia exilicauda chi*)

January 2014 Preliminary Draft for Peer Review

Clear Lake hitch adult. Photo courtesy of Rick Macedo

Charlton H. Bonham, Director
Department of Fish and Wildlife

Report to the Fish and Game Commission
A STATUS REVIEW OF CLEAR LAKE HITCH

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EXECUTIVE SUMMARY

This status review report describes the current status of Clear Lake hitch (*Lavinia exilicauda chi*) (CLH) in California as informed by the scientific information available to the California Department of Fish and Wildlife (Department, CDFW, CDFG).

Background

- September 25, 2012: The Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity to list CLH as threatened under the California Endangered Species Act (CESA) (Center for Biological Diversity 2012).
- September 26, 2012: The Commission sent a memorandum to the Department, referring the petition to the Department for its evaluation.
- October 12, 2012: The Commission provided notice of the received petition from the Center for Biological Diversity to list CLH as threatened under CESA (Cal. Reg. Notice Register 2012, Vol. 41-Z, p.1502).
- December 12, 2012 the Commission granted a 30-day extension on the submission date for the Department's Initial Review of Petition to List the Clear Lake Hitch as threatened under CESA.
- January 31, 2013: The Department provided the Commission with an Initial Review of Petition to List the Clear Lake Hitch as Threatened under the California Endangered Species Act pursuant to Fish and Game Code, section 2073.5. The Department's review recommended that the petition provided sufficient information to indicate the petitioned action may be warranted, and the petition should be accepted and considered (CDFW 2013).
- March 6, 2013: At its scheduled public meeting in Mt. Shasta, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received by the Commission and found that the petition provided sufficient information to indicate the petitioned action may be warranted.
- March 22, 2013: The Commission published its Notice of Findings in the California Regulatory Notice Register (CA Reg. Notice Register 2013, Vol. 12-Z p. 488), stating the petition was accepted for consideration, and designated CLH as a candidate species.

Summary of Findings

Note to Reviewer: This Summary of Findings will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

Status

Threats

Petitioned Action

Management and Recovery Recommendations

INTRODUCTION

This status review report addresses the Clear Lake hitch (*Lavinia exilicauda chi*) (CLH), the subject of a petition to list the species as threatened under the California Endangered Species Act (CESA) (Fish & G. Code § 2050 *et seq*.).

Petition History

On September 25, 2012, the Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity (Petitioner) to list the CLH as a threatened species under CESA.

On September 26, 2012 the Commission sent a memorandum to the California Department of Fish and Wildlife (Department, CDFW, and CDFG) referring the petition to the Department for its evaluation.

On October 12, 2012, as required by Fish and Game Code, section 2073.3, notice of the petition was published in the California Notice Register (Cal. Reg. Notice Register 2012, Vol. 41-Z, p.1502).

On December 12, 2012 the Commission granted a 30-day extension on the submission date for the Department's Initial Review of Petition to List the CLH as threatened under CESA.

On January 31, 2013, the Department provided the Commission with its Initial Review of Petition to List the CLH as threatened under CESA. Pursuant to Fish and Game Code, section 2073.5, subdivision (a) (2), the Department recommended that the petition provided sufficient information to indicate the petitioned action may be warranted.

On March 6, 2013 at its scheduled public meeting in Mt. Shasta, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received, and found that sufficient information existed to indicate the petition may be warranted and accepted the petition for consideration.

Subsequently, on March 22, 2013 the Commission published its Notice of Findings for CLH in the California Regulatory Notice Register, designating the CLH as a candidate species (CA Reg. Notice Register 2013, Vol. 12-Z p. 488).

Department Review

Following the Commission's action to designate CLH as a candidate species, the Department notified affected and interested parties and solicited data and comments on the petitioned action, pursuant to Fish and Game Code, section 2074.4 (see also Cal. Code Regs., Title 14, § 670.1(f)(2)) (CDFW 2013). All comments received are included in Appendix D to this report. The Department commenced its review of the status of the species as required by Fish and Game Code section 2074.6.

This report reflects the Department's scientific assessment to date of the status of CLH in California. At this point, the report will undergo independent and competent peer review by scientists with acknowledged expertise relevant to the status of CLH. Once peer review is completed Appendix E will contain the specific input provided to the Department by the individual peer reviewers (Cal. Code Regs., Title 14, § 670.1(f) (2)).

BIOLOGY

Species Description

Clear Lake hitch is a member of the cyprinid family (Cyprinidae), growing to 35 centimeters (cm) standard length (SL), and with laterally compressed bodies, small heads and upward pointing mouths (Moyle et al. 1995). They are separated from other California minnows by their long anal fin consisting of 11 to 14 rays. The dorsal fin (10 to 12 rays) originates behind the origin of the pelvic fins. Juvenile CLH have a silver coloration with a black spot at the base of the tail. As CLH grow older the spot is lost and they appear yellow-brown to silvery-white on the back. The body becomes deeper in color as the length increases (Hopkirk 1973; Moyle 2002). CLH show little change in pigmentation during the breeding season (Hopkirk 1973). The deep, compressed body, small upturned mouth, and numerous long slender gill rakers (26 to 32) reflect the zooplankton-feeding strategy of a limnetic forager (Moyle 2002). This lake adapted subspecies also has larger eyes and larger scales than other hitch subspecies.

Taxonomy

Hopkirk (1973) described CLH as a lake-adapted subspecies based primarily on the greater number of fine gill rakers. CLH are distinguished from other subspecies of hitch by their deeper body, larger eyes, larger scales and more gill rakers (Hopkirk 1973). Recent research on 10 microsatellite loci supports Hopkirk's description of CLH as a distinct subspecies (Aguilar et al. 2009). However, mitochondrial DNA analysis has not been able to distinguish CLH as a distinct subspecies from other hitch in California. Yet, based upon the morphological and microsatellite analysis there is sufficient evidence to warrant the designation of CLH as a distinct subspecies of hitch (Hopkirk 1973; Moyle et al. 1995; Aguilar et al. 2009).

CLH can hybridize with other Cyprinidae species and hybridization is known to occur with the genetically similar California roach (*Lavinia symmetricus*) (Miller 1945b; Avise and Ayala 1976; Moyle and Massingill 1981; Moyle et al. *in review*). However, there is no documentation of these hybrids in Clear Lake. CLH were known to hybridize in Clear Lake with the now extinct thicktail chub (*Gila crassicauda*) (Moyle et al. *in review*).

Range and Distribution

The entire CLH population is confined to Clear Lake, Lake County, California, and to associated lakes and ponds within the Clear Lake watershed such as Thurston Lake and Lampson Pond (Figure 1). Populations previously identified in the Blue Lakes, west of Clear Lake, have apparently been extirpated (Macedo 1994).

Comment [JS1]: Blue Lakes, Thurston Lake, and Lampson Pond are small and not a substitute for the Clear Lake population. However, their ecology and status may give insight into factors involved in Clear Lake. Why was the Blue Lakes population extirpated?

Comment [JS2]: Can Blue Lakes be included in the map?

Figure 1. Map depicting the Clear Lake watershed.

Life History

Physical adaptations to lake conditions allow CLH greater than 50 millimeters (mm) SL to feed almost exclusively on water fleas (*Daphnia* spp.) (Geary 1978; Geary and Moyle 1980; Moyle 2002). Stomach analysis indicates that CLH feed primarily in the day rather than at night (Geary 1978). Juveniles less than 50 mm SL are found in shallow, littoral zone (near-shore) waters and feed primarily on the larvae and pupae of chironomidae; planktonic crustaceans including the genera *Bosnia* and *Daphnia*; and historically on the eggs, larvae, and adults of Clear Lake gnat (*Chaoborus astictopus*) (Lindquist et al. 1943; Geary 1978; Geary and Moyle 1980). Growth in CLH is faster and total size greater than that of other hitch subspecies (Nicola 1974). By three months CLH have reached 44 mm SL and will continue to grow to between 80 to 120 mm by the end of their first year (Geary and Moyle 1980). Females become mature by their second or third year, whereas males tend to mature in their first or second year (Kimsey 1960). Females grow faster and are larger at maturity than males (Hopkirk 1973; Geary 1978; Ringelberg and McGinnis 2009). The larger size of CLH in comparison to hitch from other locations translates to greater fecundity. Accordingly, spawning females in Clear Lake average 36,000 eggs each year (Geary and Moyle 1980) compared to an average of 26,000 eggs for hitch in Beardsley Reservoir (Nicola 1974).

Comment [JS3]: Longevity may be an important issue. Longevity based upon scales appears to be 4-6 years (Geary 1978, Moyle 2002), but the periodically relatively high population sizes are often spaced farther apart than that. Have otoliths been examined to determine if hitch in Clear Lake live much longer than scales indicate (due to little growth in old fish), as has been demonstrated in a number of lake fishes, such as Tui chubs, Cui ui, tahoe suckers, etc. This may explain how hitch have managed to persist despite infrequent good reproductive success.

Clear Lake tributaries are numerous and located around the lake basin (Figure 1). Most streams have headwaters at higher elevations in the surrounding foothills; others have headwaters in lower elevations of the basin, and nearly all have low gradients. Some streams are more substantial than others with flowing water year round. Most are seasonal with remnant pools occurring by late spring, and subsequently dry during summer months. Those that retain water year round often have long stream reaches that are ephemeral. CLH spawn in these low-gradient tributary streams and form spawning migrations that resemble small scale salmon runs. Spawning migrations usually occur in response to heavy spring rains, from mid-February through May and occasionally into June (Murphy 1948b; Kimsey 1960; Swift 1965; Chi Council for Clear Lake Hitch (CCCLH) 2013 (unpublished data)). During wet years, CLH spawning migrations may also opportunistically extend into the upper reaches of various small tributaries, drainage ditches, and even flooded meadows (Moyle et al. *in review*). CLH have also been observed spawning along the shores of Clear Lake, over clean gravel in water 1 to 10 cm deep where wave action cleans the gravel of silt (Kimsey 1960). The success of these atypical spawning areas is not clearly understood and may be limited due to losses from egg desiccation and juvenile predation (Kimsey 1960; Rowan, J. personal communication, October 10, 2013, unreferenced).

CLH spawn at water temperatures of 14 to 18°C in the lower reaches of tributaries. Egg deposition occurs along the margins of streams in very shallow riffles over clean, fine-to-medium sized gravel (Murphy 1948b; Kimsey 1960). Eggs are fertilized by one to five males as they are released from the females (Murphy 1948b; Moyle 2002). Eggs are non-adhesive and sink to the bottom after fertilization, where they become lodged among the interstices in the gravel. The eggs immediately begin to absorb water and swell to more than double their original size. This rapid expansion provides a protective cushion of water between the outer membrane and the developing embryo (Swift 1965) and may help to secure eggs in gravel interstices. The embryos hatch after approximately 7 days, and larvae become free-swimming after another 7 days (Swift

1965). Larvae must then move downstream to the lake before stream flows become ephemeral (Moyle 2002).

Within Clear Lake, larvae remain near shore and are thought to depend upon stands of tules (*Schoenoplectus acutus*) and submerged weeds for cover until they assume a limnetic lifestyle (CDFG 2012). Juvenile CLH require rearing habitat with water temperatures of 15° C or greater for survival (Moyle 2002; Franson 2012 and 2013). Juveniles are found in littoral shallow-water habitats and move into deeper offshore areas after approximately 80 days, when they are between 40 to 50 mm SL (Geary 1978; CDFG 2012). Adult CLH are usually found in the limnetic zone (well-lit, surface waters away from shore) of Clear Lake. The limnetic feeding behavior of adult fish is supported by stomach analysis of CLH where very little content of benthic midges was found, even though the fish were collected in the profundal (deep-water) habitat during the survey (Cook et al. 1964). Additional data collected by the Department during the early 1980s indicates CLH are present in the littoral zone from April to July and are absent from this habitat during other months (Week 1982).

Adult CLH are vulnerable to predation during their spawning migration by mergansers (*Mergus* spp.), herons (*Ardea* spp.), bald eagles (*Haliaeetus leucocephalus*), and other birds, river otter (*Lontra canadensis*), northern raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*) (Bairrington 1999). In addition, CLH have been recovered from the stomachs of black bass (*Micropterus* spp.) caught in the lake (Bairrington 1999). Most predation by black bass likely occurs during spring staging periods as CLH congregate and begin to ascend tributaries to spawn (Rowan, J. personal communication, October 10, 2013, unreferenced).

Habitat that May be Essential to the Continued Existence of the Species

At various life stages CLH utilize stream and lacustrine (lake) habitat present in the watershed (Figure 1). Adult fish spawn in the tributaries of the lake during the spring and juvenile fish emerge from the tributaries and utilize near shore habitats to continue growth and seek refuge from predators. As juveniles mature into adults they move to the main body of the lake and assume a limnetic lifestyle until returning to spawn in the tributaries the following spring.

Comment [JS4]: Based upon habitat uses by most hitch compared to inland silverside and largemouth bass, is the limnetic zone a relative refuge; are spawning success and survival of juveniles in tule beds and other shoreline habitats the major potential problems. Are data available to answer this question?

SPECIES STATUS AND POPULATION TRENDS

An assessment of the status of CLH should include statistically valid population estimates conducted over time, to provide population data and trends. CLH studies to date have consisted primarily of qualitative sampling and are not suitable for deriving population estimates; however, these study results can provide insight into the current status of the species.

The population trends for this status review focus on three sets of data available to the Department for analysis. First, commercial catch records, submitted to the department by operators on Clear Lake, contain incidental catch information on CLH dating back to 1961. Operators were required to keep records of CLH caught incidentally while operations focused on other species in the lake. Second, the Lake County Vector Control District (LCVCD) has been conducting sampling efforts along the shoreline of Clear Lake since 1987. Although sampling efforts are not specific to CLH, LCVCD recorded incidental data on CLH captured during each sampling. Third, spawning observation data have been collected by volunteers with the CCCLH since 2005. Spawning observation data provide an estimate of the number of CLH in any given spawning tributary during the observation period. Results are summarized by the CCCLH each year following the completion of the spawning season. Information on population trends prior to 1961 is focused on small sampling efforts, published articles, and traditional ecological knowledge from tribal members. Although not quantifiable, this data provides an idea of the status and distribution of CLH prior to larger qualitative sampling efforts.

Environmental conditions required for successful spawning and biological impacts to the survivorship of CLH are highly variable from year to year and often result in multiple years with reduced spawning success or reduced recruitment into the population. The information presented in Figure 2 comes from the three qualitative sampling efforts conducted at Clear Lake and measured rainfall totals during the past 52 years in the watershed. Trend data in commercial catch records were represented for a given year by totaling the number of CLH captured per year and dividing by the number of days commercial operations occurred. Commercial catch data are comprised primarily of adult CLH. The CLH spawning trend data were calculated by totaling the number of CLH observed and dividing by the number of observation periods. LCVCD data on CLH captures represent the total number of CLH captured per year. LCVCD data is comprised primarily of juvenile CLH. The data represented from Table 6 of CDFG (1999) were calculated by using 20,000 as a total catch baseline for percent of total catch for CLH. Total rainfall data for January to June of each year was measured at the Clear Lake Highlands and U.S. Geological Survey rainfall gauges. Figure 2 does not reflect population numbers but rather trends in the abundance of CLH in any given year. As a proxy for changes in an established population size, biologists often use qualitative information as an indicator of population trends.

The trends of all data show a highly variable population that responds both positively and negatively to environmental parameters and varies significantly from year to year. Rainfall totals do not appear to be significantly correlated to the abundance of CLH during the timeframe. It is likely that a combination of environmental factors is impacting the CLH population. The fluctuating abundance trend has continued throughout the duration of the qualitative sampling efforts and indicates CLH populations have at times been extremely low and at other times relatively robust.

Comment [JS5]: Is the commercial fishing effort that supplies important incidental catch numbers quantifiable or was it reasonably similar among years. You are using number of days commercial operations occurred—is that a good measure of effort among years? The incidental catch numbers may be very misleading if effort was substantially different among years; can the incidental catch be converted to catch per unit effort to provide a more useful index?

Comment [JS6]: Rainfall totals or January – June totals (figure 2) are not a good index of stream runoff conditions during the mid-February to May period when hitch are spawning and fry are moving down to the lake (they certainly don't match my experience with streamflow conditions in the central coast for the last 1- 2 decades). A better proxy would be runoff totals (or days over 10 cfs?) at the USGS gage on Kelsey Creek or other available stream gages (Adobe Cr?).

Comment [JS7]: See comment above

Figure 2. Clear Lake hitch population trends over the past 52 years as measured by three methods of qualitative sampling and spawning season rainfall totals as recorded at the Clear Lake Highlands and U.S. Geological Survey 385525122335501 rainfall gauges. Data in blue tones corresponds to the primary y axis and data in red tones corresponds to the secondary y axis.

Comment [JS8]: See rainfall comment above

In 2013 the Department conducted a mark-and-recapture study to gain a better understanding of the CLH spawning population in Cole and Kelsey creeks. Unfortunately, too few individuals were marked and recaptured to give a statistically valid population estimate (Ewing 2013). Electrofishing surveys in June 2012 identified thousands of young of year CLH in near shore habitats along the southwestern shoreline of Clear Lake (CDFG 2012). Volunteers with the CCCLH conducted direct observations of CLH in spawning tributaries of Clear Lake in 2013, and spawning observations identified less than 500 CLH present (CCCLH 2013). Of those fish, 300 to 400 were found below the Kelsey Creek detention dam. No single day count totaled more than 70 fish in any spawning tributary in 2013 (CCCLH 2013).

CCCLH qualitative spawning observations between 2005 and 2013 indicated peak single day CLH spawning runs of 1,000 to 5,000 fish (CCCLH 2013), and daily observation averages ranged from 3.5 to 183.1 fish (Figure 2). However, these observations make no distinction between previously counted fish, and it may be more prudent to look at fixed location single day counts from this time period. The highest number of CLH observations recorded was approximately 5,000 during 2005; concurring with beach seine data that demonstrate a higher than average number of CLH caught in 2005 as well (CCCLH 2013; LCVCD 2013). The increased number of juvenile CLH captured in the 2005 beach seine sampling is the likely reason for the increase in adult spawning observations between 2007 and 2009. Appendix A contains summary graphs and figures, prepared by CCCLH, for observations made between 2005 and 2013.

There is sufficient information from these spawning observations to suggest the number of spawning tributaries being used by CLH decreased in 2013 compared to the average from 2005 to 2012 (Figure 3) (CCCLH 2013). However, the data limitations do not allow for quantification of observation time on each creek (survey effort) compared with the number of fish observed to aid in understanding the extent of use in each tributary. Appendix B contains figures depicting the decline in annual spawning runs in Clear Lake tributaries between 2005 and 2013 (CCCLH 2013). Historic accounts and habitat suitability predications suggest that CLH originally spawned, to some degree, in all the tributaries to Clear Lake (Robinson Rancheria Ecological Center (RREC) 2011). However, reports on Pomo geography speak of Pomo tribes in the area travelling to Kelsey Creek to capture CLH and even of war when a tribe tried to divert Kelsey Creek to gain control of the important CLH supply (Barrett 1906; Kniffen 1939). Based on the reports it is unclear to what extent CLH spawned in other tributaries to Clear Lake. It can be surmised the majority of CLH spawning occurred in Kelsey Creek during this period. Over the past eight years the number of occupied spawning tributaries has decreased from a high of 12 in 2006 to three in 2013 (CCCLH 2013). Currently, Adobe Creek seems to have the largest spawning run in the Clear Lake watershed while Kelsey and Cole creeks support smaller spawning runs. Based on historical accounts the primary spawning tributary has shifted from Kelsey Creek to Adobe Creek (Kniffen 1939; CCCLH 2013).

Figure 3. Number of occupied Clear Lake hitch spawning tributaries documented by CCCLH observers between 2005 and 2013.

Comment [JS9]: The number of occupied spawning tributaries seems to track pretty closely with runoff during March through May. 2005 and 2006 and 2010 and 2011 were the et years for spring runoff and hitch access. 2007 and 2013 were the dry years with winter/spring stream flow dropping quickly. 2012 was relatively dry, but the majority of stream flow was late (March and April).

This chart would benefit by graphing both the number of streams and the mid-February to May rainfall total or number of days above a threshold flow.

LCVCD has been collecting beach seine data at various sites around the lake for more than two decades. The sampling is designed to measure abundance of threadfin shad (*Dorosoma petenense*) and inland silversides (*Menidia beryllina*) as part of a Clear Lake gnat (*Chaoborus astictopus*) surveillance program. Incidental captures of CLH are recorded during these surveys; however, the data collected are not appropriate for a statistically valid evaluation of CLH populations as the sample design varies significantly in timing, water quality conditions, and lake depth during surveys. Additionally, sample locations are in areas that contain open unvegetated beaches that are not preferred habitat for CLH. Although surveys were not conducted to assess CLH, capture data for these surveys is consistent with other data sources in demonstrating a population that has poor recruitment in many years interspersed with few years of high levels of recruitment (Figure 4) (LCVCD 2013). In most years less than 100 CLH are captured during the surveys (17 of 24 years). Four of the six years when more than 100 CLH were captured were between 2005 and 2010. The greatest numbers of CLH were captured in 1991, a year that was described by the Department as a boom for juvenile fish in the lake (Bairrington 1999). Commercial fisheries data from 1991 also indicate an increase in CLH numbers captured during operations; over 6,000 CLH were captured and released by commercial fishery operators between March and May in 1991 (CDFW Commercial Fisheries Data). Data from the early 1990s also indicate an increase in zooplankton and macroinvertebrate numbers resulting in increased available forage for CLH (Winder et al. 2010).

Figure 4. Summary of Clear Lake hitch captured during Lake County Vector Control District beach seine surveys conducted from 1987 to 2010.

The data available to the Department that cover the greatest timeframe come from commercial harvest records for Clear Lake. These data, 1961 to 2001, provide estimates of CLH numbers captured incidentally during operations (Figure 5). Multiple times throughout the past 50 years the number of CLH captured has surpassed 10,000 fish. There are also several years where CLH were almost or entirely absent from sample collections. These data suggest that CLH can sustain a population through multiple years of suppressed spawning or recruitment or both.

Comment [JS10]: Too bad the commercial harvest had not continued soo that we would have recent data.

Figure 5. Number of Clear Lake hitch captured incidentally during commercial harvest operations between 1961 and 2001.

In the 1980s, the Department began sampling Clear Lake fishes to assess native and sport fish populations in the lake. Surveys found CLH occupying littoral habitats between April and July each year (Week 1982). The surveys were directed towards littoral zone use and provide no information on CLH outside of those months (Week 1982). An electrofishing survey was completed in April of 1987, and CLH was the most abundant fish sampled at locations around Rattlesnake Island and Clearlake Oaks subdivision; however, only a total of 52 CLH were captured during the survey (CDFG 1988). It must be noted that this sampling was on a very small scale, targeted black crappie (*Pomoxis nigromaculatus*), and occurred in habitats where CLH would likely be found during this time period. Additional spring and fall sampling between 1995 and 2006 found CLH to be the most abundant native fish, but the overall capture numbers were relatively low with a peak catch per unit effort (CPUE) of only 0.087 for juvenile fish in the fall of 2000 and 0.169 for adult fish in the spring of 1999. CPUE's were based on the number of fish caught per minute of electrofishing (Cox 2007). Electrofishing surveys conducted during late June 2007 reported low numbers of CLH recorded during the survey (Rowan 2008). The low numbers of CLH may be attributed to the sampling timeframe in late June. As noted in Cook et al. 1964, CLH were absent from littoral zone sampling following the start of summer. In an effort to reduce impacts to CLH while sampling, the Department's Clear Lake surveys between 2008 and 2012 were all confined to the timeframe of late June and July when CLH numbers are greatly reduced in the littoral zone.

Comment [JS11]: Most abundant, but only 52 CLH captured? Electrofishing the small juveniles may not be an effective sampling technique. Trap nets?

Comment [JS12]: It appears to concerns about mortality eliminated sampling during the crucial period of CLH juvenile use of the littoral zone, so you did not get the necessary data. Isn't the data worth some incidental mortality?

If the species is listed, such an approach in collecting permits and monitoring may cripple effective monitoring needed to track population status. Similarly, it seems that the incidental catch data in the commercial harvest was extremely valuable data; can a resumption of carp and blackfish commercial harvest be encouraged to produce hitch data?

As late as 1972, CLH and other nongame fish were described as comprising the bulk of the Clear Lake fishery (Puckett 1972). The Lake County Mosquito Abatement District conducted surveys between 1961 and 1963 examining the relationship between fish and midges. These surveys identified CLH as the third most abundant fish in the lake. The majority of CLH were captured in the littoral and profundal zones using gill nets. However, the limnetic zone was not sampled since midges do not occur in this area. A total of 1,229 fish was taken during these surveys (Cook et al. 1964).

Field notes from CDFG biologists in 1955 note CLH runs with large numbers in Kelsey Creek (CDFG 1955). Similar notes from 1956 indicate spawning CLH in Kelsey Creek as numbering in the hundreds and Seigler Creek containing 400 CLH for every 100 feet of stream above the Anderson Brothers ford (CDFG 1956). CLH were the second most abundant fish caught during various gill net surveys in the lake at that time (Lindquist et al. 1943). Surveys conducted between 1938 and 1941, for examination of fish and gnat interactions, describe the runs of Sacramento splittail (*Pogonichthys ciscoides*) and CLH as numbering in the tens of thousands (Lindquist et al. 1943). A photograph from 1890 depicts a spawning run so thick that CLH formed a blanket across the creek (Figure 6). Early stories from the area describe fish runs so thick that streams were difficult to ford by horses and wagons, and residents shoveled spawning fish to bring home for hog feed (Rideout 1899). The volume of dead fish found during spawning runs on Clear Lake tributaries created a stench that was intolerable to lakeshore residents (Dill and Cordone 1997). It is not entirely clear if spawning runs such as those depicted in Figure 6 occurred every year or fluctuated based on tributary flows, but it is likely they fluctuated in a similar fashion to what was observed during the past decade of CCCLH spawning surveys. Regardless, the body of evidence lends support for claims of CLH as common and the most abundant fish in Clear Lake during the late nineteenth and early twentieth centuries (Coleman 1930; Jordan and Gilbert 1894).

Figure 6. Photo from 1890s depicting spawning CLH being stranded in Kelsey Creek.

FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE

Present or Threatened Modification or Destruction of Habitat

Wetland Habitat Loss

Wetlands provide critical rearing habitat for juvenile fishes native to Clear Lake (Geary 1978; CDFG 2012). Prior to the arrival of European settlers in the mid-1800s, Clear Lake was surrounded by large tracts of wetlands. Throughout the expansion of European settlements around the lake, the wetland habitat was drained and filled to provide urban and agricultural lands. Currently, the Clear Lake watershed contains over 16,000 acres of land dedicated to agricultural production (Lake County Department of Agriculture 2011; Forsgen Associates Inc. 2012). Comparisons of historical versus current wetland habitat reveal a loss of approximately 85%, from 9,000 acres in 1840 to 1,500 acres by 1977 (Week 1982; Bairrington 1999; Suchanek et al. 2002; ; Lake County Department of Public Works 2003; Giusti 2009; CEPA 2012). Loss of wetland habitat coupled with competition for existing habitat with introduced fishes has led to a decline in available rearing habitat for juvenile CLH (Week 1982).

Spawning Habitat Exclusion and Loss

Dams, Barriers, and Diversions

Cache Creek Dam was constructed at the outlet of Clear Lake in 1915, and Yolo County Flood Control and Water Conservation District (YCFCWCD) manipulates the lake water level several feet seasonally to allow for diversions for irrigation (CDWR 1975). Clear Lake is allowed to fluctuate on a yearly basis, a maximum of 7.56 feet above a mean level plane referred to as the "Rumsey gage" (CDWR 1975). The effects of lake water manipulations on CLH populations have not been quantified. Manipulation of water levels in the Clear Lake watershed likely results in decreased water quality, a reduction in spawning and rearing habitat, and increased risk of predation (Converse et al. 1998; Wetzel 2001; Gafny et al. 2006; Cott et al. 2008; Hudon et al 2009). All of these impacts can lead to the extinction of native species that evolved in lakes free of habitat modifications resulting from impoundment structures (Wetzel 2001). Impounded systems also tend to be dominated by non-native species (Moyle and Light 1996).

CLH spawn in low-gradient tributary streams to Clear Lake. All of the tributary streams to Clear Lake have been altered (Appendix C) to various degrees by dams, barriers, and diversions. Stream alterations can block migratory routes and decrease stream flows necessary for spawning. The result can be loss of spawning and rearing habitat, loss of nursery areas, increases in predation, competition from non-native aquatic species, and decreased water quality (Murphy 1948 and 1951; Moyle 2002;). A limited physical habitat analysis survey was conducted in 2013 on Adobe, Kelsey, Manning, Middle, and Scotts creeks. Results of the survey indicate all of the creeks had low Index of Biological Integrity (IBI) scores and are either partially or not supportive of aquatic life (Mosley 2013). Examples of alterations to Clear Lake tributaries that have impacted CLH include agricultural irrigation pumps and diversions, aggregate mining activity, flood control structures, road crossings, bridge aprons, and off-highway vehicle (OHV) use (McGinnis and Ringelberg 2008).

Comment [JS13]: Not in references

Adobe Creek, Highland Creek, Middle Creek, Clover Creek, and Kelsey Creek have experienced a reduction in fish spawning habitat since the installation of dams and increased irrigation (Murphy 1951; Macedo 1994; McGinnis and Ringelberg 2006). A barrier assessment was completed in 2006 for Middle Creek and the Kelsey Creek fish ladder (McGinnis and Ringelberg 2006). The assessment found physical barriers to fish migration were associated with bridge aprons and weirs as well as habitat barriers from historical gravel operations (McGinnis and Ringelberg 2006). The Kelsey Creek fish ladder was found unsuitable for passage of CLH. The jump heights and velocities at the ladder were determined to be too great for CLH (McGinnis and Ringelberg 2006). Spawning observations by CCCLH from 2005 to 2013 witnessed fish stranded below multiple barriers within the watershed (CCCLH 2013).

Many Clear Lake tributaries are no longer used for spawning or have reduced spawning runs as a result of artificial structures that continue to impede spawning migrations (Figure 7). While some operational and physical modifications to these structures have been implemented over the years, they continue to adversely impact spawning CLH, especially during dry years when spring stream flows are low.

In preparation of this report, the Department estimated the loss of CLH spawning and rearing habitat due to constructed barriers and impediments within the tributaries to Clear Lake (Figure 7). The barrier assessment determined the approximate locations of barriers and estimated miles of stream habitat as determined from the California Native Diversity Database, CDFW Geographic Information System, CDFW Fish Passage Assessment Database, California GIS street layer, and Google Earth Maps. Using that data, the Department estimated 180 river miles were historically available to spawning CLH and that barriers have eliminated or reduced access to greater than 92% of the historically available spawning habitat. Physical barriers, such as the footings of bridges, low water crossings, dams, pipes, culverts, and water diversions in Kelsey, Scotts, Middle, Clover, and other creeks interrupt or eliminate migration to spawning areas (McGinnis and Ringelberg 2008). Appendix C contains a list of several tributaries and some of their associated barriers.

Figure 7. Clear Lake hitch spawning barriers located on tributaries throughout the watershed.

Water is frequently diverted from Clear Lake tributaries, during the CLH spawning season, under riparian rights associated with land ownership in the watershed. These water diversions consist of direct diversion from surface water intake pumps and from shallow off-channel wells that capture groundwater flows. The primary purpose of water diversions from Clear Lake tributaries is for agricultural production and frost protection. Water diversions for frost protection have been shown to temporarily reduce in-stream flow by as much as 95% (Deitch et al. 2009). Natural flow regimes are thought to favor the success of native fishes over non-native fishes (Marchetti and Moyle 2001). The impact of diversion on CLH spawning tributaries is poorly understood. In some tributaries, water diversion has contributed to early drying of stream reaches and desiccation of CLH eggs masses and newly hatched juveniles (Macedo, R., personal communication, November 25, 2013, unreferenced). Additionally, significant flow reductions can lead to increased water temperatures, reduced available aquatic habitat, altered or decreased biodiversity, increases in non-native species, and alterations to fish assemblages (Marchetti and Moyle 2001; Bunn and Arthington 2002; Bellucci et al. 2011).

The impacts of spawning habitat alterations to CLH may be inferred by the fate of another native Clear Lake fish that required tributaries for spawning; the Clear Lake splittail was last recorded in 1972 (Puckett 1972). The Clear Lake splittail formerly spawned later in the season than did CLH, and the drying up of tributaries contributed to their demise (Moyle 2002). All stream spawners had “declined precipitously” by 1944 (Murphy 1951). Therefore, earlier drying of tributaries by both natural and anthropogenic processes likely impacts the CLH population.

Dredging and Mining

Since the first European settlers arrived at Clear Lake and began gravel mining and dredging operations, there have been documented deleterious effects on the watershed (Suchanek et al. 2002). Field notes from CDFG personnel conducting stocking assessments documented Kelsey Creek so loaded with silt from gravel operations that creek visibility was zero (CDFG 1955). Smaller scale mining and dredging in tributary streams has occurred since early settlement and has altered the amount and distribution of stream gravels (Thompson et al. 2013). In some tributaries, gravel extraction has resulted in the incising and channelizing of the streams and stream level changes by as much as 15 feet (Suchanek et al. 2002; Eutenier, D. April 17, 2013 comment letter). After 1965 about one million metric tons of gravel products per year were removed from the watershed until the partial moratorium on aggregate mining in 1981 (Richerson et al. 1994). Gravel was removed from Clear Lake tributaries to provide road base for new roads created to accommodate the expanding population of the area (Suchanek et al. 2002). Currently, approximately 58 acres in the Clear Lake watershed are used for mining purposes (Forsgren Associates Inc. 2012).

Many areas along the tributaries to Clear Lake were channelized in response to frequent flooding during the late winter and early spring (Maclanahan et al. 1972; U.S. Army Corps of Engineers 1974). As a result of gravel extraction and channelization, some areas were covered with riprap or confined by levees to prevent further erosion and flooding. Erosion problems have contributed to sediment entering Clear Lake and providing increased phosphorous loads that impair water quality (Richerson et al. 1994).

Gravel extraction results in channelization and down cutting of the stream bank, a decrease in suitable spawning habitat, and increasing flow velocity and amount of coarse material that passes through the system (Brown et al. 1998).

Water Quality Impacts

The Clear Lake watershed has seen a significant increase in the amount of contaminants entering the lake over the past 75 years (Richerson et al. 1994). An increase in agriculture and mining, and a shift to an urban environment, has resulted in adverse water quality impacts in the lake (Mioni et al. 2011; California Environmental Protection Agency [CEPA] 2012).

Erosion from construction, dredging, mining, agriculture, OHV use, grazing, and urbanization has resulted in increased sediment loads to the Clear Lake watershed (Forsgren Associates Inc. 2012). Increased sediment loads transport nutrient rich soil, particularly phosphorous, into Clear Lake and reduce spawning habitat by increasing substrate "embeddedness" (Mosley 2013). During the late 1990s and early 2000s soil erosion and sedimentation became an increasing problem as existing agricultural lands were converted to vineyards (Forsgren Associates Inc. 2012). From 2002 to 2011 vineyard acreage in the Clear Lake watershed increased from approximately 5,500 acres to 8,000 acres (Lake County Department of Agriculture 2011).

Development and expansion of extensive agriculture in the Clear Lake watershed during the late 1890s until present day reclaimed the lake's natural wetland filtration system for agricultural use. An increase in agricultural production and a decrease in wetland filtration increased nutrient flows into Clear Lake. Wetland reclamation projects altered the transport of sediment and nutrients, particularly phosphorous, into Clear Lake, resulting in an increase in noxious cyanobacteria blooms that cover the lake in warmer months (Suchanek et al. 2002). As a result of continued water quality issues, Clear Lake was added to the Clean Water Act Section 303(d) list of impaired water bodies in 1988 (CEPA 2010 and 2012). In recent years, noxious cyanobacteria blooms have at a minimum remained constant and may have increased (CEPA 2012).

Cyanobacteria blooms have occurred at Clear Lake since the mid-1900s. Studies indicate an increase in phosphorous was the driver behind water quality impairments and noxious cyanobacteria blooms (Horne 1975; Richerson et al. 1994; CEPA 2012). The blooms originally consisted primarily of *Microcystis*, but in recent years the blooms have been attributed to both *Microcystis* and *Lyngbya.* These taxa represent both non-nitrogen fixing (*Microcystis*) and nitrogen fixing (*Lyngbya*) cyanobacteria and raise concerns that both phosphorous and nitrogen entering the lake need to be controlled (Mioni et al. 2011; CEPA 2012). Cyanobacteria blooms have the ability to both directly and indirectly impact CLH by direct interference with the growth of *Daphnia*, a limnetic organism that is a food source for adult CLH, and interference with food web efficiency. No studies have been conducted at Clear Lake to quantify the impact of cyanobacteria blooms on the ecosystem, but studies conducted at other water bodies with varying degrees of cyanobacteria blooms provide information on their impacts to the aquatic environment. Cyanobacteria blooms reduce the amount of light penetration in the water column and cause a reduction in producers that are unable to reposition themselves to gain more light (Havens 2008). Organisms such as epiphyton, benthic algae, and rooted vascular plants have a reduced ability to function in the ecosystem as a result of cyanobacteria blooms. As the bacteria alter the nutrient cycle of the lake they replace the producers in space and mass. The expanding bacteria begin to deplete CO_2 from the water body, which increases pH and reduces growth of other producers (Havens 2008). The decreased CO_2 and increased pH can create surface scums and result in mortality of fishes, including CLH. In the summer of 1969, a large fish die off, due to heavy cyanobacteria growth and low oxygen levels, was reported at Clear Lake. An estimated 170,000 fish died, consisting primarily of carp, CLH, and blackfish (CDFG News Release 1969). Sub lethal and lethal effects of toxins released during cyanobacteria blooms are also seen in fish and their associated food web (Havens 2008).

On September 19, 2007, the U.S. Environmental Protection Agency (EPA) approved a control program as a nutrient Total Maximum Daily Load (TMDL) for Clear Lake with the goal of reducing point and non-point source phosphorous entering the lake (CEPA 2012). Sources for phosphorous entering the lake include agricultural and urban runoff, timber harvest, road maintenance, construction, gravel mining, dredging, and fire. Additional amounts of nutrients from home fertilizers, marijuana grows, sewer, and septic systems cannot be quantified.

To allow for increased yields on agricultural land and to prevent nuisance insect species around the lake, pesticides became commonplace during the early and mid-1900s. For many decades the Clear Lake gnat, a primary food source for CLH, was targeted with pesticides to reduce its population. Between 1949 and 1957, the Clear Lake gnat was targeted with the pesticide dichlorodiphenyldichloroethane (DDD). During these years it is estimated that 99 percent of the gnat larvae in the lake were killed. Concentrations of DDD were magnitudes higher in invertebrates, fish, and birds than in the surrounding water in which they were found (Lindquist and Roth 1950; Rudd 1964). Sampling conducted during the late 1950s identified CLH, as well as other fish species, contaminated with DDD (Hunt and Bischoff 1960). Contamination levels ranged from 5.27 to 115 parts per million (ppm) for edible flesh of sampled fishes (Hunt and Bischoff 1960). CLH were at the lower level of DDD contamination for Clear Lake fishes at 10.9 to 28.1 ppm for edible flesh content (Hunt and Bischoff 1960). The results of DDD in the Clear Lake watershed resulted in the first major ecological disaster at the lake and the first records of pesticide bioaccumulation in the wildlife of the lake (Suchanek et al. 2002).

Following the resurgence of gnat populations in response to growing resistance to DDD, two additional measures were taken to reduce the gnat population. Gnat eggs were targeted with a petroleum product, and adult gnats were targeted at roosting locations with Malathion. Additional applications of methyl parathion were also made in 1962 (Suchanek et al. 2002). Clear Lake gnats are still present at the lake, but populations are significantly reduced from historical levels. The likely cause of the reduced population of gnats is introduced fishes, primarily inland silversides (Suchanek et al. 2002). In 2010 and 2012 Clear Lake gnat populations reached levels not seen in decades. These gnat population booms appeared to coincide with years of low population levels of inland silversides (Scott, J. 2013 personal communication, Aug 1, 2013, unreferenced). Qualitative sampling data on CLH does not allow for a direct comparison of CLH numbers in years with increases in the gnat population.

In recent years, two herbicides, Komeen™ (copper sulfate) and SONAR™ (fluridone), have been used extensively to manage the *Hydrilla verticillata* infestation at the lake. Applied concentrations of Komeen™ do not kill fish directly; however, the impacts to macroinvertebrates may indirectly impact CLH populations (Bairrington 1999). These systemic herbicides also pose a threat to non-target vascular aquatic plants, such as tules and submerged vegetation, which juvenile CLH require for rearing habitat. As noted previously, there has already been a significant reduction in wetland habitat around the lake, and any additional reductions would further limit the amount of habitat available for CLH. Initial studies indicate a reduction in tule habitat following SONAR™ applications (Bairrington 1999). Environmental monitoring of eradication activities in 1996 and 1997 found that invertebrate species declined within the treatment area but rebounded quickly following the toxicity decay of the herbicide (Bairrington 1999). Post-treatment electrofishing surveys noted an increase in the number and abundance of fish species (Bairrington 1999).

Mining operations within the watershed contributed to sulphur and mercury contamination in Clear Lake. The Sulphur Bank Mercury Mine began operations in 1865 and ended in 1957 (Osleger et al. 2008; Giusti 2009) Originally the mine focused on extracting sulphur, but as operations continued into the late 1920s and the sulphur was found to be contaminated with mercury sulfide, operations switched to extracting mercury from the large-scale open-pit mine (Giusti 2009). As a result of contamination, the mine was classified as an EPA Superfund Site in 1990 (Suchanek et al. 1993). The mine is thought to have contaminated the lake with both mercury and arsenic (Suchanek et al. 1993). Studies have found the mercury concentrations in sediment to be high (over 400 ppm) in the vicinity of the mine, decreasing as distance from the mine increases (Suchanek et al. 2002). The mine continues to produce low pH acid mine drainage that delivers sulfate to the lake. Over the past decade, the EPA has taken several actions to remediate contamination from the mine. These include erosion control measures, removal of contaminated soil, storm water diversion, and well capping (U.S. Environmental Protection Agency 2012).

During the 1970s, elevated concentrations of mercury were found in the fish of the lake (Curtis 1977). Mercury contamination can lead to significant impacts to the reproductive success of fishes and can result in reduced brain function, altered size and function of gonads and reduced gamete production (Sandheinrich and Miller 2006; Crump and Trudeau 2009). In 2003, a mercury TMDL was developed for Clear Lake to reduce methylmercury in fish by reducing overall mercury loads to Clear Lake (CEPA 2010). Levels of mercury found in fish, including CLH, are between 0.06 and 0.32 µg/g (CEPA 2002). Concentrations of mercury present in Clear Lake fishes have resulted in health advisories on their consumption, but are below acute toxicity thresholds (Harnly et al. 1997). Mercury levels are close to or within the effect thresholds for reproduction and growth for fathead minnow (0.32 to 0.62 µg/g) and rainbow trout (National Oceanic and Atmospheric Administration [NOAA] 2011). Concentrations with no effect on rainbow trout growth and development are 0.02 to 0.09 µg/g (NOAA 2011). Lacking specific studies on CLH, based on surrogate effect levels for fathead minnows and rainbow trout, it is reasonable to suspect that CLH may be experiencing sub lethal chronic and reproductive effects from mercury contamination.

Overexploitation

Commercial Harvest

Commercial fish harvest at Clear Lake has been occurring since the early 1900s. Harvested fish were distributed to fish markets in California for sale for human consumption and animal feed. Prior to 1941, the majority of commercial operations centered on harvesting catfish (*Ictalurus* or *Ameiurus* spp.) from the lake. Although exact numbers are unavailable, it is likely that large numbers of catfish were taken during this period (Bairrington 1999). In 1942 commercial harvest of catfish was banned at Clear Lake. Beginning in the 1930s commercial harvest focused on Sacramento blackfish (*Orthodon microlepidotus*), a native species, and common carp (*Cyprinus carpio*), a non-native species. From 1932 to 1962 the annual average catch rate was 295,000 pounds for the commercial fishery (Bairrington 1999). A ratio of 1.33:1 for blackfish to carp was the average during commercial fishing operations (Bairrington 1999). In 1976 the only recorded capture and sale of CLH for commercial purposes was submitted to the Department, a total of 1,550 pounds was reported captured and sold at market that year (CDFW Commercial Fisheries Data). This is the only instance in the records of CLH being captured for commercial sale, primarily due to lack of interest and low sale price for the species (CDFW Commercial Fisheries Data). By 1960 commercial fishing operators were required to count and release all bycatch from commercial operations. CLH were found in large numbers some years and were recorded and returned to the lake when captured (Figure 5; CDFW Commercial Fisheries Data). The Department has received no commercial permit applications for operations on Clear Lake over the past several years. The lack of permit applications indicates that at this time commercial fishing operations at Clear Lake have ceased (CDFW Commercial Fishing Permit Data).

Comment [JS14]: It seems like a resumption of commercial harvest of catfish might subsidize the blackfish and carp fishery and restore the incidental capture data on hitch that have been missing for the last decade.

Cultural Harvest

Clear Lake hitch are culturally significant to several Pomo tribes that inhabit the Clear Lake watershed. Two Pomo tribes fought a war over Kelsey Creek and its important CLH supply (Barrett 1906; Kniffen 1939). Historically, large runs of CLH provided a staple food source for the local tribes (RREC 2011). During spawning runs, CLH were captured by constructing a series of dams in the creeks from which the fish were then scooped with baskets. The fish were cured to provide a food source throughout the year (Kniffen 1939). Historical accounts from tribal members speak of CLH being easy to find as they spawned in large numbers in the tributaries to the lake (Scotts Valley Band of Pomo Indians historical accounts 2013). There are no estimates of the number of CLH that were taken for cultural harvest during any specific timeframe. However, an account from a tribal member indicates that, historically, a single family may have taken a couple thousand fish during the spawning runs (Big Valley EPA 2013). Tribal accounts indicate the harvest of CLH continued until the decline in spawning runs in the mid-1980s (Big Valley EPA 2013). Prior to designation of CLH as a candidate species for listing, regulations in the Clear Lake watershed allowed for the harvest of CLH in spawning tributaries by hand or hand-held dip net. In 2013 the Department issued CESA Memoranda of Understanding (Fish and Game Code, § 2081(a)) to three tribes to authorize collection of CLH for scientific research and public education (Kratville, D. personal communication, October 7, 2013, unreferenced).

Predation and Competition

Non-native fish introductions into Clear Lake date back as far as the late 1800s (Dill and Cordone 1997). Prior to the introduction of non-native fish species, between 12 and 14 native fish species occupied Clear Lake (Bairrington 1999; Moyle 2002; Thompson et al. 2013). Currently, approximately ten native species and 20 non-native species inhabit the lake (Bairrington1999; Thompson et al. 2013). Over the past 100 years one native species, thicktail chub (*Gila crassicauda*), has gone extinct and two native species, hardhead (*Mylopharodon concephalus*), and Clear Lake splittail, have been extirpated from the lake. Sacramento perch (*Archoplites interruptus*), has not been captured in sampling efforts since 1996 (Bairrington 1999; CDFW Commercial Fisheries Data; Thompson et al. 2013). The majority of non-native species introductions have been conducted by the Department, various local agencies, and angling groups in an effort to increase sport fishing opportunities. Introductions of fish at Clear Lake have been warmwater sport fish (black bass, sunfish (*Lepomis* spp.), catfish, etc.) or forage species for piscivorous sport fish. The Department has not stocked fish in Clear Lake in the past decade. The four fish species listed below were introduced without authorization from the Department (Bairrington 1999; Rowan J. personal communication, October 10, 2013, unreferenced). Inland silverside, threadfin shad, smallmouth bass (*Micropterus dolomieu*), and pumpkinseed (*Lepomis gibbosus*) were introduced to provide forage for other game fishes, provide Clear Lake gnat control, or as part of a new sport fishery (Anderson et al. 1986; Dill and Cordone 1997; Bairrington 1999). Non-native game fishes comprise nearly 100 percent of the sport catch from the lake. Incidental captures of native species occur infrequently and are rarely recorded during creel and tournament surveys (Rowan J. personal communication, October 10, 2013, unreferenced).

Non-native fish introductions can have significant impacts on native fish species. Inland silverside and threadfin shad are thought to compete directly with CLH for food resources (Geary and Moyle 1980; Anderson et al. 1986; Bairrington 1999). All three species are limnetic foragers that rely on macroinvertebrates for food. There are no direct comparisons, but years with declines in threadfin shad and inland silverside are thought to coincide with increases in CLH numbers, and years with decreased threadfin shad and inland silverside result in increased young of year recruitment for other native and non-native species (Rowan J. personal communication, October 10, 2013, unreferenced). Competition for juvenile rearing habitat has increased with the reduction in wetland habitat and increase in non-native fish species. Rearing habitat is essential for CLH recruitment to any year class. A reduction in recruitment leads to a decrease in spawning adults in the following years. A species with highly fluctuating population trends, such as CLH, is particularly vulnerable to population level impacts in years with reduced recruitment. Piscivorous fish species such as largemouth bass (*Micropterus salmoides*) prey directly on both juvenile and adult CLH. Although no comprehensive diet studies have been done, incidental data indicate that CLH are found in the stomachs of piscivorous species in the lake (Moyle et al. in progress). Omnivorous species such as catfish (*Ameiurus* spp.) are known to prey on various life stages of native fishes. It is suggested that the introduction of catfish to Clear Lake may have played a role in the decline of native fish species (Dill and Cordone 1997). The introduction of catfish was described, by Captain J.D. Dondero of the Division of Fish and Game, as having solved the problem of large spawning runs of fish dying in tributaries to Clear Lake and that the population of nongame fish diminished following their introduction (Dill and Cordone 1997). Jordan and Gilbert (1894) also describe catfish as being destructive to the spawn of other species. The rates at which CLH are consumed in relation to other prey species and the amount of CLH consumed are unknown. It is likely that during years when alternative prey abundance is low, CLH predation increases (Eagles-Smith et al. 2008).

Disease and Parasites

Disease outbreaks in fishes have been known to occur at Clear Lake. The outbreaks are primarily koi herpes virus (KHV) and it affects introduced carp and goldfish. Native minnows, including CLH, show no effects from KHV. Fish fungi (*Saprolegnia* spp.) have been observed on fishes captured in Clear Lake and results from physical injury or infection. CLH are susceptible to fish fungi but it is not readily observed in captured fish. All fish in Clear Lake are susceptible to anchor worms (*Lernaea* spp.) and heavy infestations can lead to mortality. No CLH with heavy anchor worm infestations have been observed during CDFW fishery surveys at Clear Lake (Rowan J. personal communication, October 10, 2013, unreferenced). The Big Valley Rancheria Band of Pomo Indians has documented light loads of anchor worms occurring on CLH (Big Valley Rancheria 2012 and 2013).

Other Natural Occurrences or Human Related Activities

Climate Change

It is likely that native fishes in California will be vulnerable to physical and chemical changes as a result of climate change (Moyle et al. 2012). Research has shown that the annual mean temperature in North America has increased between 1955 and 2005 and is predicted to continue increasing in the future (Field et al. 1999; Hayhoe et al. 2004); however, it varies across North America, is more pronounced in spring and winter, and has affected daily minimum temperatures more than daily maximum temperatures (Field et al. 2007). In general, climate change models for California indicate an increase in overall air temperature, decreased and warmer rainfall, and an increase in overall water temperatures (California Climate Change Center [CCCC] 2012). Cold storms are expected to decrease, giving way to warmer storms that create earlier run-off and less water storage capabilities (Field et al. 1999; Hayhoe et al. 2004; CCCC 2012). Climate change in the Clear Lake watershed is likely to cause some changes to the interannual variability in rainfall. The change in rainfall variability would likely increase the occurrence of drought and flood years (Clear Lake Integrated Watershed Management Plan [CLIWMP] 2010). Expected climate change impacts to California and the Clear Lake watershed will be significant during annual CLH spawning cycles. CLH require winter and spring storms that provide suitable spawning flows in the tributaries of Clear Lake. A shift in timing, temperature, and amount of runoff could significantly impact the ability of CLH to successfully spawn. A climate driven change in the Clear Lake watershed could result in the loss of spawning habitat, reduced access to spawning habitat, stranding of spawning and juvenile fish, and egg desiccation.

A report on the projected effects of climate on California freshwater fishes, prepared for the California Energy Commission's California Climate Change Center, determined CLH to be critically vulnerable to impacts from climate change (Moyle et al. 2012). The report evaluated criteria such as population size, population trends, range, lifespan, and vulnerability to stochastic events to identify the degree of vulnerability of each fish species. The Intergovernmental Panel on Climate Change has stated that of all ecosystems, freshwater ecosystems will have the highest proportion of species threatened with extinction due to climate change (Kundzewicz et al. 2007). Freshwater lake species are more susceptible to extirpation because they are unable to emigrate should habitat changes occur (CA Natural Resources Agency 2009).

Recreational Activities

The natural resources of the Clear Lake watershed are a tremendous recreational resource for residents and visitors to Lake County. As the largest freshwater lake wholly in California, with opportunities for multiple aquatic recreational activities, the lake receives tens thousands of visitors per year. According to 2008 data acquired from Lake County quagga mussel (*Dreissena rostriformis*) inspection sticker application forms; there were 11,230 boats that visited the lake that year. Jet skis and pleasure boats accounted for 41 percent of the boating activity at the lake (CLIWMP 2010).

Permanent structures, associated with boat docks, boat ramps, and swimming beaches, have reduced littoral zone habitat around the lake. These structures require clearing of littoral zone habitat to maintain access for recreational boaters and swimmers. It is estimated that there are over 600 private boat docks and boat ramps on the lake shoreline. In addition to reducing littoral zone habitat these structures provide additional habitat for non-native sport fish, such as largemouth bass, that prey on CLH.

Recreational and tournament angling generate a significant amount of the activity in the Clear Lake aquatic environment. In 2008, 18 percent of all boats entering the lake identified their recreational activity as angling (CLIWMP 2010). In a single year creel survey conducted in 1988 by the Department, CLH comprised two percent of the recreational sport catch (Macedo 1991).

The number of angling tournaments, primarily targeting largemouth bass, has drastically increased over the last three decades in response to Clear Lake's reputation as a premiere sport fishery. Between 2001 and 2008 the number of angling tournaments increased from 98 to 208 per year (Rowan J. personal communication, October 10, 2013, unreferenced). It is believed that recreational and tournament anglers' capture CLH incidentally while angling. The impact to CLH from the increase in angling tournaments is unknown, but is likely negligible because tournament anglers do not target CLH and bycatch would be an inadvertent snagging on an artificial lure, a rare occurrence.

REGULATORY AND LISTING STATUS

Federal

On September 25, 2012 the Center for Biological Diversity petitioned the U.S. Fish and Wildlife Service (USFWS) to list CLH as endangered or threatened under the federal Endangered Species Act (ESA). As of the publication of this status review there has been no action taken on the petition by USFWS.

The U.S. Forest Service (USFS) lists CLH as a sensitive species. USFS sensitive species are those plant and animal species identified by a regional forester that are not listed or proposed for listing under the federal ESA for which population viability is a concern.

State

The Department designated CLH as a Species of Special Concern (SSC) in 1994. A SSC is a species, subspecies, or distinct population of an animal native to California that currently satisfies one or more of the following (not necessarily mutually exclusive) criteria:

- Is extirpated from the State or, in the case of birds, in its primary seasonal or breeding role;
- Is listed as Federally, but not State, threatened or endangered;
- Is experiencing, or formerly experienced, serious (noncyclical) population declines or range restrictions (not reversed) that, if continued or resumed, could qualify it for State threatened or endangered status;
- Has naturally small populations exhibiting high susceptibility to risk from any factor(s) that if realized, could lead to declines that would qualify it for State threatened or endangered status.

The intent of designating a species as a SSC is to:

- Focus attention on animals at conservation risk by the Department, other State, local and Federal government entities, regulators, land managers, planners, consulting biologists, and others;
- Stimulate research on poorly known species;
- Achieve conservation and recovery of these animals before they meet California Endangered Species Act criteria for listing as threatened or endangered.

There are no provisions in the Fish and Game Code that specifically prohibit take of CLH or protect its habitat.

Other Rankings

The American Fisheries Society ranks CLH as vulnerable, meaning the taxon is in imminent danger of becoming threatened throughout all or a significant portion of its range (Jelks et al. 2011).

EXISTING MANAGEMENT EFFORTS

Resource Management Plans

An increase in resource management efforts throughout the Clear Lake watershed has benefitted CLH, and several plans and strategies are in place to assist in reducing the threats to CLH.

The Clear Lake Integrated Watershed Management Plan (2010) was prepared by two resource conservation districts and provides details of past and current resource management within the Clear Lake watershed. The plan seeks to identify opportunities to improve and protect the health and function of the watershed and identifies specific implementation actions to improve and protect watershed resources. Recommended actions are prioritized on a timeline. As funding allows, implementation of these actions will be undertaken by various non-governmental organizations (NGO) and local, state, and federal agencies that share an interest in promoting the health and function of the watershed. Multiple action items listed in the plan would benefit CLH and their habitats. Several tributaries to Clear Lake have completed Watershed Assessment plans as well. These include Kelsey Creek Watershed Assessment (2010), Middle Creek Watershed Assessment (2010), and Scotts Creek Watershed Assessment (2010). These plans were all completed by Lake County Water Resources Division for West and East Lake Resource Conservation Districts.

With adoption of the TMDL for Clear Lake, several projects are in process or have been completed to reduce the amount of phosphorous entering the lake. Specifically, the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project seeks to reduce the amount of phosphorous entering the lake by 40 percent (CEPA 2012). Lake County and the California Department of Transportation have implemented several best management practices (BMPs) for managing storm water runoff to reduce the amount of phosphorous and other contaminants that enter the lake. Both the USFS and Bureau of Land Management (BLM) have undertaken projects to reduce nutrients entering the lake as a result of off-highway vehicles and other land uses. BLM, in coordination with Scotts Valley Band of Pomo Indians, received a grant to implement the Eightmile Valley Sediment Reduction and Habitat Enhancement Project Design. Controlling sediment from Eightmile Valley is crucial to controlling the amount of nutrients entering the lake. Many of these projects are still in design or early implementation and it will be several years before changes in nutrient loads within the lake can be observed and studied.

The adverse effects from an increase in sedimentation as a result of conversion of various types of agricultural land to vineyard resulted in the formation of the Erosion Prevention and Education Committee (EPEC). The EPEC is a group of county agencies and private entities that provide educational outreach regarding erosion control and water quality protection. In addition, the Lake County Grading Ordinance was approved in 2007 and requires grading permits and Erosion Control and Sediment Detention Plans for projects with the probability of resulting in increased sedimentation (Forsgren Associates, Inc. 2012).

Concerns over the reduction in habitat quality resulting from gravel mining prompted Lake County to adopt an Aggregate Resources Management Plan in 1994. The plan called for a moratorium on gravel mining in several tributaries to Clear Lake. The implementation of gravel mining regulations has resulted in reduced in-stream and bank erosion and increased riparian habitat along the creeks (CEPA 2008).

To prevent further destruction of wetland habitat along the lake shoreline, in 2000 and 2003 amendments, Lake County adopted Section 23-15 of the Clear Lake Shoreline Ordinance that prohibits the destruction of woody species and tules. In addition to the ordinance, there is a no net-loss requirement for commercial, resort, and public properties that seek to clear vegetation from areas along the shoreline (CLIWMP 2010).

RREC produced an Adaptive Management Plan (HAMP) for the Clear Lake Hitch, *Lavinia exilicauda chi* (RREC 2011). The HAMP describes the current status of CLH habitat and problems for habitat recovery. The habitat assessments are included in a management plan that identifies action items, issues of uncertainty, stakeholder involvement, sustainability, and plan amendment procedures. The RREC is currently in the process of revising the HAMP.

The Department has created or approved two Conceptual Area Protection Plans (CAPP) for the Clear Lake Watershed. The creation of a CAPP for an area allows the Department, as well as local and federal agencies, and NGOs, to apply for land acquisition funding from the Wildlife Conservation Board. The first, the Clear Lake CAPP, was approved in 2002 and addresses land acquisition needs in the area of Middle Creek. The plan focuses on protecting wetland and riparian habitat for the benefit of natural resources. The second CAPP, Big Valley Wetlands, is currently in development with possible approval in 2014. The Big Valley Wetlands CAPP focuses on land acquisitions in the western portion of the Clear Lake watershed for the purpose of protecting wetland and riparian habitat. Both CAPP’s will benefit CLH in the protection of riparian and wetland habitat critical for spawning and rearing CLH. Land acquisitions that seek to protect and restore existing CLH habitat should create a stable environment for CLH populations.

The Department published a Clear Lake Fishery Management Plan in 1999 (Bairrington 1999). The plan provides a review of past and present biological information for Clear Lake. The primary focus of the plan is to maintain fishery resources of the lake and enhance recreational fishing opportunities. The plan identifies areas of controversy between various stakeholder groups in the watershed, and states that “adapting to the biological and social settings at Clear Lake involves a variety of compromises between these groups and the non-angling groups who wish to ensure the well-being of Clear Lake’s native fish species.” The plan identifies the decline in native fish species at Clear Lake as being detrimental both socially and biologically. No specific guidelines are given for addressing impacts to native species, but restoration of spawning habitat and natural flow regimes are discussed as critical for native species survival.

Monitoring and Research

Comment [JS15]: As indicated earlier, a study of hitch age structure using otoliths would be useful to determine longevity in the lake and resilience to infrequent good spawning success.

In 2013 the Department attempted to conduct a status assessment of the CLH population present in Cole and Kelsey creeks. Sampling produced too few fish to facilitate a statistically valid mark and recapture study. As a result, a population estimate was not completed. The Department has proposed additional funding in 2014 to begin a multi-year mark-recapture study to determine a statistically valid population estimate or index of CLH.

The CCCLH has been conducting annual spawning observations since 2005. A simple protocol is followed that identifies the time, observer, and number of CLH observed. Volunteers have put in hundreds of hours monitoring CLH spawning runs during this time period. Although not quantitative, the surveys provide a glimpse into the number of spawning CLH and how successful spawning is in a particular season. Results of these surveys are included in Appendices A and B and summarized in Section 4.1 and 4.2 above.

Habitat Restoration Projects

In recent years, local, state, and federal agencies have begun implementing actions to aid in the protection and restoration of Clear Lake wetland habitat. The Middle Creek Flood Damage Reduction and Ecosystem Restoration Project will restore up to 1,400 acres of wetland habitat around Middle Creek and Rodman Slough, essentially doubling the amount of existing wetland habitat in the watershed (CLIWMP 2010).

Impacts of Existing Management Efforts

To date, existing management efforts have focused on CLH habitat restoration in the watershed. Wetland restoration projects that would significantly benefit CLH have been proposed and have been or will be implemented through the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project and the two CAPPs that cover portions of the watershed. Wetland restoration is expected to aid in increasing spawning success and juvenile recruitment into the population. Increased wetland acreage would enhance filtration of tributary waters resulting in decreased amounts of nutrients entering the lake and an increase in the water table. The increased water table will help maintain surface flow in tributaries, resulting in suitable spawning habitat being maintained throughout the spawning season. The Clear Lake Shoreline Ordinance has resulted in a “no net loss” of shoreline wetland habitat around the lake since its enactment. However, because these wetland restoration projects are either recent or yet to be implemented, a thorough assessment of direct and indirect impacts to CLH populations cannot be included in this status review.

Establishment of TMDLs for mercury and nutrients has led to a reduction in inputs and an increase in monitoring efforts in the Clear Lake watershed. Past and future steps by the federal government will reduce mercury contamination resulting from the Sulphur Bank Mercury Mine. Most of the identified initial actions for cleanup have been implemented. The focus will now be on two long-term projects to address waste pile and lake sediment cleanup, which should result in significant reductions in mercury contamination in the watershed. Nutrient loads entering Clear Lake have been addressed by several measures including wetland restoration, BMPs for storm water runoff, and erosion control measures. Many of these projects are in the early stages of implementation, and a thorough assessment of impacts to CLH is yet to be been completed. It is likely that reduced mercury and nutrient loads in Clear Lake will result in a significant benefit to CLH.

SCIENTIFIC DETERMINATIONS REGARDING THE STATUS OF CLEAR LAKE HITCH IN CALIFORNIA

CESA directs the Department to prepare this report regarding the status of CLH based upon the best scientific information available to the Department. CESA's implementing regulations identify key factors that are relevant to the Department's analyses. Specifically, a "species shall be listed as endangered or threatened ... if the Commission determines that its continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities." (Cal. Code Regs., tit. 14, § 670.1 (i)(1)(A)).

The definitions of endangered and threatened species in the Fish and Game Code provide guidance to the Department's scientific determination. An endangered species under CESA is one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, over exploitation, predation, competition, or disease." (Fish & G. Code, § 2062). A threatened species under CESA is one "that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [CESA]." (*Id.*, § 2067).

The preceding sections of this status review report describe the best scientific information available to the Department, with respect to the key factors identified in the regulations. The Department's scientific determinations regarding these factors as peer review begins are summarized below.

Present or Threatened Modification or Destruction of Habitat

Beginning with the arrival of European settlers in the mid-1800s, alterations to habitats in the watershed have directly impacted the ability of CLH to survive. Habitats necessary for both spawning and rearing have been reduced or severely decreased in suitability in the past century resulting in an observable decrease in the overall abundance of CLH and its habitat. Spawning tributaries have been physically altered by a combination of dams, diversions, and mining operations that have altered the course and timing of spring flows and the amount and quality of spawning habitat available for CLH. Dams create barriers to CLH passage that reduce the amount of available spawning habitat while altering the natural flow regime of tributaries. Water diversions in tributaries have resulted in decreased flows during critical spawning migrations for CLH. Loss of eggs, juvenile, and adult fish due to desiccation and stranding from water diversions are likely a significant impact on CLH populations. Gravel mining removed large amounts of spawning substrate during peak operations in the mid-1900s. Spawning substrate has been restored slowly after gravel mining was discontinued in the majority of the watershed. Water quality impacts to the watershed have resulted in Clear Lake being listed as an impaired water body and led to the establishment of TMDLs for both mercury and nutrients for the lake. It is unclear to what extent the water quality impacts are affecting CLH populations. The Department considers modification and destruction of habitat a significant threat to the continued existence of CLH.

Overexploitation

Harvest of CLH has occurred by both Pomo tribes and commercial fishery operators at Clear Lake. Historic accounts from tribal members indicate that significant amounts of CLH were harvested during spawning runs. In recent years, the amount of harvest by the Pomo has been minimal, and the CLH are used strictly for educational and cultural reasons. Since the early 1990s commercial fishery operations have been required to return all CLH captured to the lake. Prior to that, CLH had not been regularly harvested for sale. It is likely that incidental catch during commercial harvest operations resulted in mortality of some CLH. However, there is no information indicating that overexploitation threatens the continued existence of CLH.

Predation

Direct predation of CLH by fish, birds, and mammals is known to occur in suitable habitats within the watershed. Spawning runs are vulnerable to predation from birds and mammals as fish migrate upstream and become stranded at various locations. Stranding occurs both naturally and as a result of habitat modifications described above. Non-native fishes prey directly on different life stages of CLH in all occupied habitats. CLH have been found during stomach content analyses of largemouth bass. Incidental observations indicate that largemouth bass may target CLH as the CLH stage at the entrance to ascend spawning tributaries in early spring. Other introduced fishes, such as catfish species, also prey on CLH. A detailed diet study on introduced fishes is necessary to determine the extent of predation from introduced fishes. There is scientific information suggesting that predation by introduced fishes threatens the continued existence of CLH.

Competition

The extent of impacts on CLH from competition with other aquatic species is poorly understood. Studies conducted on diet analysis of CLH indicate that there is competition between CLH and other macroinvertebrate consuming fish species, primarily inland silversides and threadfin shad. Observations by Department biologists and others indicate that CLH populations fluctuate on alternating cycles with inland silverside populations. CLH directly compete with other native and non-native fishes for juvenile rearing habitat. The majority of fishes in Clear Lake utilize near shore wetland habitat for juvenile rearing. With the decrease in wetland habitat over the past century, there is increased competition for the remaining habitat. Although no formal studies have been completed, it is likely that competition for resources threatens the continued existence of CLH.

Disease

There are no known diseases that are significant threats to the continued existence of CLH.

Other Natural Occurrences or Human-related Activities

Expected climate change impacts to California and the Clear Lake watershed will be significant during annual CLH spawning cycles. CLH require winter and spring storms that provide suitable spawning flows in the tributaries of Clear Lake. A shift in timing, temperature, and amount of runoff could significantly impact the ability of CLH to successfully spawn. A report on the projected effects of climate on California freshwater fishes determined CLH to be critically vulnerable to impacts from climate change.

Numerous recreational activities take place in Clear Lake each year. The majority of recreational activities pose no significant threat to the survival of CLH. However, it is believed that recreational and tournament anglers' capture CLH incidentally, at a low rate. The extent of impacts to CLH from angling is unknown, but likely do not threaten the continued existence of CLH.

SUMMARY OF KEY FINDINGS

Comment [JS16]: It appears that the decline of hitch after introduction catfish and later inland silverside and the apparent inverse year-to-year relationship between silverside/threadfin shad and hitch support competition and predation as ongoing threats.
The many barriers and diversion impacts on spawning have made successful (and widespread) spawning less likely and more subject to year to year runoff effects (now and with future climate change).
However, the data on hitch abundance are limited but point to a boom or bust pattern in population abundance (with uncertain longevity of individual fish). The threats and the present pattern indicate that extinction is a real possibility without intervention to improve the amount and regularly of spawning success and juvenile survival in the littoral environment.

At present time, the species can be found in portions of its historic habitat and qualitative surveys indicate a variable interannual population. Based on qualitative survey efforts to date a population estimate or index of CLH is not attainable. Without a current population or index for CLH it is necessary to estimate impacts not based on a set baseline but rather against trends seen in abundance and distribution in sampling efforts over the past half century.

It will be imperative for the Department and the conservation community to study and monitor the population of CLH over the next decade. A review of the scientific determinations regarding the status of CLH indicates there are significant threats to the continued existence of the species, particularly related to historical and ongoing habitat modification, predation from introduced species, and competition. Many of these threats are currently or in the near future being addressed by existing management efforts. Monitoring impacts from existing management efforts will be imperative to assessing the future status of CLH.

RECOMMENDATION FOR PETITIONED ACTION

CESA directs the Department to prepare this report regarding the status of CLH in California based upon the best scientific information available. CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)). The Department includes and makes its recommendation in its status report as submitted to the Commission in an advisory capacity based on the best available science.

Based on the criteria described above, the scientific information available to the Department does/does not indicate that CLH are threatened with extinction and likely to become an endangered species in the foreseeable future. The listing recommendation will be provided in this report after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

PROTECTION AFFORDED BY LISTING

It is the policy of the State to conserve, protect, restore and enhance any endangered or any threatened species and its habitat. (Fish & G. Code, § 2052.) If listed as an endangered or threatened species, unauthorized "take" of CLH will be prohibited, making the conservation, protection, and enhancement of the species and its habitat an issue of statewide concern. As noted earlier, CESA defines "take" as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill. (*Id.*, § 86.) Any person violating the take prohibition would be punishable under State law. The Fish and Game Code provides the Department with related authority to authorize "take" under certain circumstances. (*Id.*, §§ 2081, 2081.1, 2086, 2087 and 2835.) As authorized through an incidental take permit, however, impacts of the taking on CLH caused by the activity must be minimized and fully mitigated according to State standards.

Comment [JS17]: If listed, monitoring / collecting permits should be should be relatively liberal to allow collection of necessary data.

Additional protection of CLH following listing would also occur with required public agency environmental review under CEQA and its federal counter-part, the National Environmental Policy Act (NEPA). CEQA and NEPA both require affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on endangered, rare, and threatened special status species. Under CEQA's "substantive mandate," for example, state and local agencies in California must avoid or substantially lessen significant environmental effects of their projects to the extent feasible. With that mandate and the Department's regulatory jurisdiction generally, the Department expects related CEQA and NEPA review will likely result in increased information regarding the status of CLH in California as a result of, among other things, updated occurrence and abundance information for individual projects. Where significant impacts are identified under CEQA, the Department expects project-specific required avoidance, minimization, and mitigation measures will also benefit the species. State listing, in this respect, and required consultation with the Department during state and local agency environmental review under CEQA, is also expected to benefit the species in terms of related impacts for individual projects that might otherwise occur absent listing.

If CLH are listed under CESA, it may increase the likelihood that State and federal land and resource management agencies will allocate additional funds towards protection and recovery actions. However, funding for species recovery and management is limited, and there is a growing list of threatened and endangered species.

MANAGEMENT RECOMMENDATIONS AND RECOVERY MEASURES

Current data on CLH suffers from being largely anecdotal and qualitative in nature. Studies designed to provide quantitative data on CLH populations and the factors that affect the ability of CLH to survive and reproduce are necessary for species management. The following management recommendations were generated by Department staff with considerations from local agencies, non-profits, and interested parties.

- Derive a statistically valid population estimate or index allowing assessment of impacts to the overall population and provide a baseline to maintain a sustainable population level.
- Conduct a thorough assessment of barriers to fish movement on primary spawning streams and provide recommendations for restoration actions on substantial barriers.
- Complete a detailed analysis of spawning habitat in primary spawning streams and provide recommendations for restoration actions.
- Implement identified restoration activities to increase available spawning habitat for CLH.
- Conduct a review of reservoir operations at Highland Springs, Adobe Creek, and Kelsey Creek detention dams to assess water release operations that may be impacting CLH, development and implementation of guidelines for minimizing impacts.
- Conduct an in stream flow analysis of primary spawning tributaries to determine impacts of water diversions on stream flows, particularly during spawning season.
- Coordinate with landowners, stakeholders, and permitting agencies on developing strategies for reducing in stream diversions during spawning season.
- Determine the value of wetland habitat in the watershed pertaining to survivorship of juvenile CLH and make appropriate recommendations on restoration or modification.
- Analyze food web interactions of CLH and non-native fish to determine potential impacts to CLH.
- Conduct a diet analysis of predatory fish species to determine the extent of their impact on CLH.
- Conduct creel surveys to gain a better understanding of CLH capture rates during both recreational and tournament angling.
- Develop a comprehensive monitoring program to assess both native and non-native fish populations and their distribution in the watershed.
- Identify habitats within the watershed that may be suitable for CLH translocations.

- Coordinate the above research and restoration efforts with interested stakeholders in the watershed.
- Develop an outreach program to provide updates to stakeholders on recovery and management efforts.

PUBLIC RESPONSE

Note to Reviewer: Public response will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

PEER REVIEW

Note to Reviewer: Peer review will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

LITERATURE CITED

Aguilar, A. and J. Jones. 2009. Nuclear and Mitochondrial Diversification in two Native California Minnows: Insights into Taxonomic Identity and Regional Phylogeography. Molecular Phylogenetics and Evolution 51 (2): 373-381.

Anderson, N.L., D.L. Woodward and A.E. Colwell. 1986. Pestiferous dipterans and two recently introduced aquatic species at Clear Lake. Proceedings of the California Mosquito Vector Control Association. 54:163-167.

Anderson, N.L., 1989. Letter to Rick Macedo containing notes and data from LCVCD sampling efforts.

Avise, J.C. and F.J. Ayala. 1976. Genetic differentiation in speciose versus depauperate phylads: Evidence from the California minnows. Evolution 30:46-58.

Barrett, S.A., 1906. The Ethno-Geography of the Pomo and Neighboring Indians. University of California Publications in American Archeology and Ethnology. Vol 6 No. 1.

Bairrington, P., 1999. CDFG Clear Lake Fishery Management Plan.

Bellucci, C. J., Becker, M., & Beauchene, M. (2011). Characteristics of macroinvertebrate and fish communities from 30 least disturbed small streams in Connecticut. *Northeastern Naturalist, 18*(4), 411-444.

Big Valley EPA, 2013. Hitch interview notes with families of Big Valley Rancheria and Elem Indian Colony.

Big Valley Rancheria, 2012. Hitch *Lavinia exilicauda* Chi Hopkirk ecology and water quality studies in Big Valley sub-basin creeks in 2012.

Big Valley Rancheria, 2013. Big Valley sub-basin creek water quality, quantity, and Hitch *Lavinia exilicauda* Chi Hopkirk ecology program. Spring, 2013.

Brown, A.V., M.M. Little, and K.B. Brown, 1998. Impacts of gravel mining on gravel bed streams. *Transactions of the American Fisheries Society*. 127:979-994.

Bunn, S.E., and A.H. Arthington, 2002. Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity. *Environmental Management*. Vol. 30:4. Pp 492-507.

California Climate Change Center, 2012. Our Changing Climate 2012 Vulnerability and Adaptation to the Increasing Risks from Climate Change in California.

California Department of Fish and Game, 1955-1956. Field notes on Kelsey and Seigler Creeks.

California Department of Fish and Game, 1961-2001. Commercial Catch data for Clear Lake

California Department of Fish and Game, 1969. News Release on Fish Dieoffs at Clear Lake.

California Department of Fish and Game, 1988. Clear Lake Electrofishing Survey, April 2, 1987 Memorandum.

California Department of Fish and Game, 2012. Electrofishing data, Memorandum in progress.

California Department of Fish and Wildlife, 2013. Report to the Fish and Game Commission Evaluation of the Petition from the Center for Biological Diversity to List Clear Lake Hitch (*Lavinia exilicauda chi*) as a Threatened Species under the California Endangered Species Act.

California Department of Fish and Wildlife, 2013. Commercial Fisheries Data from catch records.

California Department of Fish and Wildlife, 2013. Commercial Operators permit applications.

California Department of Fish and Wildlife, April 24, 2013. Press Release – CDFW Seeks Public Comment and Data Regarding Clear Lake Hitch.

California Department of Water Resources. 1975. Clear Lake Water Quality Data.

California Natural Resources Agency, 2009. California Climate Adaptation Strategy Discussion Draft.

California Environmental Protection Agency RWQCBCVR, 2002. Clear Lake TMDL for Mercury Staff Report.

California Environmental Protection Agency RWQCBCVR, 2008, Monitoring and Implementation Plan Clear Lake Mercury and Nutrient TMDL's.

California Environmental Protection Agency RWQCBCVR, 2010. Clear Lake Mercury Total Maximum Daily Load Update.

California Environmental Protection Agency RWQCBCVR, 2012. Clear Lake Nutrient Total Maximum Daily Load Control Program 5-year Update.

California Regulatory Notice Register, 2012. No. 41-Z. p.1501

California Regulatory Notice Register, 2013. No. 12-Z. p.488

Center for Biological Diversity, 2012. Petition to List Clear Lake Hitch (*Lavinia exilicauda chi*) as Threatened under the California Endangered Species Act. 58 pp.

Chi Council for the Clear Lake Hitch (CCCLH). 2013. Hitch spawning survey results, 2005-2013. Available at http://lakelive.info/chicouncil/

Clear Lake Integrated Watershed Management Plan, February 2010. Prepared for West Lake and East Lake Resource Conservation Districts.

Coleman, G.A. 1930. A biological survey of Clear Lake, Lake County. *Calif. Fish and Game* 16: 221-227.

Converse,Y.A., C.P. Hawkins and R. A. VALDEZ, 1998. Habitat Relationships of Subadult Humpback Chub in the Colorado River through Grand Canyon: Spatial Variability and Implications of Flow Regulation. *REGULATED RIVERS: RESEARCH & MANAGEMENT* **14**: 267–284

Cook, S. F., Jr., J. D. Connors, and R. L. Moore, 1964. The impact of the fishery on the midges of Clear Lake, Lake County, CA, *Annals of the Entomological Society of America*, Vol. 57, pp. 701-707.

Cott, P. A., Sibley, P. K., Somers, W. M., Lilly, M. R., & Gordon, A. M. (2008). A REVIEW OF WATER LEVEL FLUCTUATIONS ON AQUATIC BIOTA WITH AN EMPHASIS ON FISHES IN ICE-COVERED LAKES1. *Journal of the American Water Resources Association, 44*(2), 343-359.

Cox, B., 2007. CDFG Clear Lake Fishery Surveys Summary Report.

Curtis T.C. 1977. Pesticide Laboratory report. California Department of Fish and Game, E.P. No. P-133. 3pp.

Crump, KL and VL Trudeau, 2009. Mercury-induced reproductive impairment in fish. *Environmental Toxicology and Chemistry*. 28(5):895-907.

Deitch, M.J., G.M. Kondolf, and A.M. Merenlender. 2009. Hydrologic impacts of smallscale instream diversions for frost and heat protection in the California wine country. River Research and Applications, Volume 25, Issue 2, pages 118-134.

Dill, W. A., and A. J. Cordone. 1997. Fish Bulletin 178. History and Status of Introduced Fishes in California 1871-1996. California. Fish and Game. 414 pp.

Eagles-Smith, C.A., T.H. Suchanek, A.E. Colwell, N.L. Anderson, and P.B. Moyle. 2008. Changes in fish diets and food web mercury bioaccumulation induced by an invasive planktivorous fish. Ecological Applications 18(Supplement): A213–A226.

Ewing, B., 2013. Summary of the Clear Lake Hitch Population Estimate for Cole and Kelsey Creeks, Lake County.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller, 1999. *Confronting Climate Change in California: Ecological Impacts on the Golden State.* Union of Concerned Scientists, Cambridge, MA and Ecological Society of America, Washington, DC.

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

Forsgren Associates Inc, 2012. Clear Lake Watershed Sanitary Survey 2012 Update Final.

Franson, S. 2013. Summary of Spring 20-13 Field Monitoring with Locations chosen for observing egg and larval development of Clear Lake Hitch (*Lavinia exilicauda chi*).

Gafny, S., A. Gasith, and M. Goren 2006. Effect of water level fluctuation on shore spawning of *Mirogrex terraesanctae* (Steinitz), (Cyprinidae) in Lake Kinneret, Israel. Journal of Fish Biology vol 41:6 pages 863-871

Geary, R.E. 1978. Life history of the Clear Lake hitch *(Lavinia exilicauda chi).* Unpublished Master's Thesis, University of California, Davis. 27 pp.

Geary, R.E. and P.B. Moyle. 1980. Aspects of the ecology of the hitch, *Lavinia exilicauda* (Cyprinidae), a persistent native cyprinid in Clear Lake, California. Southwest. Nat. 25:385-390.

Giusti, G. 2009. Human Influences to Clear Lake, California A 20^{th} Century History.

Harnly, M., S. Seidel, P. Rojas, R. Fornes, P. Flessel, D. Smith, R. Kreutzer, and L. Goldman. 1996. Biological monitoring for mercury within a community with soil and fish contamination. *Environmental Health Perspectives*, Vol. 105:4, 424-429.

Havens, K.E. 2008. Cyanobaterial Harmful Algal Blooms: State of the Science and Research Needs. Chapter 33: Cyanobacteria blooms: effects on aquatic ecosystems.
Hayhoe, K., D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider,K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S. Kalkstein, J. Lenihan, C.K.Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Science 101:12422-12427.

Hopkirk, J.D. 1973. Endemism in fishes of the Clear Lake region of central California. University of California Publications in Zoology 96: 160 pp.

Horne, A.J. 1975. The Effects of Copper, Major and Minor Nutrient Element Additions, and Lake Water Movements on Blue-Green Algal Bloom Development in Clear Lake.

Hudon, C., Armellin, A., Gagnon, P., & Patoine, A. (2010). Variations in water temperatures and levels in the St. Lawrence River (quebec, canada) and potential implications for three common fish species. *Hydrobiologia, 647*(1), 145-161.

Hunt, E.G. and A.I. Bischoff. 1960. Inimical effects on wildlife or periodic DDD applications to Clear Lake. California Fish and Game 46:91-106.

Jelks, H L., Stephen J. Walsh, Noel M. Burkhead, Salvador Contreras-Balderas, Edmundo Diaz-Pardo, Dean A. Hendrickson, John Lyons, Nicholas E. Mandrak, Frank McCormick, Joseph S. Nelson, Steven P. Platania, Brady A. Porter, Claude B. Renaud, Juan Jacobo Schmitter-Soto, Eric B. Taylor & Melvin L. Warren Jr. (2008): Conservation Status of Imperiled North American Freshwater and Diadromous Fishes, Fisheries, 33:8, 372-407.

Jordan, D.S., and C.H. Gilbert. 1894. List of Fishes Inhabiting Clear Lake, California. Bulletin of the United States Fish Commission, Vol. XIV.

Kelsey Creek Watershed Assessment, February 2010. Prepared for East Lake and West Lake Resource Conservation Districts.

Kimsey, J.B. and L.O. Fisk. 1960. Keys to the freshwater and anadromous fishes of California. Calif. Fish Game 46:453-79.

Kniffen, F.B. 1939. Pomo Geography. University of California Publications in American Archaeology and Ethnology. Vol. 36 No. 6 pp. 353-400.

Kratville, D. October 7, 2013. Email correspondence on CESA MOU's issued for CLH.

Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen and I.A. Shiklomanov, 2007: Freshwater resources and their management. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210.

Lake County Department of Agriculture, 2011. Crop Report

Lake County Department of Public Works Water Resources Division, 2003. Clear Lake Wetlands Geographic Information Systems Data User Manual.

Lake County Vector Control District, 2013. Copy of verified Beach Seine 1987-2010 CL Hitch with notes.

Lindquist, A.W., C.D. Deonier, and J.E. Hanley. 1943. The relationship of fish to the Clear Lake gnat, in Clear Lake, California. Calif. Fish Game 29:196-202.

Lindquist, A.W. and A.R. Roth. 1950. Effect of dichlorodiphenyl dichloroethane on larva of the Clear Lake gnat in California. *Journal of Economic Entomology* 43:328-332.

Macclanahan, J., E. W. Danley, H. F. Dewitt, and W. Wolber. 1972[app]. Flood control project maintenance and repair, 1971 inspection report. California Department of Water Resources Bulletin 149-71.

Macedo, R., 1991. Creel Survey at Clear Lake, California March – June, 1988. CDFG Administrative Report No. 91-3.

Macedo, R. 1994. Swimming Upstream Without a Hitch. Outdoor California: January/February 1994.

Marchetti, M.P. and P.B. Moyle, 2001. Effects of flow regime on fish assemblages in a regulated California stream. *Ecological Applications*. 11(2). Pp. 530-539.

McGinnis, D. and E. Ringelberg. 2006. Lake County Fish Barrier Assessment. Technical Memo.

Middle Creek Watershed Assessment, February 2010. Prepared for West Lake Resource Conservation District.

Miller, R.R. 1945. A new cyprinid fish from Southern Arizona, and Sonora, Mexico, with description of a new subgenus of *Gila* and a review of related species. Copeia 1945:104-110.

Miller, R.R. 1963. Synonymy, characters and variation of *Gila crassicauda*, a rare California minnow, with an account of its hybridization with *Lavinia exilicauda*. California Fish and Game 49 (1): 20-29.

Mioni, C., R. Kudela, and D. Baxter. 2011. Harmful cyanobacteria blooms and their toxins in Clear Lake and the Sacramento-San Joaquin delta (California). Central Valley Regional Water Quality Control Board: 10-058-150.

Moyle, P.B. and M. Massingill. 1981. Hybridization between hitch, *Lavinia exilicauda*, and Sacramento blackfish, *Orthodon microlepidotus*, in San Luis Reservoir, California. California Fish Game 67:196-198.

Moyle, P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern in California, 2nd edition.

Moyle, P.B. and T. Light, 1996. Fish Invasions in California: Do Abiotic Factors Determine Success? Ecology 77:1666-1670.

Moyle, P. B. 2002. Inland Fishes of California. Berkeley: University of California Press.

Moyle, PB., JD Kiernam, PK Crain and RM Quinones, 2012. Projected Effects of Future Climates on Freshwater Fishes of California. A White Paper from the California Energy Commission's California Climate Change Center.

Moyle P.B., J.V Katz, and R.M. Quinones. In review. Fish Species of Special Concern for California. Prepared for California Department of Fish and Game, Sacramento

Murphy, G.I. 1948. Notes on the biology of the Sacramento hitch *(Lavinia e. exilicauda)* of Clear Lake, Lake County, California. Calif. Fish Game 34:101-110.

Murphy, G.I. 1951. The fishery of Clear Lake, Lake County, California. *Calif. Fish and Game* 37: 439-484.

National Oceanic and Atmospheric Administration, 2011. Table 2. Toxicity associated with mercury in tissues (ug/g) wet weight.

Nicola, S.J. 1974. The life history of the hitch, *Lavinia exilicauda* Baird and Girard, in Beardsley Reservoir, California. Inland Fish. Admin. Rep. 74-6:1-16.

Osleger, D.A., R.A. Zierenberg, T.H. Suchanek, J.S. Stoner, S. Morgan, and D.P. Adam. 2008. Clear Lake sediments: anthropogenic changes in physical sedimentology and magnetic response. Ecological Applications 18 (Supplement): A239-A256.

Puckett, L., 1972. CDFG Memorandum-Fisheries Survey Clear Lake, Lake County.

Richerson P.J., T.H. Suchanek, and S.J. Why. 1994. The Causes and Control of Algal Blooms in Clear Lake, Clean Lakes Diagnostic/Feasibility Study for Clear Lake, California. Prepared for USEPA Region IX.

Ridout, W.L. 1899. A Fish Jam on Kelsey Creek. *Overland Monthly and Out West Magazine.* Volume 34, Issue 202. p. 333.

Robinson Rancheria Environmental Center (RREC). 2011. Draft Adaptive Management Plan for the Clear Lake Hitch, *Lavinia exilicauda chi*. Available at http://www.robinsonrancheria.org/environmental/water.htm.

Rowan, J., 2008. CDFG Clear Lake, Lake County Memorandum.

Rudd, R.L. 1964. *Pesticides and the Living Landscape*. University of Wisconsin Press, Madison, WI.

Sandheinrich, MB. And KM Miller, 2006. Effects of dietary methylmercury on reproductive behavior of fathead minnows (*Pimephales promelas*). *Environmental Toxicology and Chemistry.* 25(11):3053-3057.

Scotts Creek Watershed Assessment, February 2010. Prepared for West Lake Conservation District.

Scotts Valley Band of Pomo Indians, 2013. Historical accounts provided to CDFW by Steve Elliott and Wanda Quitiquit.

State of California Fish and Game Commission, March 11, 2013. California Fish and Game Commission Notice of Findings

State of California Fish and Game Commission, October 2, 2012. California Fish and Game Commission Notice of Receipt of Petition

Suchanek, T.H., P.J. Richerson, L.A. Woodward, D.G. Slotton, L.J. Holts and C.E. Woodmansee. 1993. Ecological Assessment of the Sulphur Bank Mercury Mine Superfund Site, Clear Lake, California: A Survey and Evaluation of Mercury In: Sediment, Water, Plankton, Periphyton, Benthic Invertebrates and Fishes Within the Aquatic Ecosystem of Clear Lake, California. Phase 1- Preliminary Lake Study Report. Prepared for EPA-Region IX, Superfund Program. 113 pp., plus 2 attachments.

Suchanek, T.H., P.J. Richerson, D.C. Nelson, C.A. Eagles-Smith, D.W. Anderson, J.J. Cech, Jr., G. Schladow, R. Zierenberg, J.F. Mount, S.C. McHatton, D.G. Slotton, L.B. Webber, A.L. Bern and B.J. Swisher. 2002. Evaluating and managing a multiply-stressed ecosystem at Clear Lake, California: A holistic ecosystem approach. "Managing For Healthy Ecosystems: Case Studies," CRC/Lewis Press. pp. 1233-1265.

Swift, C. 1965. Early development of the hitch, *Lavinia exilicauda,* of Clear Lake, California. Calif. Fish Game 51:74-80.

Thompson, L.C., G.A. Giusti, K.L. Weber, and R.F. Keiffer. 2013. The native and introduced fishes of Clear Lake: a review of the past to assist with decisions of the future. California Fish and Game 99(1):7-41.

U.S. Army Corps of Engineers. 1974[app]. Flood plain information: Big Valley streams (Manning, Adobe, Kelsey, and Cole Creeks), Kelseyville, California. Department of the Army, Sacramento District, Corps of Engineers, Sacramento, California, USA.

U.S. Environmental Protection Agency, 2012. Sulphur Bank Mercury Mine News Release – EPA to Begin Construction of Test Covers in Clear Lake.

Week, L., 1982. Habitat Selectivity of Littoral Zone Fishes at Clear Lake, CDFG California. Administrative Report No. 82-7.

Wetzel, R.G., 2001. Limnology lake and River Ecosystems, 3rd ed. Pg. 834.

Winder, M., J. Reuter and G. Schladow, 2010. Clear Lake Report: Clear Lake Historical Data Analysis.

Appendix A. Summary graphs of spawning observations between 2005 and 2013

Appendix B. Figures depicting CLH observations on spawning tributaries

Appendix C. Description of barriers associated with CLH spawning tributaries

Highland Springs Creek: There is a flood control dam on Highland Springs Creek, a tributary to Adobe Creek, which is impassable to CLH.

Adobe Creek: There is a flood control dam on Adobe Creek above Bell Hill Road that is impassable to CLH. There are two culverts on Adobe Creek that are mitigation barriers to spawning CLH when the water flows and velocity are not too great, but these culverts block CLH migration.

Alley Creek: Alley Creek has been channeled and diverted into Clover Creek. Alley Creek historically supported CLH runs. During some time and under certain conditions migrating CLH can access Alley Creek via the Clover channel bypass, but not when the diversion has silt or sand obstructing it.

Clover Creek: There was a diversion barrier on Clover Creek, a tributary of Middle Creek, which prevented fish passage into Clover Creek and Alley Creek. In 2004 the Robinson Rancheria received a Tribal Wildlife Grant to mitigate the diversion barrier. The work has been completed and the barrier has been modified and no longer obstructs fish passage. However, CLH must pass a concrete diversion structure at the junction with Alley Creek to the northwest of Upper Lake to gain the upper reaches of Clover Creek. This diversion structure usually becomes a complete barrier when filled with gravel and sediment.

Forbes Creek: Forbes Creek has a concrete storm water diversion structure that impedes and at times blocks CLH passage.

Kelsey Creek: On Kelsey Creek, the main barriers to CLH migration are a detention dam 2 to 3 miles upstream of Clear Lake, and the Main Street Bridge in Kelseyville. The rock and concrete weir constructed at the base of the Main Street Bridge is a barrier to the passage of CLH (Peter Windrem, personnel communication, 2012). The structure has a fish ladder which is nonfunctional and the site is nonetheless a total barrier to CLH (McGinnis and Ringelberg, 2008). The Kelsey Creek detention structure below Dorn Crossing has retractable gates which can be opened during the CLH spawning season. However, altered flow patterns and slight increases in the slope of the streambed have been enough to reduce the number of spawning CLH that can pass through the detention structure and move upstream. Also, rock riprap situated below the retention dam seems to have impeded the upstream migration of CLH and needs to be modified to provide a clear channel for fish transit. A number of drop-structures in Kelsey Creek intended for gravel aggradation impede migration. Some of these do not seem to impede CLH passage under current conditions, but CLH navigate them with difficulty especially on the downstream passage. Further upstream, culverts that once tended to clog with debris and block fish migration at the Merritt Road crossing have been removed and replaced by a bridge that poses no impediment to CLH passage.

Lyons Creek: A high culvert on Lyons Creek at Lakeshore Drive prevents CLH from moving upstream. Lyons Creek also has a concrete barrier at the County's Juvenile Hall facility that completely prevents fish passage.

Manning Creek: A dam upstream of known CLH spawning areas in the lower reaches of Manning Creek may prevent CLH from spawning further upstream.

Middle Creek: On Middle Creek, a rock and concrete weir at the Rancheria Road Bridge has been a total fish passage barrier for CLH. Remedial work has been done downstream, with more weirs installed in an effort to elevate the gradient so that CLH could surmount the barrier and work was done to improve their stability after high flows, but it remains to be seen if this will allow CLH passage. Similar weirs to capture and hold gravel were installed many years ago in Adobe Creek and Kelsey Creek that do not impede CLH passage, but there is concern the installed weirs on Middle Creek may be potential barriers to CLH. A downstream weir at Rancheria Road is a partial barrier and improperly sized rip rap at this location acts as partial migration barrier (McGinnis and Ringelberg 2008). CLH were seen recently at Middle Creek Bridge and Highway 20 and although there are no obvious barriers, they did not appear to be able to navigate the swift currents there due to the lack of resting pools. If CLH could surmount Rancheria Bridge, many additional miles of spawning grounds would be accessible to CLH up to areas south of Hunter Bridge, where habitat suitability ends because the channel is braided and shallow due to gravel mining.

Scotts Creek: On Scotts Creek, a rock and concrete weir at the Decker Bridge is a total barrier to the passage of CLH. As water levels have been lower, a barrier at the lower end of Tule Lake is problematic for fish passage to Tule Lake and its tributary Mendenhall Creek, Scotts Creek and tributaries, Bachelor Valley/Witter Springs area tributaries, and Blue Lakes and tributaries. There is a one-way flow gate on the Blue Lakes outlet at Scotts Creek that prevents CLH from entering Blue Lakes.

Seigler Canyon Creek: There are two barriers to CLH migration into Seigler Canyon Creek, an exposed sewer pipe and a road crossing. The sewer pipeline which crosses Seigler Canyon Creek for Anderson Marsh State Park was modified in the 1990s and completely blocks CLH access to that creek, once a major spawning tributary.

Page	Line	Reviewer Comment	Department Response
7	35-38	Blue Lakes, Thurston Lake, and Lampson Pond are small and not a substitute for the Clear Lake population. However, their ecology and status may give insight into factors involved in Clear Lake. Why was the Blue Lakes population extirpated?	Noted- It is not known why CLH were extirpated from Blue lake. However, spawning habitat is extremely limited in Blue Lakes and that may have been the cause.
7	35-38	Can Blue Lakes be included in the map?	Accepted- Figure updated
8	1-18	Longevity may be an important issue. Longevity based upon scales appears to be 4-6 years (Geary 1978, Moyle 2002), but the periodically relatively high population sizes are often spaced farther apart than that. Have otoliths been examined to determine if hitch in Clear Lake live much longer than scales indicate (due to little growth in old fish), as has been demonstrated in a number of lake fishes, such as Tui chubs, Cui ui, tahoe suckers, etc. This may explain how hitch have managed to persist despite infrequent good reproductive success.	Noted- Aging fish based on otolith analysis has been discussed within the Department.
9	28-33	Based upon habitat uses by most hitch compared to inland silverside and largemouth bass, is the limnetic zone a relative refuge; are spawning success and survival of juveniles in tule beds and other shoreline habitats the major potential problems. Are data available to answer this question?	Noted- There is no area that could be described as a refuge for CLH. As detailed in the document there are impacts to CLH in all habitats they occupy.
10	1	Is the commercial fishing effort that supplies important incidental catch numbers quantifiable or was it reasonably similar among years. You are using number of days commercial operations occurred—is that a good measure of effort among years? The incidental catch numbers may be very misleading if effort was substantially different among years; can the incidental catch be converted to catch per unit effort to provide a more useful index?	Noted- Catch per unit effort would be a better indicator of the CLH population however, the records do not contain details on number of hours fished, number of hauls or any other metric to allow that kind of evaluation.
10	18	Rainfall totals or January –June totals (figure 2) are not a good index of stream runoff conditions during the mid-February to May period when hitch are spawning and fry are moving down to the lake (they certainly don't match my experience with streamflow conditions in the central coast for the last 1- 2 decades). A better proxy would be runoff totals (or days over 10 cfs?) at the USGS gage on Kelsey Creek or other available stream gages (Adobe Cr?).	Accepted- Stream flows on Kelsey Creek have been added in a figure and discussed in the Dams, Barriers, and Diversions section.
10	35	See comment above	Noted
11	Figure 2	See rainfall comment above	Noted
13	Figure 3	The number of occupied spawning tributaries seems to track pretty closely with runoff during March through May. 2005 and 2006 and 2010 and 2011 were the et years for spring runoff and hitch access. 2007 and 2013 were the dry years with winter/spring stream flow dropping quickly. 2012 was relatively dry, but the majority of stream flow was late (March and April).	Accepted- Information on water year applied to graph and added to text.
13	Figure 3	This chart would benefit by graphing both the number of streams and the mid-February to May rainfall total or number of days above a threshold flow.	Accepted- Points categorized as wet, normal, or dry based on spawning season stream flows.
13	30-36	Too bad the commercial harvest had not continued so that we would have recent data.	Noted- Commercial operations ceased following the retirement of the last operator.
14	1	Most abundant, but only 52 CLH captured? Electrofishing the small juveniles may not be an effective sampling technique. Trap nets?	Noted- The Department is experimenting with several sampling methods for CLH.
14	12	It appears to concerns about mortality eliminated sampling during the crucial period of CLH juvenile use of the littoral zone, so you did not get the necessary data. Isn't the data worth some incidental mortality?	Noted- When the surveys were designed they were for general fish surveys on the lake. It was requested of the Department that we reduce impacts to CLH as much as possible since the surveys were not directly targeted at them and were conducted using boat electrofishers.
14	12	If the species is listed, such an approach in collecting permits and monitoring may cripple effective monitoring needed to track population status. Similarly, it seems that the incidental catch data in the commercial harvest was extremely valuable data; can a resumption of carp and blackfish commercial harvest be encouraged to produce hitch data?	Noted- The Department works very closely with individuals conducting research on CLH. All research has been approved in a timely manner to allow for continued research on the species. Commercial catfish harvest has been banned at Clear Lake and no operators have applied for permits to catch other species in the lake.
16	5	Not in references	Accepted- reference added.
21	11	It seems like a resumption of commercial harvest of catfish might subsidize the blackfish and carp fishery and restore the incidental capture data on hitch that have been missing for the last decade.	Noted- Commercial harvest of most freshwater fishes has been banned in California.
28	4	As indicated earlier, a study of hitch age structure using otoliths would be useful to determine longevity in the lake and resilience to infrequent good spawning success.	Noted

31	24	It appears that the decline of hitch after introduction catfish and later inland silverside and the apparent inverse year-to-year relationship between silverside/threadfin shad and hitch support competition and predation as ongoing threats. The many barriers and diversion impacts on spawning have made successful (and widespread) spawning less likely and more subject to year to year runoff effects (now and with future climate change). However, the data on hitch abundance are limited but point to a boom or bust pattern in population abundance (with uncertain longevity of individual fish). The threats and the present pattern indicate that extinction is a real possibility without intervention to improve the amount and regularly of spawning success and juvenile survival in the littoral environment.	Noted- As described in the management actions section the Department agrees that spawning success is critical to the survival of the species
32	24	If listed, monitoring / collecting permits should be relatively liberal to allow collection of necessary data.	Noted- Permit requirements for CESA species are described in Fish and Game Code and Title 14.

State of California – Natural Resources Agency
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EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

January 13, 2014

Peter B. Moyle
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Dear Dr. Moyle

CLEAR LAKE HITCH (*LAVINIA EXILICAUDA CHI*); DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW STATUS REPORT

Thank you for agreeing to serve as a scientific peer reviewer for the Department of Fish and Wildlife (Department) Draft Status Report of the Clear Lake hitch (*Lavinia exilicauda chi*). A copy of the Department's peer review draft status report, dated January 2014, is enclosed for your use in that review. The Department seeks your expert analysis and input regarding the scientific validity of the report and its assessment of the status of Clear Lake hitch in California based on the best scientific information currently available. The Department is interested in and respectfully requests that you focus your peer review effort on the body of relevant scientific information and the Department's assessment of the required population and life history elements prescribed in the California Endangered Species Act (CESA). The Department would appreciate receiving your peer review input on or before February 10, 2014.

The Department seeks your review as part of formal proceedings pending before the California Fish and Game Commission under CESA. As you may know, the Commission is a constitutionally established entity distinct from the Department, exercising exclusive statutory authority under CESA to list species as endangered or threatened. The Department serves in an advisory capacity during listing proceedings, charged by the Fish and Game Code to focus on the best scientific information available to make related recommendations to the Commission.

The Commission first received the petition to list Clear Lake hitch as threatened on September 25, 2012. The Commission accepted the petition for further consideration and the species was formally designated as a candidate species on March 22, 2013 following publication of regulatory notice by the Office of Administrative Law. The Clear Lake hitch is currently protected under CESA in California in that capacity.

The peer review Status Report forwarded to you today reflects the Department's effort over the past year to identify and analyze the best scientific information available regarding the status of Clear Lake hitch in California. Headed into peer review, the Department believes the best available science indicates that listing the species as threatened under CESA is warranted at this time. To be clear, we ask that you focus

your review on the scientific information and the Department's related assessment of the required population and life history elements prescribed in CESA rather than focusing on the tentative conclusion we share as a matter of professional courtesy. We underscore, however, that scientific peer review plays a critical role in the Department's effort to develop and finalize its recommendation to the Commission as required by the Fish and Game Code.

Again, because of the importance of your effort, we ask you to focus your review on the best scientific information available regarding the status of Clear Lake hitch in California. As with our own effort to date, your peer review of the science and analysis regarding each of the population and life history categories prescribed in CESA (*i.e.*, present or threatened habitat modification, overexploitation, predation, competition, disease, and other natural occurrences or human-related activities that could affect the species) are particularly important as well as whether they indicate, in your opinion, that Clear Lake hitch is likely to become, in the foreseeable future, at serious risk of becoming extinct throughout all or a significant portion of its range in California.

We ask that you assess our work for quality and conduct a thorough and proper review. As with all peer review processes, the reviewer is not the final arbiter, but your comments will inform our final decision-making. Also, please note that the Department releases this peer review report to you solely as part of the peer review process, and it is not yet public.

For ease of review, I invite you to use "track changes" in WORD, or provide comments in list form by page and line number of the report. Please submit your comments electronically to Kevin Thomas at kevin.thomas@wildlife.ca.gov, or he may be reached by telephone at (916) 358-2845.

If there is anything the Department can do to facilitate your review, please let me know. Thank you again for your contribution to the status review effort and the important input it provides during the Commission's related proceedings.

Sincerely,

Stafford Lehr
Chief, Fisheries Branch

Enclosure(s)

cc: Tina Bartlett
CDFW-NCR

Thomas Gibson
CDFW-OGC

Katherine Hill
CDFW-NCR

Kevin Thomas
CDFW-NCR

State of California
Natural Resources Agency
Department of Fish and Wildlife

REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF CLEAR LAKE HITCH (*Lavinia exilicauda chi*)

January 2014 Preliminary Draft for Peer Review

Clear Lake hitch adult. Photo courtesy of Rick Macedo

Charlton H. Bonham, Director
Department of Fish and Wildlife

Report to the Fish and Game Commission

A STATUS REVIEW OF CLEAR LAKE HITCH

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EXECUTIVE SUMMARY

This status review report describes the current status of Clear Lake hitch (*Lavinia exilicauda chi*) (CLH) in California as informed by the scientific information available to the California Department of Fish and Wildlife (Department, CDFW, CDFG).

Background

- September 25, 2012: The Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity to list CLH as threatened under the California Endangered Species Act (CESA) (Center for Biological Diversity 2012).
- September 26, 2012: The Commission sent a memorandum to the Department, referring the petition to the Department for its evaluation.
- October 12, 2012: The Commission provided notice of the received petition from the Center for Biological Diversity to list CLH as threatened under CESA (Cal. Reg. Notice Register 2012, Vol. 41-Z, p.1502).
- December 12, 2012 the Commission granted a 30-day extension on the submission date for the Department's Initial Review of Petition to List the Clear Lake Hitch as threatened under CESA.
- January 31, 2013: The Department provided the Commission with an Initial Review of Petition to List the Clear Lake Hitch as Threatened under the California Endangered Species Act pursuant to Fish and Game Code, section 2073.5. The Department's review recommended that the petition provided sufficient information to indicate the petitioned action may be warranted, and the petition should be accepted and considered (CDFW 2013).
- March 6, 2013: At its scheduled public meeting in Mt. Shasta, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received by the Commission and found that the petition provided sufficient information to indicate the petitioned action may be warranted.
- March 22, 2013: The Commission published its Notice of Findings in the California Regulatory Notice Register (CA Reg. Notice Register 2013, Vol. 12-Z p. 488), stating the petition was accepted for consideration, and designated CLH as a candidate species.

Summary of Findings

Note to Reviewer: This Summary of Findings will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

Status

Threats

Petitioned Action

Management and Recovery Recommendations

INTRODUCTION

This status review report addresses the Clear Lake hitch (*Lavinia exilicauda chi*) (CLH), the subject of a petition to list the species as threatened under the California Endangered Species Act (CESA) (Fish & G. Code § 2050 *et seq*.).

Petition History

On September 25, 2012, the Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity (Petitioner) to list the CLH as a threatened species under CESA.

On September 26, 2012 the Commission sent a memorandum to the California Department of Fish and Wildlife (Department, CDFW, and CDFG) referring the petition to the Department for its evaluation.

On October 12, 2012, as required by Fish and Game Code, section 2073.3, notice of the petition was published in the California Notice Register (Cal. Reg. Notice Register 2012, Vol. 41-Z, p.1502).

On December 12, 2012 the Commission granted a 30-day extension on the submission date for the Department's Initial Review of Petition to List the CLH as threatened under CESA.

On January 31, 2013, the Department provided the Commission with its Initial Review of Petition to List the CLH as threatened under CESA. Pursuant to Fish and Game Code, section 2073.5, subdivision (a) (2), the Department recommended that the petition provided sufficient information to indicate the petitioned action may be warranted.

On March 6, 2013 at its scheduled public meeting in Mt. Shasta, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received, and found that sufficient information existed to indicate the petition may be warranted and accepted the petition for consideration.

Subsequently, on March 22, 2013 the Commission published its Notice of Findings for CLH in the California Regulatory Notice Register, designating the CLH as a candidate species (CA Reg. Notice Register 2013, Vol. 12-Z p. 488).

Department Review

Following the Commission's action to designate CLH as a candidate species, the Department notified affected and interested parties and solicited data and comments on the petitioned action, pursuant to Fish and Game Code, section 2074.4 (see also Cal. Code Regs., Title 14, § 670.1(f)(2)) (CDFW 2013). All comments received are included in Appendix D to this report. The Department commenced its review of the status of the species as required by Fish and Game Code section 2074.6.

This report reflects the Department's scientific assessment to date of the status of CLH in California. At this point, the report will undergo independent and competent peer review by scientists with acknowledged expertise relevant to the status of CLH. Once peer review is completed Appendix E will contain the specific input provided to the Department by the individual peer reviewers (Cal. Code Regs., Title 14, § 670.1(f) (2)).

BIOLOGY

Species Description

Clear Lake hitch is a member of the cyprinid family (Cyprinidae), growing to 35 centimeters (cm) standard length (SL), and with laterally compressed bodies, small heads and upward pointing mouths (Moyle et al. 1995). They are separated from other California minnows by their long anal fin consisting of 11 to 14 rays. The dorsal fin (10 to 12 rays) originates behind the origin of the pelvic fins. Juvenile CLH have a silver coloration with a black spot at the base of the tail. As CLH grow older the spot is lost and they appear yellow-brown to silvery-white on the back. The body becomes deeper in color as the length increases (Hopkirk 1973; Moyle 2002). CLH show little change in pigmentation during the breeding season (Hopkirk 1973). The deep, compressed body, small upturned mouth, and numerous long slender gill rakers (26 to 32) reflect the zooplankton-feeding strategy of a limnetic forager (Moyle 2002). This lake adapted subspecies also has larger eyes and larger scales than other hitch subspecies.

Taxonomy

Hopkirk (1973) described CLH as a lake-adapted subspecies based primarily on the greater number of fine gill rakers. CLH are distinguished from other subspecies of hitch by their deeper body, larger eyes, larger scales and more gill rakers (Hopkirk 1973). Recent research on 10 microsatellite loci supports Hopkirk's description of CLH as a distinct subspecies (Aguilar et al. 2009). However, mitochondrial DNA analysis has not been able to distinguish CLH as a distinct subspecies from other hitch in California. Yet, based upon the morphological and microsatellite analysis there is sufficient evidence to warrant the designation of CLH as a distinct subspecies of hitch (Hopkirk 1973; Moyle et al. 1995; Aguilar et al. 2009).

CLH can hybridize with other Cyprinidae species and hybridization is known to occur with the genetically similar California roach (*Lavinia symmetricus*) (Miller 1945b; Avise and Ayala 1976; Moyle and Massingill 1981; Moyle et al. *in review*). However, there is no documentation of these hybrids in Clear Lake. CLH were known to hybridize in Clear Lake with the now extinct thicktail chub (*Gila crassicauda*) (Moyle et al. *in review*).

Range and Distribution

The entire CLH population is confined to Clear Lake, Lake County, California, and to associated lakes and ponds within the Clear Lake watershed such as Thurston Lake and Lampson Pond (Figure 1). Populations previously identified in the Blue Lakes, west of Clear Lake, have apparently been extirpated (Macedo 1994).

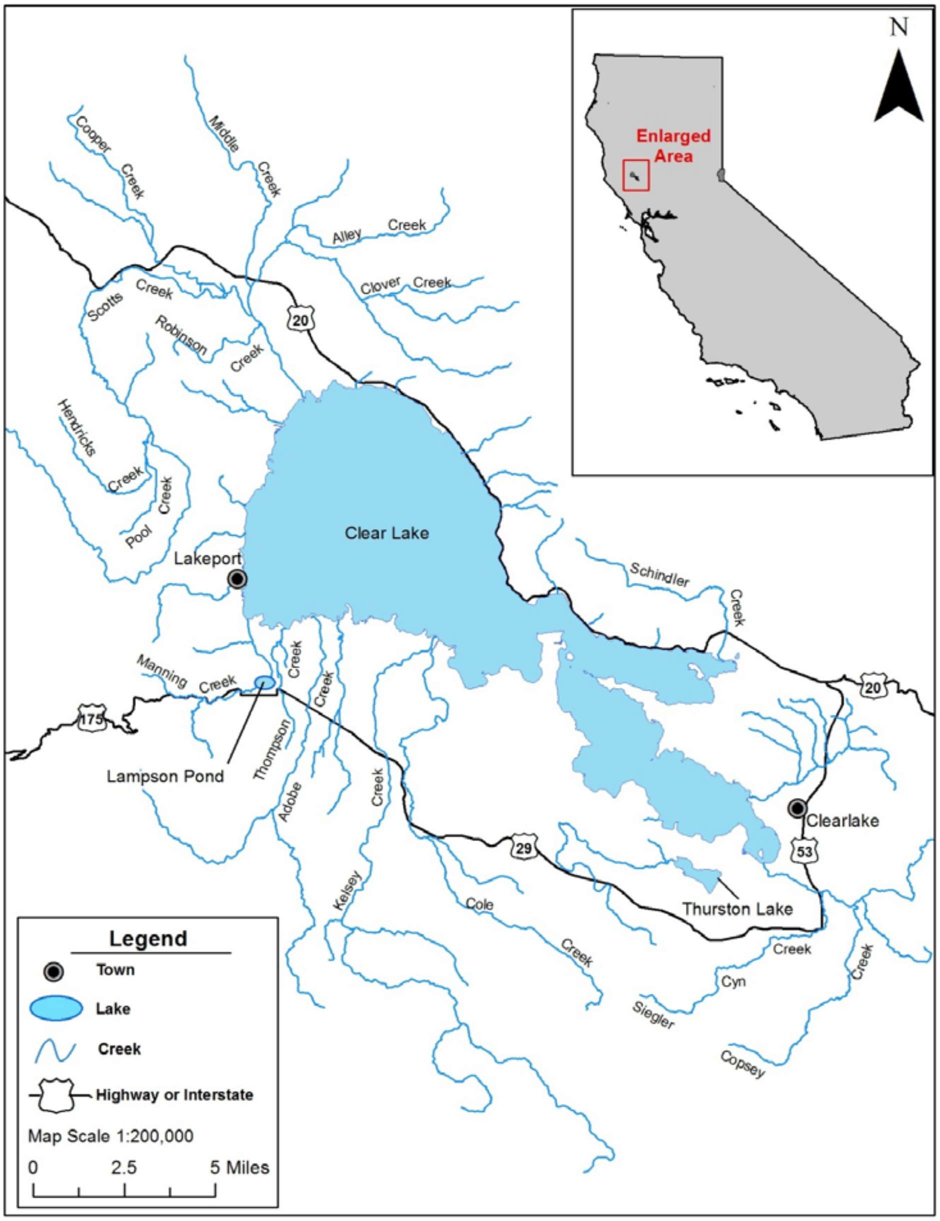

Figure 1. Map depicting the Clear Lake watershed.

Life History

Physical adaptations to lake conditions allow CLH greater than 50 millimeters (mm) SL to feed largely ~~almost exclusively~~ on water fleas (*Daphnia* spp.) (Geary 1978; Geary and Moyle 1980; Moyle 2002). Stomach analysis indicates that CLH feed primarily in the day rather than at night (Geary 1978). Juveniles less than 50 mm SL are found in shallow, littoral zone (near-shore) waters and feed primarily on the larvae and pupae of C~~c~~hironomidae; planktonic crustaceans including the genera *Bosmin~~ni~~a* and *Daphnia*; and historically on the eggs, larvae, and adults of Clear Lake gnat (*Chaoborus astictopus*) (Lindquist et al. 1943; Geary 1978; Geary and Moyle 1980). Growth in CLH is faster and total size greater than that of other hitch subspecies (Nicola 1974). By three months CLH have reached 44 mm SL and will continue to grow to between 80 to 120 mm by the end of their first year (Geary and Moyle 1980). Females become mature by their second or third year, whereas males tend to mature in their first or second year (Kimsey 1960). Females grow faster and are larger at maturity than males (Hopkirk 1973; Geary 1978; Ringelberg and McGinnis 2009). The larger size of CLH in comparison to hitch from other locations translates to greater fecundity. Accordingly, spawning females in Clear Lake average 36,000 eggs each year (Geary and Moyle 1980) compared to an average of 26,000 eggs for hitch in Beardsley Reservoir (Nicola 1974). Scale analysis indicates CLH live up to 6 years but it is likely that some individuals live longer (Moyle 2002).

CLH spawn in both lake tributaries and in the lake itself. Clear Lake tributaries are numerous and located around the lake basin (Figure 1). Most streams have headwaters at higher elevations in the surrounding foothills; others have headwaters in lower elevations of the basin, and nearly all have low gradients in their lower reaches. Some streams have ~~are more substantial than others with~~ flowing water year round, at least in headwaters. ~~.~~ The lower reaches of tributary streams ~~Most~~ are seasonal with remnant pools occurring by late spring, and subsequently dry during summer months in most years. ~~Those that retain water year round often have long stream reaches that are ephemeral.~~ CLH spawn in these low-gradient tributary streams and have ~~form~~ spawning migrations that resemble small scale salmon runs. Spawning migrations usually occur in response to heavy spring rains, from mid-February through May and occasionally into June (Murphy 1948b; Kimsey 1960; Swift 1965; Chi Council for Clear Lake Hitch (CCCLH) 2013 (unpublished data)). During wet years, CLH spawning migrations may also opportunistically extend into the upper reaches of various small tributaries, drainage ditches, and even flooded meadows (Moyle et al. *in review*). CLH have also been observed spawning along the shores of Clear Lake, over clean gravel in water 1 to 10 cm deep where wave action cleans the gravel of silt (Kimsey 1960). The success of these ~~atypical~~ spawning events ~~areas~~ is not clearly understood and may be limited due to losses from ~~egg desiccation and juvenile~~ predation on eggs and larvae, especially by alien fishes such as bluegill and Mississippi silverside (Kimsey 1960; Rowan, J. personal communication, October 10, 2013, unreferenced).

Comment [PM1]: ? which ones?

CLH spawn at water temperatures of 14 to 18°C in the lower reaches of tributaries. Egg deposition occurs along the margins of streams in very shallow riffles over clean, fine-to-medium sized gravel (Murphy 1948b; Kimsey 1960). Eggs are fertilized by one to five males as they are released from the females (Murphy 1948b; Moyle 2002). Eggs are non-adhesive and sink to the bottom after fertilization, where they become lodged among the interstices in the gravel. The eggs immediately begin to absorb water and swell to more than double their original size. This rapid expansion provides a protective cushion of water between the outer membrane and the developing embryo (Swift 1965) and may help to secure eggs in gravel interstices. The embryos hatch after approximately 7 days, and larvae become free-swimming after another 7 days (Swift 1965). Larvae must then move downstream to the lake before stream flows become ephemeral (Moyle 2002).

Within Clear Lake, larvae remain near shore and are thought to depend upon stands of tules (*Schoenoplectus acutus*) and submerged weeds for cover until they assume a limnetic lifestyle (CDFG 2012). Juvenile CLH require rearing habitat with water temperatures of 15° C or greater for survival (Moyle 2002; Franson 2012 and 2013). Juveniles are found in littoral shallow-water habitats and move into deeper offshore areas after approximately 80 days, when they are between 40 to 50 mm SL (Geary 1978; CDFG 2012). Adult CLH are usually found in the limnetic zone (well-lit, surface waters away from shore) of Clear Lake. The limnetic feeding behavior of adult fish is supported by stomach analysis of CLH where very little content of benthic midges was found, even though the fish were collected in the profundal (deep-water) habitat during the survey (Cook et al. 1964). Additional data collected by the Department during the early 1980s indicates CLH are present in the littoral zone from April to July and are scarce in ~~absent from~~ this habitat during other months (Week 1982).

Adult CLH are vulnerable to predation during their spawning migration by mergansers (*Mergus* spp.), herons (*Ardea* spp.), bald eagles (*Haliaeetus leucocephalus*), and other birds, river otter (*Lontra canadensis*), northern raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*) (Bairrington 1999). In addition, CLH have been recovered from the stomachs of black bass (*Micropterus* spp.) caught in the lake (Bairrington 1999). Most predation by black bass likely occurs during spring staging periods as CLH congregate and begin to ascend tributaries to spawn (Rowan, J. personal communication, October 10, 2013, unreferenced).

Comment [PM2]: Are you sure? Bass fisherman use a hitch luare in the lake....

Habitat that May be Essential to the Continued Existence of the Species

At various life stages CLH utilize stream and lacustrine (lake) habitat present in the watershed (Figure 1). Adult fish spawn in the tributaries of the lake during the spring and juvenile fish emerge from the tributaries and utilize near shore habitats to continue growth and seek refuge from predators. As juveniles mature into adults they move to the main body of the lake and assume a limnetic lifestyle until returning to spawn in the tributaries or shallows of the lake during the following spring.

SPECIES STATUS AND POPULATION TRENDS

Ideally, a~~A~~n assessment of the status of CLH should include statistically valid population estimates conducted over time, to provide population data and trends. CLH studies to date have consisted primarily of qualitative sampling and are not suitable for deriving population estimates; however, these study results can provide insight into the current status of the species. Glimpses into baseline numbers suggest that hitch were once very abundant. One of the oldest records is that of Livingston Stone (1876) who lived on the lake in 1872 and 1873. He states " They ran up the streams in spring to spawn in countless numbers. It is not unusual to see one or two acres of ground covered with hitch, which the Indians have dried for food." If you assume each drying fish is about 10 x 3 inches, this results in an estimate of about 200,000 fish per acre. Obviously, such numbers are at best 'ball park' estimates but they do suggest hitch were vastly more abundant then than they are today.

The population trends for this status review focus on three sets of data available to the Department for analysis. First, commercial catch records, submitted to the department by operators on Clear Lake, contain incidental catch information on CLH dating back to 1961. Operators were required to keep records of CLH caught incidentally while operations focused on other species in the lake. Second, the Lake County Vector Control District (LCVCD) has been conducting sampling efforts along the shoreline of Clear Lake since 1987. Although sampling efforts are not specific to CLH, LCVCD recorded incidental data on CLH captured during each sampling. Third, spawning observation data have been collected by volunteers with the CCCLH since 2005. Spawning observation data provide an estimate of the number of CLH in any given spawning tributary during the observation period. Results are summarized by the CCCLH each year following the completion of the spawning season. Information on population trends prior to 1961 is focused on small sampling efforts, published articles, and traditional ecological knowledge from tribal members. Although not quantifiable, this data provides an idea of the status and distribution of CLH prior to larger qualitative sampling efforts.

Environmental conditions required for successful spawning and biological impacts to the survivorship of CLH are highly variable from year to year and often result in multiple years with reduced spawning success or reduced recruitment into the population. The information presented in Figure 2 comes from the three qualitative sampling efforts conducted at Clear Lake and measured rainfall totals during the past 52 years in the watershed. Trend data in commercial catch records were represented for a given year by totaling the number of CLH captured per year and dividing by the number of days commercial operations occurred. Commercial catch data are comprised primarily of adult CLH. The CLH spawning trend data were calculated by totaling the number of CLH observed and dividing by the number of observation periods. LCVCD data on CLH captures represent the total number of CLH captured per year. LCVCD data is comprised primarily of juvenile CLH. The data represented from Table 6 of CDFG (1999) were calculated by using 20,000 as a total catch baseline for percent of total catch for CLH. Total rainfall data for January to June of each year was measured at the Clear Lake Highlands and U.S. Geological Survey rainfall gauges. Figure 2 does not reflect population numbers but rather trends in the abundance of CLH in any given year. As a proxy for changes in an established population size, biologists often use qualitative information as an indicator of population trends.

The trends of all data show a highly variable population that responds both positively and negatively to environmental parameters and varies significantly from year to year. Rainfall totals do not appear to be significantly correlated to ~~the~~ abundance of CLH during the timeframe. It is likely that a combination of environmental factors is impacting the CLH population. The fluctuating abundance trend has continued throughout the duration of the qualitative sampling efforts and indicates CLH populations have at times been extremely low and at other times relatively high ~~robust~~.

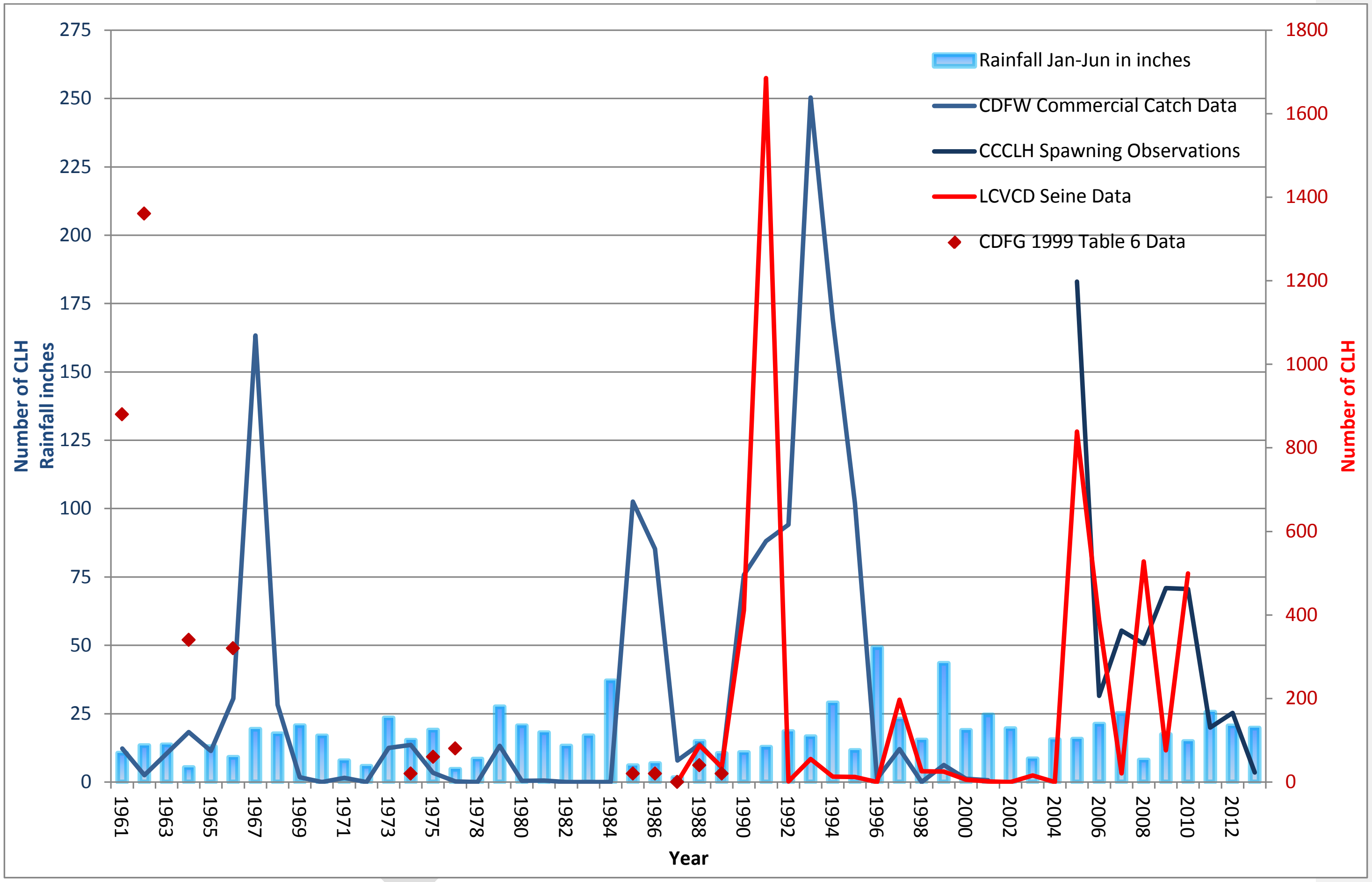

Figure 2. Clear Lake hitch population trends over the past 52 years as measured by three methods of qualitative sampling and spawning season rainfall totals as recorded at the Clear Lake Highlands and U.S. Geological Survey 385525122335501 rainfall gauges. Data in blue tones corresponds to the primary y axis and data in red tones corresponds to the secondary y axis.

In 2013 the Department conducted a mark-and-recapture study to gain a better understanding of the CLH spawning population in Cole and Kelsey creeks. Unfortunately, too few individuals were marked and recaptured to give a statistically valid population estimate (Ewing 2013). Electrofishing surveys in June 2012 identified thousands of young of year CLH in near shore habitats along the southwestern shoreline of Clear Lake (CDFG 2012). Volunteers with the CCCLH conducted direct observations of CLH in spawning tributaries of Clear Lake in 2013, and spawning observations identified less than 500 CLH present (CCCLH 2013). Of those fish, 300 to 400 were found below the Kelsey Creek detention dam. No single day count totaled more than 70 fish in any spawning tributary in 2013 (CCCLH 2013).

CCCLH qualitative spawning observations between 2005 and 2013 indicated peak single day CLH spawning runs of 1,000 to 5,000 fish (CCCLH 2013), and daily observation averages ranged from 3.5 to 183.1 fish (Figure 2). However, these observations make no distinction between previously counted fish, and it may be more prudent to look at fixed location single day counts from this time period. The highest number of CLH observations recorded was approximately 5,000 during 2005; concurring with beach seine data that demonstrate a higher than average number of CLH caught in 2005 as well (CCCLH 2013; LCVCD 2013). The increased number of juvenile CLH ~~captured~~ in ~~the~~ 2005 ~~beach seine sampling~~ is the likely reason for the increase in adult spawning observations between 2007 and 2009. Appendix A contains summary graphs and figures, prepared by CCCLH, for observations made between 2005 and 2013.

There is sufficient information from these spawning observations to suggest the number of spawning tributaries being used by CLH decreased in 2013 compared to the average from 2005 to 2012 (Figure 3) (CCCLH 2013). However, the data limitations do not allow for quantification of observation time on each creek (survey effort) compared with the number of fish observed to aid in understanding the extent of use in each tributary. Appendix B contains figures depicting the decline in annual spawning runs in Clear Lake tributaries between 2005 and 2013 (CCCLH 2013). Historic accounts and habitat suitability predications suggest that CLH originally spawned, to some degree, in all the tributaries to Clear Lake (Robinson Rancheria Ecological Center (RREC) 2011). However, reports on Pomo geography speak of Pomo tribes in the area travelling to Kelsey Creek to capture CLH and even of war when a tribe tried to divert Kelsey Creek to gain control of the important CLH supply (Barrett 1906; Kniffen 1939). Based on this~~e~~ reports it is unclear to what extent CLH spawned in other tributaries to Clear Lake. It can be surmised the majority of CLH spawning occurred in Kelsey Creek during this period. Over the past eight years the number of occupied spawning tributaries has decreased from a high of 12 in 2006 to three in 2013 (CCCLH 2013). Currently, Adobe Creek seems to have the largest spawning run in the Clear Lake watershed while Kelsey and Cole creeks support smaller spawning runs. Based on historical accounts the most important ~~primary~~ spawning tributary has shifted from Kelsey Creek to Adobe Creek (Kniffen 1939; CCCLH 2013).

Comment [PM3]: I disagree. Kelsey Creek presumably supported the largest run because of its size but there is no reason to think the fish did not use every available tributary as they do today.

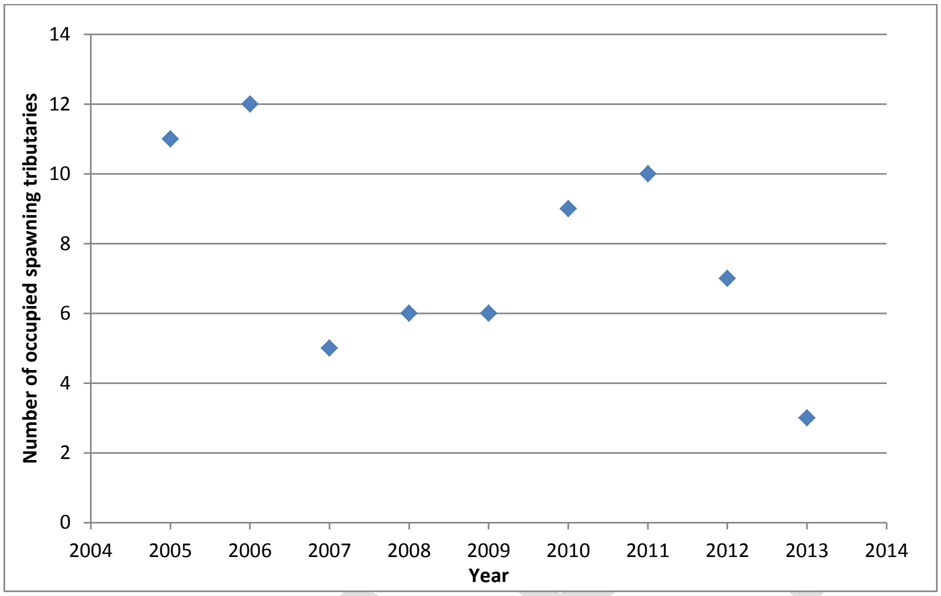

Figure 3. Number of occupied Clear Lake hitch spawning tributaries documented by CCCLH observers between 2005 and 2013.

LCVCD has been collecting beach seine data at various sites around the lake for more than two decades. The sampling is designed to measure abundance of threadfin shad (*Dorosoma petenense*) and Mississippi~~inland~~ silversides (*Menidia* ~~-~~*audens*~~*beryllina*~~) as part of a Clear Lake gnat (*Chaoborus astictopus*) surveillance program. Incidental captures of CLH are recorded during these surveys; however, the data collected are not appropriate for a statistically valid evaluation of CLH populations as ~~the~~ sampling~~e~~ ~~design~~ varies significantly in timing, water quality conditions, and lake depth during surveys. Additionally, sample locations are in areas that contain open unvegetated beaches that are not preferred habitat for CLH. Although surveys were not conducted to assess CLH, capture data for these surveys is consistent with other data sources in demonstrating a population that has poor recruitment in many years interspersed with few years of high levels of recruitment (Figure 4) (LCVCD 2013). In most years less than 100 CLH are captured during the surveys (17 of 24 years). Four of the six years when more than 100 CLH were captured were between 2005 and 2010. The greatest numbers of CLH were captured in 1991, a year that was described by the Department as a boom for juvenile fish in the lake (Bairrington 1999). Commercial fisheries data from 1991 also indicate an increase in CLH numbers captured during operations; over 6,000 CLH were captured and released by commercial fishery operators between March and May in 1991 (CDFW Commercial Fisheries Data). Data from the early 1990s also indicate an increase in zooplankton and macroinvertebrate numbers resulting in increased available forage for CLH (Winder et al. 2010).

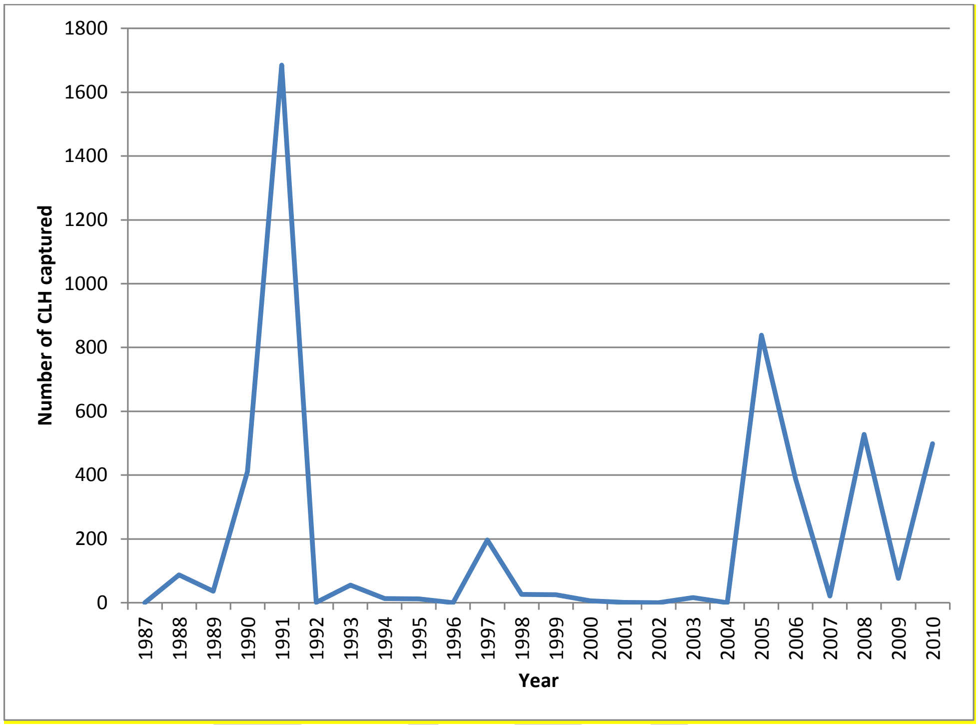

Figure 4. Summary of Clear Lake hitch captured during Lake County Vector Control District beach seine surveys conducted from 1987 to 2010.

The data available to the Department that cover the greatest timeframe come from commercial harvest records for Clear Lake. These data, 1961 to 2001, provide estimates of CLH numbers captured incidentally during operations (Figure 5). Multiple times throughout the past 50 years the number of CLH captured has surpassed 10,000 fish. There are also several years where CLH were almost or entirely absent from sample collections. These data suggest that CLH can sustain a population through multiple years of suppressed spawning or recruitment or both.

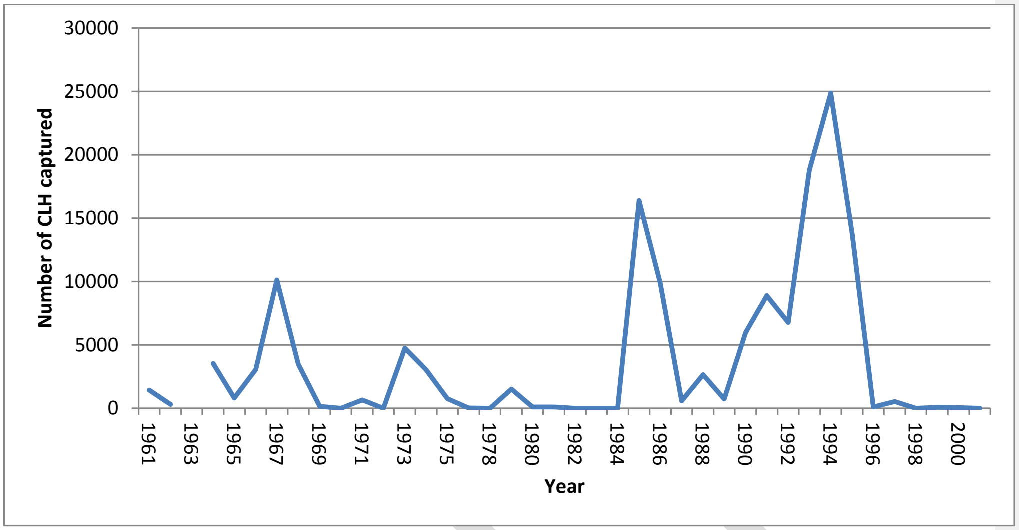

Figure 5. Number of Clear Lake hitch captured incidentally during commercial harvest operations between 1961 and 2001.

In the 1980s, the Department began sampling Clear Lake fishes to assess native and sport fish populations in the lake. Surveys found adult and juvenile (?) CLH occupying littoral habitats between April and July each year (Week 1982). The surveys were directed towards littoral zone use and provide no information on CLH outside of those months (Week 1982). An electrofishing survey was completed in April of 1987, and CLH was the most abundant fish sampled at locations around Rattlesnake Island and Clearlake Oaks subdivision; however, only a total of 52 CLH were captured during the survey (CDFG 1988). It must be noted that this sampling was on a very small scale, targeted black crappie (*Pomoxis nigromaculatus*), and occurred in habitats where CLH would not? likely be found during this time period. Additional spring and fall sampling between 1995 and 2006 found CLH to be the most abundant native fish, but the overall capture numbers were relatively low with a peak catch per unit effort (CPUE) of only 0.087 for juvenile fish in the fall of 2000 and 0.169 for adult fish in the spring of 1999. CPUE's were based on the number of fish caught per minute of electrofishing (Cox 2007). Electrofishing surveys conducted during late June 2007 reported low numbers of CLH recorded during the survey (Rowan 2008). The low numbers of CLH may be attributed to the sampling timeframe in late June. As noted in Cook et al. 1964, CLH were absent from littoral zone sampling following the start of summer. In an effort to reduce impacts to CLH while sampling, the Department's Clear Lake surveys between 2008 and 2012 were all confined to the timeframe of late June and July when CLH numbers are greatly reduced in the littoral zone.

As late as 1972, CLH and other nongame fish were described as comprising the bulk of the Clear Lake fishery (Puckett 1972). The Lake County Mosquito Abatement District conducted surveys between 1961 and 1963 examining the relationship between fish and midges. These surveys identified CLH as the third most abundant fish in the lake.

Comment [PM4]: Using a boat electrofisher?

The majority of CLH were captured in the littoral and profundal zones using gill nets. However, the limnetic zone was not sampled since midges do not occur in this area. A total of 1,229 fish was taken during these surveys (Cook et al. 1964).

Field notes from CDFG biologists in 1955 note CLH runs with large numbers in Kelsey Creek (CDFG 1955). Similar notes from 1956 indicate spawning CLH in Kelsey Creek as numbering in the hundreds and Seigler Creek containing 400 CLH for every 100 feet of stream above the Anderson Brothers ford (CDFG 1956). CLH were the second most abundant fish caught during various gill net surveys in the lake in ~~at that time (Lindquist et al. 1943).~~ Surveys conducted between 1938 and 1941, for examination of fish and gnat interactions(Lindquist et al. 1943); ~~, describe the~~ runs of Sacramento splittail *(Pogonichthys ciscoides~~Ptychocheilus grandis~~)* and CLH were described as numbering in the tens of thousands (Lindquist et al. 1943). A photograph from 1890 depicts a spawning run so thick that CLH formed a blanket across the creek (Figure 6). Early stories from the area describe fish runs so thick that streams were difficult to ford by horses and wagons, and residents shoveled spawning fish to bring home for hog feed (Rideout 1899). The volume of dead fish found during spawning runs on Clear Lake tributaries created a stench that was intolerable to lakeshore residents (Dill and Cordone 1997). It is not entirely clear if spawning runs such as those depicted in Figure 6 occurred every year or fluctuated based on tributary flows, but it is likely they fluctuated in a similar fashion to what was observed during the past decade of CCCLH spawning surveys. Regardless, the body of evidence lends support for claims of CLH as common and the most abundant fish in Clear Lake during the late nineteenth and early twentieth centuries (Coleman 1930; Jordan and Gilbert 1894).

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Comment [PM5]: Hard to tell what species....

Figure 6. Photo from 1890s depicting spawning fish, most likely CLH, being stranded in Kelsey Creek.

FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE

Present or Threatened Modification or Destruction of Habitat

Wetland Habitat Loss

Wetlands provide critical rearing habitat for juvenile fishes native to Clear Lake (Geary 1978; CDFG 2012). Prior to the arrival of European settlers in the mid-1800s, Clear Lake was surrounded by large tracts of wetlands. Throughout the expansion of European settlements around the lake, the wetland habitat was drained and filled to provide urban and agricultural lands. Currently, the Clear Lake watershed contains over 16,000 acres of land dedicated to agricultural production (Lake County Department of Agriculture 2011; Forsgen Associates Inc. 2012). Comparisons of historical versus current wetland habitat reveal a loss of approximately 85%, from 9,000 acres in 1840 to 1,500 acres by 1977 (Week 1982; Bairrington 1999; Suchanek et al. 2002; ; Lake County Department of Public Works 2003; Giusti 2009; CEPA 2012). Loss of wetland habitat coupled with competition for existing habitat with introduced fishes has led to a decline in available rearing habitat for juvenile CLH (Week 1982).

Spawning Habitat Exclusion and Loss

Dams, Barriers, and Diversions

Cache Creek Dam was constructed at the outlet of Clear Lake in 1915, and Yolo County Flood Control and Water Conservation District (YCFCWCD) manipulates the lake water level several feet seasonally to allow for diversions for irrigation (CDWR 1975). Clear Lake is allowed to fluctuate on a yearly basis, a maximum of 7.56 feet above a mean level plane referred to as the “Rumsey gage” (CDWR 1975). The effects of lake water manipulations on CLH populations have not been quantified. Manipulation of water levels in the Clear Lake watershed likely results in decreased water quality, a reduction in spawning and rearing habitat, and increased risk of predation (Converse et al. 1998; Wetzel 2001; Gafny et al. 2006; Cott et al. 2008; Hudon et al 2009). All of these impacts can lead to the extinction of native species that evolved in lakes free of habitat modifications resulting from impoundment structures (Wetzel 2001). Impounded systems also tend to be dominated by non-native species (Moyle and Light 1996).

Comment [PM6]: Clear Lake is not a classic impoundment being a natural lake. One could argue that keeping lake levels higher in spring could benefit hitch (more littoral habitat for young).

CLH spawn in low-gradient tributary streams to Clear Lake. All of the tributary streams to Clear Lake have been altered (Appendix C) to various degrees by dams, barriers, and diversions. Stream alterations can block migratory routes and decrease stream flows necessary for spawning. The result can be loss of spawning and rearing habitat, loss of nursery areas, increases in predation, competition from non-native aquatic species, and decreased water quality (Murphy 1948 and 1951; Moyle 2002;). A limited physical habitat analysis survey was conducted in 2013 on Adobe, Kelsey, Manning, Middle, and Scotts creeks. Results of the survey indicate all of the lower reaches? of the creeks had low Index of Biological Integrity (IBI) scores and are either partially or not supportive of aquatic life (Mosley 2013). Examples of alterations to Clear Lake tributaries that have impacted CLH include agricultural irrigation pumps and diversions, aggregate mining activity, flood control structures, road crossings, bridge aprons, and off-highway vehicle (OHV) use (McGinnis and Ringelberg 2008).

Comment [PM7]: Not in references; would like to see a copy.

Adobe Creek, Highland Creek, Middle Creek, Clover Creek, and Kelsey Creek have experienced a reduction in fish spawning habitat since the installation of dams and increased irrigation (Murphy 1951; Macedo 1994; McGinnis and Ringelberg 2006). A barrier assessment was completed in 2006 for Middle Creek and the Kelsey Creek fish ladder (McGinnis and Ringelberg 2006). The assessment found physical barriers to fish migration were associated with bridge aprons and weirs as well as habitat barriers from historical gravel operations (McGinnis and Ringelberg 2006). The Kelsey Creek fish ladder was found unsuitable for passage of CLH. The jump heights and velocities at the ladder were determined to be too great for CLH (McGinnis and Ringelberg 2006). Spawning observations by CCCLH from 2005 to 2013 witnessed fish stranded below multiple barriers within the watershed (CCCLH 2013).

Many Clear Lake tributaries are no longer used for spawning or have reduced spawning runs as a result of artificial structures that continue to impede spawning migrations (Figure 7). While some operational and physical modifications to these structures have been implemented over the years, they continue to adversely impact spawning CLH, especially during dry years when spring stream flows are low.

In preparation of this report, the Department estimated the loss of CLH spawning and rearing habitat due to constructed barriers and impediments within the tributaries to Clear Lake (Figure 7). The barrier assessment determined the approximate locations of barriers and estimated miles of stream habitat as determined from the California Native Diversity Database, CDFW Geographic Information System, CDFW Fish Passage Assessment Database, California GIS street layer, and Google Earth Maps. Using that data, the Department estimated 180 river miles were historically available to spawning CLH and that barriers have eliminated or reduced access to greater than 92% of the historically available spawning habitat. Physical barriers, such as the footings of bridges, low water crossings, dams, pipes, culverts, and water diversions in Kelsey, Scotts, Middle, Clover, and other creeks interrupt or eliminate migration to spawning areas (McGinnis and Ringelberg 2008). Appendix C contains a list of several tributaries and some of their associated barriers.

Comment [PM8]: Good thing to do!

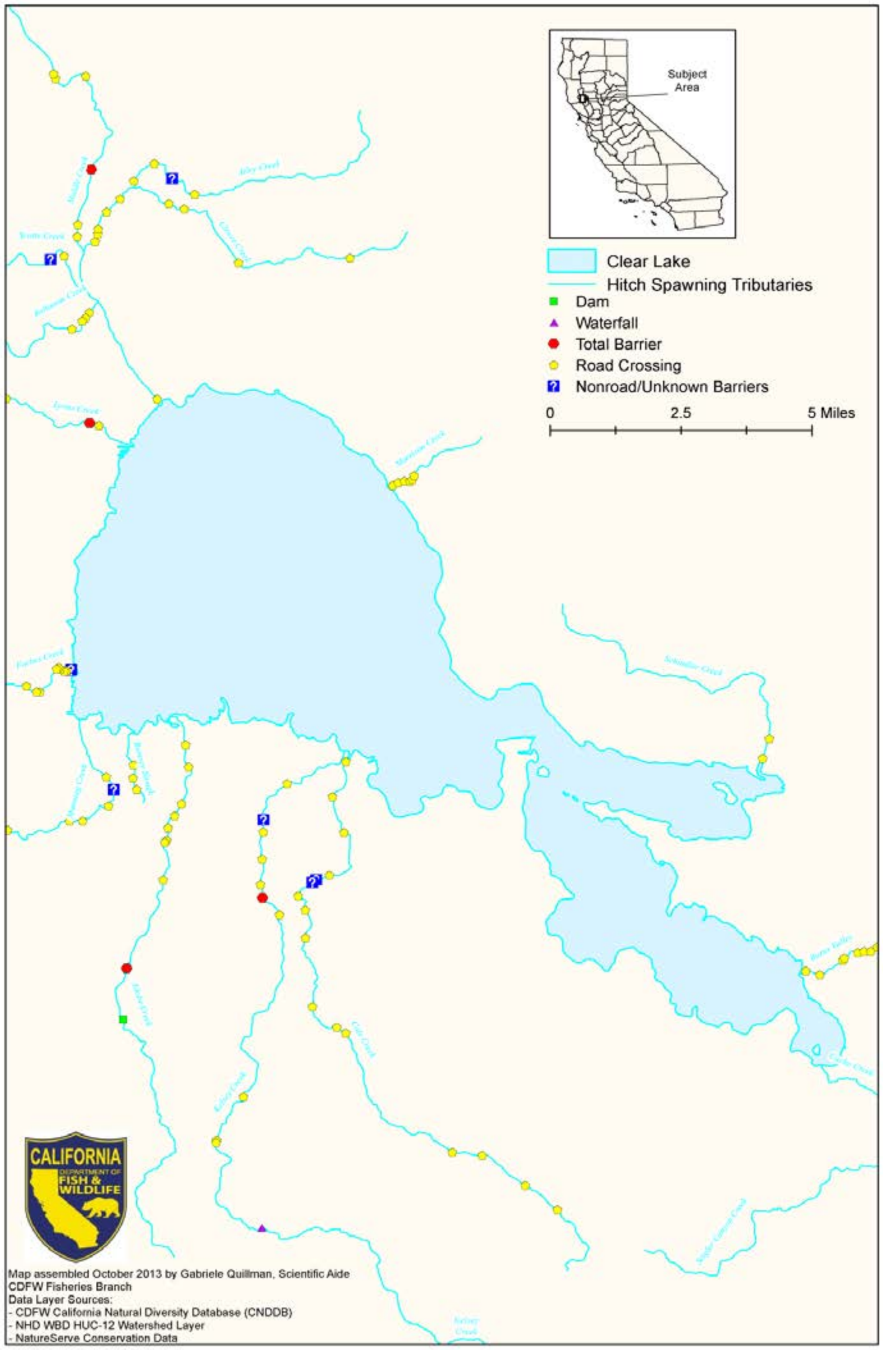

Figure 7. Clear Lake hitch spawning barriers located on tributaries throughout the watershed.

Water is frequently diverted from Clear Lake tributaries, during the CLH spawning season, under riparian rights associated with land ownership in the watershed. These water diversions consist of direct diversion from surface water intake pumps and from shallow off-channel wells that capture groundwater flows. The primary purpose of water diversions from Clear Lake tributaries is for agricultural production and frost protection. Water diversions for frost protection have been shown to temporarily reduce in-stream flow by as much as 95% (Deitch et al. 2009). Natural flow regimes are thought to favor the success of native fishes over non-native fishes (Marchetti and Moyle 2001). The impact of diversion on CLH spawning tributaries is poorly understood. In some tributaries, water diversion has contributed to early drying of stream reaches and desiccation of CLH eggs masses and newly hatched juveniles (Macedo, R., personal communication, November 25, 2013, unreferenced). Additionally, significant flow reductions can lead to increased water temperatures, reduced available aquatic habitat, altered or decreased biodiversity, increases in non-native species, and alterations to fish assemblages (Marchetti and Moyle 2001; Bunn and Arthington 2002; Bellucci et al. 2011).

The impacts of spawning habitat alterations to CLH may be inferred by the fate of another native Clear Lake fish that required tributaries for spawning; the Clear Lake splittail was last recorded in 1972 (Puckett 1972). The Clear Lake splittail formerly spawned later in the season than did CLH, and the drying up of tributaries contributed to their demise (Moyle 2002). All stream spawners had "declined precipitously" by 1944 (Murphy 1951). Cook et al (1966) noted the spittail "...underwent a drastic reduction in the 1940s" (p. 146) and feared it "...may disappear ... if increased demands upon the water further limit reproductive success." (p. 147) -Therefore, earlier drying of tributaries by both natural and anthropogenic processes likely impacts the CLH population.

Comment [PM9]: Cook SF, RL MOORE, and JD Connors. 1966. Status of the native fishes of Clear Lake, Lake County, California Wasmann Journal of Biology 24: 141-160.

Dredging and Mining

Since the first European settlers arrived at Clear Lake and began gravel mining and dredging operations, there have been documented deleterious effects on the watershed (Suchanek et al. 2002). Field notes from CDFG personnel conducting stocking assessments documented Kelsey Creek so loaded with silt from gravel operations that creek visibility was zero (CDFG 1955). Smaller scale mining and dredging in tributary streams has occurred since early settlement and has altered the amount and distribution of stream gravels (Thompson et al. 2013). In some tributaries, gravel extraction has resulted in the incising and channelizing of the streams and stream level changes by as much as 15 feet (Suchanek et al. 2002; Eutenier, D. April 17, 2013 comment letter). After 1965 about one million metric tons of gravel products per year were removed from the watershed until the partial moratorium on aggregate mining in 1981 (Richerson et al. 1994). Gravel was removed from Clear Lake tributaries to provide road base for new roads created to accommodate the expanding population of the area (Suchanek et al. 2002). Currently, approximately 58 acres in the Clear Lake watershed are used for mining purposes (Forsgren Associates Inc. 2012).

Many areas along the tributaries to Clear Lake were channelized in response to frequent flooding during the late winter and early spring (Maclanahan et al. 1972; U.S. Army Corps of Engineers 1974). As a result of gravel extraction and channelization, some areas were covered with riprap or confined by levees to prevent further erosion and flooding. Erosion problems have contributed to sediment entering Clear Lake and providing increased phosphorous loads that impair water quality (Richerson et al. 1994). Gravel extraction results in channelization and down cutting of the stream bank, a decrease in suitable spawning habitat, and increasing flow velocity and amount of coarse material that passes through the system (Brown et al. 1998).

Water Quality Impacts

The Clear Lake watershed has seen a significant increase in the amount of contaminants entering the lake over the past 75 years (Richerson et al. 1994). An increase in agriculture and mining, and a shift to an urban environment, has resulted in adverse water quality impacts in the lake (Mioni et al. 2011; California Environmental Protection Agency [CEPA] 2012).

Erosion from construction, dredging, mining, agriculture, OHV use, grazing, and urbanization has resulted in increased sediment loads to the Clear Lake watershed (Forsgren Associates Inc. 2012). Increased sediment loads transport nutrient rich soil, particularly phosphorous, into Clear Lake and reduce spawning habitat by increasing substrate “embeddedness” (Mosley 2013). During the late 1990s and early 2000s soil erosion and sedimentation became an increasing problem as existing agricultural lands were converted to vineyards (Forsgren Associates Inc. 2012). From 2002 to 2011 vineyard acreage in the Clear Lake watershed increased from approximately 5,500 acres to 8,000 acres (Lake County Department of Agriculture 2011).

Development and expansion of extensive agriculture in the Clear Lake watershed during the late 1890s until present day reclaimed the lake’s natural wetland filtration system for agricultural use. An increase in agricultural production and a decrease in wetland filtration increased nutrient flows into Clear Lake. Wetland reclamation projects altered the transport of sediment and nutrients, particularly phosphorous, into Clear Lake, resulting in an increase in noxious cyanobacteria blooms that cover the lake in warmer months (Suchanek et al. 2002). As a result of continued water quality issues, Clear Lake was added to the Clean Water Act Section 303(d) list of impaired water bodies in 1988 (CEPA 2010 and 2012). In recent years, noxious cyanobacteria blooms have at a minimum remained constant and may have increased (CEPA 2012).

Cyanobacteria blooms have occurred at Clear Lake since the mid-1900s. Studies indicate an increase in phosphorous was the driver behind water quality impairments and noxious cyanobacteria blooms (Horne 1975; Richerson et al. 1994; CEPA 2012). The blooms originally consisted primarily of *Microcystis*, but in recent years the blooms have been attributed to both *Microcystis* and *Lyngbya.* These taxa represent both non-nitrogen fixing (*Microcystis*) and nitrogen fixing (*Lyngbya*) cyanobacteria and raise concerns that both phosphorous and nitrogen entering the lake need to be controlled (Mioni et al. 2011; CEPA 2012). Cyanobacteria blooms have the ability to both directly and indirectly impact CLH by direct interference with the growth of *Daphnia*, a limnetic organism that is a food source for adult CLH, and interference with food web efficiency. No studies have been conducted at Clear Lake to quantify the impact of cyanobacteria blooms on the ecosystem, but studies conducted at other water bodies with varying degrees of cyanobacteria blooms provide information on their impacts to the aquatic environment. Cyanobacteria blooms reduce the amount of light penetration in the water column and cause a reduction in producers that are unable to reposition themselves to gain more light (Havens 2008). Primary producers ~~Organisms~~ such as epiphyton, benthic algae, and rooted vascular plants have a reduced ability to function in the ecosystem as a result of cyanobacteria blooms. As the cyanobacteria alter the nutrient cycle of the lake they replace the producers in space and mass. The expanding cyanobacteria begin to deplete CO_2 from the water body, which increases pH and reduces growth of other producers (Havens 2008). The decreased CO_2 and increased pH can create surface scums and result in mortality of fishes, including CLH. In the summer of 1969, a large fish die off, due to heavy cyanobacteria growth and low oxygen levels, was reported at Clear Lake. An estimated 170,000 fish died, consisting primarily of carp, CLH, and blackfish (CDFG News Release 1969). Sub lethal and lethal effects of toxins released during cyanobacteria blooms are also seen in fish and their associated food web (Havens 2008).

On September 19, 2007, the U.S. Environmental Protection Agency (EPA) approved a control program as a nutrient Total Maximum Daily Load (TMDL) for Clear Lake with the goal of reducing point and non-point source phosphorous entering the lake (CEPA 2012). Sources for phosphorous entering the lake include agricultural and urban runoff, timber harvest, road maintenance, construction, gravel mining, dredging, and fire. Additional amounts of nutrients from home fertilizers, marijuana culture~~grows~~, sewer, and septic systems cannot be quantified.

To allow for increased yields on agricultural land and to prevent nuisance insect species around the lake, pesticides became commonplace during the early and mid-1900s. For many decades the Clear Lake gnat an important~~, a primary~~ food source for juvenile CLH, was targeted with pesticides to reduce its population. Between 1949 and 1957, the Clear Lake gnat was targeted with the pesticide dichlorodiphenyldichloroethane (DDD). During these years it is estimated that 99 percent of the gnat larvae in the lake were killed. Concentrations of DDD were magnitudes higher in invertebrates, fish, and birds than in the surrounding water in which they were found (Lindquist and Roth 1950; Rudd 1964). Sampling conducted during the late 1950s identified CLH, as well as other fish species, contaminated with DDD (Hunt and Bischoff 1960). Contamination levels ranged from 5.27 to 115 parts per million (ppm) for edible flesh of sampled fishes (Hunt and Bischoff 1960). CLH were at the lower level of DDD contamination for Clear Lake fishes at 10.9 to 28.1 ppm for edible flesh content (Hunt and Bischoff 1960). The application ~~results~~ of DDD in the Clear Lake watershed resulted in a ~~the first~~ major ecological disaster ~~at the lake~~ and the first records of pesticide bioaccumulation in the wildlife of the lake (Suchanek et al. 2002).

Comment [PM10]: Introduction of aliens, agriculture etc were also disasters from the lake perspective.

Following the resurgence of gnat populations in response to growing resistance to DDD, two additional measures were taken to reduce the gnat population. Gnat eggs were targeted with a petroleum product, and adult gnats were targeted at roosting locations with Malathion. Additional applications of methyl parathion were also made in 1962

Comment [PM11]: ??

(Suchanek et al. 2002). Clear Lake gnats are still present at the lake, but populations are significantly reduced from historical levels. The likely cause of the reduced population of gnats is introduced fishes, primarily Mississippi ~~inland~~ silversides (Suchanek et al. 2002). In 2010 and 2012 Clear Lake gnat populations reached levels not seen in decades. These gnat population booms appeared to coincide with years of low population levels of inland silversides (Scott, J. 2013 personal communication, Aug 1, 2013, unreferenced). Qualitative sampling data on CLH does not allow for a direct comparison of CLH numbers in years with increases in the gnat population.

In recent years, two herbicides, Komeen™ (copper sulfate) and SONAR™ (fluridone), have been used extensively to manage the *Hydrilla verticillata* infestation of~~at~~ the lake. Applied concentrations of Komeen™ do not kill fish directly; however, the impacts to macroinvertebrates may indirectly impact CLH populations (Bairrington 1999). These systemic herbicides also pose a threat to non-target vascular aquatic plants, such as tules and submerged vegetation, which juvenile CLH require for rearing habitat. As noted previously, there has already been a significant reduction in wetland habitat around the lake, and any additional reductions would further limit the amount of habitat available for CLH. Initial studies indicate a reduction in tule habitat following SONAR™ applications (Bairrington 1999). Environmental monitoring of eradication activities in 1996 and 1997 found that invertebrate species declined within the treatment area but rebounded quickly following the toxicity decay of the herbicide (Bairrington 1999). Post-treatment electrofishing surveys noted an increase in the number and abundance of fish species (Bairrington 1999).

Mining operations within the watershed contributed to sulphur and mercury contamination in Clear Lake. The Sulphur Bank Mercury Mine began operations in 1865 and ended in 1957 (Osleger et al. 2008; Giusti 2009) Originally the mine focused on extracting sulphur, but as operations continued into the late 1920s and the sulphur was found to be contaminated with mercury sulfide, operations switched to extracting mercury from the large-scale open-pit mine (Giusti 2009). As a result of contamination, the mine was classified as an EPA Superfund Site in 1990 (Suchanek et al. 1993). The mine is thought to have contaminated the lake with both mercury and arsenic (Suchanek et al. 1993). Studies have found the mercury concentrations in sediment to be high (over 400 ppm) in the vicinity of the mine, decreasing as distance from the mine increases (Suchanek et al. 2002). The mine continues to produce low pH acid mine drainage that delivers sulfate to the lake. Over the past decade, the EPA has taken several actions to remediate contamination from the mine. These include erosion control measures, removal of contaminated soil, storm water diversion, and well capping (U.S. Environmental Protection Agency 2012).

During the 1970s, elevated concentrations of mercury were found in the fish of the lake (Curtis 1977). High levels of Mercury accumulation ~~contamination~~ can lead to significant impacts to the reproductive success of fishes and can result in reduced brain function, altered size and function of gonads and reduced gamete production (Sandheinrich and Miller 2006; Crump and Trudeau 2009). In 2003, a mercury TMDL was developed for Clear Lake to reduce methylmercury in fish by reducing overall mercury loads to Clear Lake (CEPA 2010). Levels of mercury found in fish, including CLH, are between 0.06 and 0.32 µg/g (CEPA 2002), which ~~. Concentrations of mercury~~

Comment [PM12]: What are the levels specifically in CLH? I suspect the higher levels are in bass, not hitch. Note; There is an entire issue of Ecological Applications (2008) devoted to Clear Lake mercury issues.

~~present in Clear Lake fishes~~ have resulted in health advisories on their consumption, but are below acute toxicity thresholds (Harnly et al. 1997). Mercury levels are close to or within the effect thresholds for reproduction and growth for fathead minnow (0.32 to 0.62 µg/g) and rainbow trout (National Oceanic and Atmospheric Administration [NOAA] 2011). Concentrations with no effect on rainbow trout growth and development are 0.02 to 0.09 µg/g (NOAA 2011). Lacking specific studies on CLH, based on surrogate effect levels for fathead minnows and rainbow trout, it is possible ~~reasonable to suspect~~ that CLH may be experiencing sub lethal chronic and reproductive effects from mercury contamination. However, Hg levels are generally much lower in plankton feeding fish such as hitch than they are for other fishes in the lake (Eagles-Smith et al. 2008).

Overexploitation

Commercial Harvest

Commercial fish harvest at Clear Lake has been occurring since the early 1900s. Harvested fish were distributed to fish markets in California for sale for human consumption and animal feed. Prior to 1941, the majority of commercial operations centered on harvesting catfish (*Ictalurus* or *Ameiurus* spp.) from the lake. Although exact numbers are unavailable, it is likely that large numbers of catfish were taken during this period (Bairrington 1999). In 1942 commercial harvest of catfish was banned at Clear Lake. Beginning in the 1930s commercial harvest focused on Sacramento blackfish (*Orthodon microlepidotus*), a native species, and common carp (*Cyprinus carpio*), a non-native species. From 1932 to 1962 the annual average catch rate was 295,000 pounds for the commercial fishery (Bairrington 1999). A ratio of 1.33:1 for blackfish to carp was the average during commercial fishing operations (Bairrington 1999). In 1976 the only recorded capture and sale of CLH for commercial purposes was submitted to the Department, a total of 1,550 pounds was reported captured and sold at market that year (CDFW Commercial Fisheries Data). This is the only instance in the records of CLH being captured for commercial sale, primarily due to lack of interest and low sale price for the species (CDFW Commercial Fisheries Data). By 1960 commercial fishing operators were required to count and release all bycatch from commercial operations. CLH were found in large numbers some years and were recorded and returned to the lake when captured (Figure 5; CDFW Commercial Fisheries Data). The Department has received no commercial permit applications for operations on Clear Lake over the past several years. The lack of permit applications indicates that at this time commercial fishing operations at Clear Lake have ceased (CDFW Commercial Fishing Permit Data).

Cultural Harvest

Clear Lake hitch are culturally significant to several Pomo tribes that inhabit the Clear Lake watershed. Two Pomo bands ~~tribes~~ fought a war over Kelsey Creek and its important CLH supply (Barrett 1906; Kniffen 1939). Historically, large runs of CLH provided a staple food source for the local native peoples ~~tribes~~ (RREC 2011). During spawning runs, CLH were captured by constructing a series of dams in the creeks from which the fish were then scooped with baskets. The fish were cured to provide a food source throughout the year (Kniffen 1939). Historical accounts from tribal members speak of CLH being easy to find as they spawned in large numbers in the tributaries to the lake (Scotts Valley Band of Pomo Indians historical accounts 2013). There are no estimates of the number of CLH that were taken for cultural harvest during any specific timeframe. However, an account from a tribal member indicates that, historically, a single family may have taken a couple thousand fish during the spawning runs (Big Valley EPA 2013). Tribal accounts indicate the harvest of CLH continued until the decline in spawning runs in the mid-1980s (Big Valley EPA 2013). Prior to designation of CLH as a candidate species for listing, regulations in the Clear Lake watershed allowed for the harvest of CLH in spawning tributaries by hand or hand-held dip net. In 2013 the Department issued CESA Memoranda of Understanding (Fish and Game Code, § 2081(a)) to three bands ~~tribes~~ to authorize collection of CLH for scientific research and public education (Kratville, D. personal communication, October 7, 2013, unreferenced).

Predation and Competition

Non-native fish introductions into Clear Lake date back as far as the late 1800s (Dill and Cordone 1997). Prior to the introduction of non-native fish species, between 12 and 14 native fish species occupied Clear Lake (Bairrington 1999; Moyle 2002; Thompson et al. 2013). Currently, approximately ten native species and 20 non-native species inhabit the lake (Bairrington1999; Thompson et al. 2013). Over the past 100 years one native species, thicktail chub (*Gila crassicauda*), has gone extinct and two native species, hardhead (*Mylopharodon concephalus*), and Clear Lake splittail, have been extirpated from the lake. Sacramento perch (*Archoplites interruptus*), has not been captured in sampling efforts since 1996 (Bairrington 1999; CDFW Commercial Fisheries Data; Thompson et al. 2013). The majority of non-native species introductions have been conducted by the Department, various local agencies, and angling groups in an effort to increase sport fishing opportunities. Introductions of fish at Clear Lake have been warmwater sport fish (largemouth and Florida bass *(Micropterus spp).* ~~black bass~~, sunfish (*Lepomis* spp.), catfish, etc.) or forage species for piscivorous sport fish. The Department has not stocked fish in Clear Lake in the past decade. The four fish species listed below were introduced without authorization from the Department (Bairrington 1999; Rowan J. personal communication, October 10, 2013, unreferenced). Inland silverside, threadfin shad, smallmouth bass (*Micropterus dolomieu*), and pumpkinseed (*Lepomis gibbosus*) were introduced to provide forage for other game fishes, provide Clear Lake gnat control, or as part of a new sport fishery (Anderson et al. 1986; Dill and Cordone 1997; Bairrington 1999). Non-native game fishes comprise nearly 100 percent of the sport catch from the lake. Incidental captures of native species occur infrequently and are rarely recorded during creel and tournament surveys (Rowan J. personal communication, October 10, 2013, unreferenced).

Non-native fish introductions ~~can~~ have significant impacts on native fish species. Miss ~~Inland~~ silverside and threadfin shad are thought to compete directly with CLH for food resources (Geary and Moyle 1980; Anderson et al. 1986; Bairrington 1999) and likely prey on larvae as well. All three species are limnetic foragers that rely on

Comment [PM13]: Now aware of any records of hardhead from the lake or tributary streams. It is present in Cache Creek below the lake but the lake is not really suitable for it nor are the upstream tribs. If you believe the earliest accounts of the lake, CA roach were once abundant in shallow water; possible but identifications not strong. Check Hopkirk.

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Comment [PM14]: Mississippi silverside (taxonomy has been reworked); the paper on the introduction of the silverside claims CDFG was a participant or at least did not discourage it.

Comment [PM15]: Doubt they are present in the lake; would like to see the proof.

Comment [PM16]: Not present.

Comment [PM17]: You need a table of all native and non-native species and their status macroinvertebrates for food. There are no direct comparisons, but years with declines in threadfin shad and inland silverside are thought to coincide with increases in CLH numbers, and years with decreased threadfin shad and inland silverside result in increased young of year recruitment for other native and non-native species (Rowan J. personal communication, October 10, 2013, unreferenced). Eagles-Smith et al. (2008) found that zooplankton populations declined precipitously as threadfin shad populations increased, causing other common plankton-feeding fishes (juvenile largemouth bass and bluegill, Mississippi silverside) to switch to benthic feeding. Hitch, being more specialized for zooplankton feeding may have been strongly affected by the threadfin shad (introduced in the 1980s), which undergoes boom-and-bust population cycles in the lake (Eagles-Smith et al (2008).

Comment [PM18]: Could you make some?

Competition for juvenile rearing habitat and food has likely increased with the reduction in wetland habitat and increase in non-native fish species. Rearing habitat is essential for CLH recruitment to any year class. A reduction in recruitment leads to a decrease in spawning adults in the following years. A species with highly fluctuating population trends, such as CLH, is particularly vulnerable to population level impacts in years with reduced recruitment. Piscivorous fish species such as largemouth bass (*Micropterus salmoides*) prey directly on both juvenile and adult CLH. Although no comprehensive diet studies have been done, incidental data indicate that CLH are found in the stomachs of piscivorous species in the lake (Moyle et al. in progress). Omnivorous species such as bullhead catfish (*Ameiurus* spp.) are known to prey on various life stages of native fishes. It is suggested that the introduction of white and channel catfish to Clear Lake may have played a role in the decline of native fish species (Dill and Cordone 1997). The introduction of white catfish (*A. catus*) was described, by Captain J.D. Dondero of the Division of Fish and Game, as having solved the problem of large spawning runs of fish dying in tributaries to Clear Lake and that the population of nongame fish diminished following their introduction (Dill and Cordone 1997). Jordan and Gilbert (1894) also describe catfish as being destructive to the spawn of other species. The rates at which CLH are consumed in relation to other prey species and the amount of CLH consumed are unknown. It is likely that during years when alternative prey abundance is low, CLH predation increases (Eagles-Smith et al. 2008).

Comment [PM19]: Note that Florida bass (M. floridae) are regarded as a separate species from LMB. They apparently initially hybridzed with LMB in the lake but now appear to be dominant. They grow larger than LMB so will be more inclined to eat adult CLH

Comment [PM20]: This is probably true, but Eagles-Smith et al. don't say this in relation to hitch or even fish predation.

Overall, alien species appear to be a major factor in contributing to hitch declines in Clear Lake. While fairly substantial runs of hitch have persisted into recent years, it is likely that the combination of introductions of Florida bass (1970s), Mississippi silverside (1967), and threadfin shad (1980s) have created an environment in which it is increasingly hard for hitch to persist. The voracious and large-sized bass will eat adults as well as juveniles. Threadfin shad deplete off shore plankton populations on which the hitch depend for much of their life. Silversides deplete inshore sources of food and presumably prey on larvae as they come out of the streams, as they have been shown to do for various fishes in the Sacramento San Joaquin Delta (ref.)

Disease and Parasites

Disease outbreaks in fishes have been known to occur at Clear Lake. The outbreaks are primarily koi herpes virus (KHV) and it affects introduced carp and goldfish. Native minnows, including CLH, show no effects from KHV. Fish fungi (*Saprolegnia* spp.) have been observed on fishes captured in Clear Lake and results from physical injury or infection. CLH are susceptible to fish fungi but it is not readily observed in captured fish. All fish in Clear Lake are susceptible to anchor worms (*Lernaea* spp.) and heavy infestations can lead to mortality. No CLH with heavy anchor worm infestations have been observed during CDFW fishery surveys at Clear Lake (Rowan J. personal communication, October 10, 2013, unreferenced). The Big Valley Rancheria Band of Pomo Indians has documented light loads of anchor worms occurring on CLH (Big Valley Rancheria 2012 and 2013).

Other Natural Occurrences or Human Related Activities

Climate Change

It is likely that native fishes in California will be vulnerable to physical and chemical changes as a result of climate change (Moyle et al. 2012). Research has shown that the annual mean temperature in North America has increased between 1955 and 2005 and is predicted to continue increasing in the future (Field et al. 1999; Hayhoe et al. 2004); however, it varies across North America, is more pronounced in spring and winter, and has affected daily minimum temperatures more than daily maximum temperatures (Field et al. 2007). In general, climate change models for California indicate an increase in overall air temperature, decreased and warmer rainfall, and an increase in overall water temperatures (California Climate Change Center [CCCC] 2012). Cold storms are expected to decrease, giving way to warmer storms that create earlier run-off and less water storage capabilities (Field et al. 1999; Hayhoe et al. 2004; CCCC 2012). Climate change in the Clear Lake watershed is likely to cause ~~some~~ changes to the interannual variability in rainfall. The change in rainfall variability would likely increase the occurrence of drought and flood years (Clear Lake Integrated Watershed Management Plan [CLIWMP] 2010). Expected climate change impacts to California and the Clear Lake watershed will be significant during annual CLH spawning cycles. CLH require winter and spring storms that provide suitable spawning flows in the tributaries of Clear Lake. A shift in timing, temperature, and amount of runoff will likely ~~could~~ significantly impact the ability of CLH to successfully spawn. ~~A~~ C~~c~~limate driven anthropogenic change in the Clear Lake watershed could result in the loss of spawning habitat, reduced access to spawning habitat, stranding of spawning and juvenile fish, and egg desiccation.

A report on the projected effects of climate on California freshwater fishes, prepared for the California Energy Commission's California Climate Change Center, determined CLH to be critically vulnerable to impacts from climate change (Moyle et al. 2012). The report evaluated criteria such as population size, population trends, range, lifespan, and vulnerability to stochastic events to identify the degree of vulnerability of each fish species. The Intergovernmental Panel on Climate Change has stated that of all ecosystems, freshwater ecosystems will have the highest proportion of species threatened with extinction due to climate change (Kundzewicz et al. 2007). Freshwater lake species are more susceptible to extirpation because they are unable to emigrate

Comment [PM21]: This has now been published
Moyle, P.B., J. D. Kiernan, P. K. Crain, and R. M. Quiñones. 2013. Climate change vulnerability of native and alien freshwater fishes of California: a systematic assessment approach. PLoS One. http://dx.plos.org/10.1371/journal.pone.0063883

should habitat changes occur (CA Natural Resources Agency 2009~~).~~ , Moyle et al. (2012. 2013) rated Clear Lake hitch as 'critically vulnerable' to extinction from the added effects of climate change, suggesting that CLH would be extinct by 2100 if steps were not taken to improve conditions for it.

Recreational Activities

The natural resources of the Clear Lake watershed are a tremendous recreational resource for residents and visitors to Lake County. As the largest freshwater lake wholly in California, with opportunities for multiple aquatic recreational activities, the lake receives tens thousands of visitors per year. According to 2008 data acquired from Lake County quagga mussel (*Dreissena rostriformis*) inspection sticker application forms; there were 11,230 boats that visited the lake that year. Jet skis and pleasure boats accounted for 41 percent of the boating activity at the lake (CLIWMP 2010).

Permanent structures, associated with boat docks, boat ramps, and swimming beaches, have reduced littoral zone habitat around the lake. These structures require clearing of littoral zone habitat to maintain access for recreational boaters and swimmers. It is estimated that there are over 600 private boat docks and boat ramps on the lake shoreline. In addition to reducing littoral zone habitat these structures provide additional habitat for non-native sport fish, such as largemouth bass, that prey on CLH.

Recreational and tournament angling generate a significant amount of the activity in the Clear Lake aquatic environment. In 2008, 18 percent of all boats entering the lake identified their recreational activity as angling (CLIWMP 2010). In a single year creel survey conducted in 1988 by the Department, CLH comprised two percent of the recreational sport catch (Macedo 1991).

The number of angling tournaments, primarily targeting largemouth bass, has drastically increased over the last three decades in response to Clear Lake's reputation as a premiere sport fishery. Between 2001 and 2008 the number of angling tournaments increased from 98 to 208 per year (Rowan J. personal communication, October 10, 2013, unreferenced). It is believed that recreational and tournament anglers' capture CLH incidentally while angling. The impact to CLH from the increase in angling tournaments is unknown, but is likely negligible because tournament anglers do not target CLH and bycatch would be an inadvertent snagging on an artificial lure, a rare occurrence.

REGULATORY AND LISTING STATUS

Federal

On September 25, 2012 the Center for Biological Diversity petitioned the U.S. Fish and Wildlife Service (USFWS) to list CLH as endangered or threatened under the federal Endangered Species Act (ESA). As of the publication of this status review there has been no action taken on the petition by USFWS.

The U.S. Forest Service (USFS) lists CLH as a sensitive species. USFS sensitive species are those plant and animal species identified by a regional forester that are not listed or proposed for listing under the federal ESA for which population viability is a concern.

State

The Department designated CLH as a Species of Special Concern (SSC) in 1994. A SSC is a species, subspecies, or distinct population of an animal native to California that currently satisfies one or more of the following (not necessarily mutually exclusive) criteria:

- Is extirpated from the State or, in the case of birds, in its primary seasonal or breeding role;
- Is listed as Federally, but not State, threatened or endangered;
- Is experiencing, or formerly experienced, serious (noncyclical) population declines or range restrictions (not reversed) that, if continued or resumed, could qualify it for State threatened or endangered status;
- Has naturally small populations exhibiting high susceptibility to risk from any factor(s) that if realized, could lead to declines that would qualify it for State threatened or endangered status.

The intent of designating a species as a SSC is to:

- Focus attention on animals at conservation risk by the Department, other State, local and Federal government entities, regulators, land managers, planners, consulting biologists, and others;
- Stimulate research on poorly known species;
- Achieve conservation and recovery of these animals before they meet California Endangered Species Act criteria for listing as threatened or endangered.

There are no provisions in the Fish and Game Code that specifically prohibit take of CLH or protect its habitat.

Other Rankings

The American Fisheries Society ranks CLH as vulnerable, meaning the taxon is in imminent danger of becoming threatened throughout all or a significant portion of its range (Jelks et al. 2011).

EXISTING MANAGEMENT EFFORTS

Resource Management Plans

An increase in resource management efforts throughout the Clear Lake watershed has benefitted CLH, and several plans and strategies are in place to assist in reducing the threats to CLH.

The Clear Lake Integrated Watershed Management Plan (2010) was prepared by two resource conservation districts and provides details of past and current resource management within the Clear Lake watershed. The plan seeks to identify opportunities to improve and protect the health and function of the watershed and identifies specific implementation actions to improve and protect watershed resources. Recommended actions are prioritized on a timeline. As funding allows, implementation of these actions will be undertaken by various non-governmental organizations (NGO) and local, state, and federal agencies that share an interest in promoting the health and function of the watershed. Multiple action items listed in the plan would benefit CLH and their habitats. Several tributaries to Clear Lake have completed Watershed Assessment plans as well. These include Kelsey Creek Watershed Assessment (2010), Middle Creek Watershed Assessment (2010), and Scotts Creek Watershed Assessment (2010). These plans were all completed by Lake County Water Resources Division for West and East Lake Resource Conservation Districts.

With adoption of the TMDL for Clear Lake, several projects are in process or have been completed to reduce the amount of phosphorous entering the lake. Specifically, the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project seeks to reduce the amount of phosphorous entering the lake by 40 percent (CEPA 2012). Lake County and the California Department of Transportation have implemented several best management practices (BMPs) for managing storm water runoff to reduce the amount of phosphorous and other contaminants that enter the lake. Both the USFS and Bureau of Land Management (BLM) have undertaken projects to reduce nutrients entering the lake as a result of off-highway vehicles and other land uses. BLM, in coordination with Scotts Valley Band of Pomo Indians, received a grant to implement the Eightmile Valley Sediment Reduction and Habitat Enhancement Project Design. Controlling sediment from Eightmile Valley is crucial to controlling the amount of nutrients entering the lake. Many of these projects are still in design or early implementation and it will be several years before changes in nutrient loads within the lake can be observed and studied.

The adverse effects from an increase in sedimentation as a result of conversion of various types of agricultural land to vineyard resulted in the formation of the Erosion Prevention and Education Committee (EPEC). The EPEC is a group of county agencies and private entities that provide educational outreach regarding erosion control and water quality protection. In addition, the Lake County Grading Ordinance was approved in 2007 and requires grading permits and Erosion Control and Sediment Detention Plans for projects with the probability of resulting in increased sedimentation (Forsgren Associates, Inc. 2012).

Concerns over the reduction in habitat quality resulting from gravel mining prompted Lake County to adopt an Aggregate Resources Management Plan in 1994. The plan called for a moratorium on gravel mining in several tributaries to Clear Lake. The implementation of gravel mining regulations has resulted in reduced in-stream and bank erosion and increased riparian habitat along the creeks (CEPA 2008).

To prevent further destruction of wetland habitat along the lake shoreline, in 2000 and 2003 amendments, Lake County adopted Section 23-15 of the Clear Lake Shoreline Ordinance that prohibits the destruction of woody species and tules. In addition to the ordinance, there is a no net-loss requirement for commercial, resort, and public properties that seek to clear vegetation from areas along the shoreline (CLIWMP 2010).

RREC produced an Adaptive Management Plan (HAMP) for the Clear Lake Hitch, *Lavinia exilicauda chi* (RREC 2011). The HAMP describes the current status of CLH habitat and problems for habitat recovery. The habitat assessments are included in a management plan that identifies action items, issues of uncertainty, stakeholder involvement, sustainability, and plan amendment procedures. The RREC is currently in the process of revising the HAMP.

The Department has created or approved two Conceptual Area Protection Plans (CAPP) for the Clear Lake Watershed. The creation of a CAPP for an area allows the Department, as well as local and federal agencies, and NGOs, to apply for land acquisition funding from the Wildlife Conservation Board. The first, the Clear Lake CAPP, was approved in 2002 and addresses land acquisition needs in the area of Middle Creek. The plan focuses on protecting wetland and riparian habitat for the benefit of natural resources. The second CAPP, Big Valley Wetlands, is currently in development with possible approval in 2014. The Big Valley Wetlands CAPP focuses on land acquisitions in the western portion of the Clear Lake watershed for the purpose of protecting wetland and riparian habitat. Both CAPP's will benefit CLH in the protection of riparian and wetland habitat critical for spawning and rearing CLH. Land acquisitions that seek to protect and restore existing CLH habitat should create a stable environment for CLH populations.

The Department published a Clear Lake Fishery Management Plan in 1999 (Bairrington 1999). The plan provides a review of past and present biological information for Clear Lake. The primary focus of the plan is to maintain fishery resources of the lake and enhance recreational fishing opportunities. The plan identifies areas of controversy between various stakeholder groups in the watershed, and states that "adapting to the biological and social settings at Clear Lake involves a variety of compromises between these groups and the non-angling groups who wish to ensure the well-being of Clear Lake's native fish species." The plan identifies the decline in native fish species at Clear Lake as being detrimental both socially and biologically. No specific guidelines are given for addressing impacts to native species, but restoration of spawning habitat and natural flow regimes are discussed as critical for native species survival.

Monitoring and Research

In 2013 the Department attempted to conduct a status assessment of the CLH population present in Cole and Kelsey creeks. Sampling produced too few fish to facilitate a statistically valid mark and recapture study. As a result, a population estimate was not completed. The Department has proposed additional funding in 2014 to begin a multi-year mark-recapture study to determine a statistically valid population estimate or index of CLH.

The CCCLH has been conducting annual spawning observations since 2005. A simple protocol is followed that identifies the time, observer, and number of CLH observed.

Volunteers have put in hundreds of hours monitoring CLH spawning runs during this time period. Although not quantitative, the surveys provide a glimpse into the number of spawning CLH and how successful spawning is in a particular season. Results of these surveys are included in Appendices A and B and summarized in Section 4.1 and 4.2 above.

Habitat Restoration Projects

In recent years, local, state, and federal agencies have begun implementing actions to aid in the protection and restoration of Clear Lake wetland habitat. The Middle Creek Flood Damage Reduction and Ecosystem Restoration Project will restore up to 1,400 acres of wetland habitat around Middle Creek and Rodman Slough, essentially doubling the amount of existing wetland habitat in the watershed (CLIWMP 2010).

Impacts of Existing Management Efforts

To date, existing management efforts have focused on CLH habitat restoration ~~in the watershed~~. Wetland restoration projects that would significantly benefit CLH have been proposed and have been or will be implemented through the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project and the two CAPPs that cover portions of the watershed. Wetland restoration is expected to aid in increasing spawning success and juvenile recruitment into the population. Increased wetland acreage would enhance filtration of tributary waters resulting in decreased amounts of nutrients entering the lake and an increase in the water table. The increased water table will help maintain surface flow in tributaries, resulting in suitable spawning habitat being maintained throughout the spawning season. The Clear Lake Shoreline Ordinance has resulted in a “no net loss” of shoreline wetland habitat around the lake since its enactment. However, because these wetland restoration projects are either recent or yet to be implemented, a thorough assessment of direct and indirect impacts to CLH populations cannot be included in this status review.

Establishment of TMDLs for mercury and nutrients has led to a reduction in inputs and an increase in monitoring efforts in the Clear Lake watershed. Past and future steps by the federal government will reduce mercury contamination resulting from the Sulphur Bank Mercury Mine. Most of the identified initial actions for cleanup have been implemented. The focus will now be on two long-term projects to address waste pile and lake sediment cleanup, which should result in significant reductions in mercury contamination in the watershed. Nutrient loads entering Clear Lake have been addressed by several measures including wetland restoration, BMPs for storm water runoff, and erosion control measures. Many of these projects are in the early stages of implementation, and a thorough assessment of impacts to CLH is yet to be been completed. It is likely that reduced mercury and nutrient loads in Clear Lake will result in a significant benefit to CLH.

SCIENTIFIC DETERMINATIONS REGARDING THE STATUS OF CLEAR LAKE HITCH IN CALIFORNIA

CESA directs the Department to prepare this report regarding the status of CLH based upon the best scientific information available to the Department. CESA's implementing regulations identify key factors that are relevant to the Department's analyses. Specifically, a "species shall be listed as endangered or threatened ... if the Commission determines that its continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities." (Cal. Code Regs., tit. 14, § 670.1 (i)(1)(A)).

The definitions of endangered and threatened species in the Fish and Game Code provide guidance to the Department's scientific determination. An endangered species under CESA is one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, over exploitation, predation, competition, or disease." (Fish & G. Code, § 2062). A threatened species under CESA is one "that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [CESA]." (*Id.*, § 2067).

The preceding sections of this status review report describe the best scientific information available to the Department, with respect to the key factors identified in the regulations. The Department's scientific determinations regarding these factors as peer review begins are summarized below.

Present or Threatened Modification or Destruction of Habitat

Beginning with the arrival of European settlers in the mid-1800s, alterations to habitats in the watershed have directly impacted the ability of CLH to survive. Habitats necessary for both spawning and rearing have been reduced or severely decreased in suitability in the past century resulting in an observable decrease in the overall abundance of CLH and its habitat. Spawning tributaries have been physically altered by a combination of dams, diversions, and mining operations that have altered the course and timing of spring flows and the amount and quality of spawning habitat available for CLH. Dams create barriers to CLH passage that reduce the amount of available spawning habitat while altering the natural flow regime of tributaries. Water diversions in tributaries have resulted in decreased flows during critical spawning migrations for CLH. Loss of eggs, juvenile, and adult fish due to desiccation and stranding from water diversions are likely a significant impact on CLH populations. Gravel mining removed large amounts of spawning substrate during peak operations in the mid-1900s. Spawning substrate has been restored slowly after gravel mining was discontinued in the majority of the watershed. Water quality impacts to the watershed have resulted in Clear Lake being listed as an impaired water body and led to the establishment of TMDLs for both mercury and nutrients for the lake. It is unclear to what extent the water quality impacts are affecting CLH populations. The Department considers modification and destruction of habitat a significant threat to the continued existence of CLH.

Overexploitation

Harvest of CLH has occurred by both Pomo bands ~~tribes~~ and commercial fishery operators at Clear Lake. Historic accounts from tribal members indicate that significant amounts of CLH were harvested during spawning runs. In recent years, the amount of harvest by the Pomo has been minimal, and the CLH are used strictly for educational and cultural reasons. Since the early 1990s commercial fishery operations have been required to return all CLH captured to the lake. Prior to that, CLH had not been regularly harvested for sale. It is likely that incidental catch during commercial harvest operations resulted in mortality of some CLH. However, there is no information indicating that overexploitation threatens the continued existence of CLH.

Predation

Comment [PM22]: This section is pretty weak.

Direct predation of CLH by fish, birds, and mammals o-ccurs ~~is known to occur in suitable habitats within the watershed~~. Spawning runs are vulnerable to predation from birds and mammals as fish migrate upstream and become stranded at various locations. Stranding occurs both naturally and as a result of habitat modifications, especially flow reductions, described above. Non-native fishes prey directly on different life stages of CLH in all ~~occupied~~ habitats. CLH have been found during stomach content analyses of largemouth bass. Incidental observations indicate that largemouth bass may target CLH as the CLH stage at the entrance to ascend spawning tributaries in early spring. Other introduced fishes, such as white and channel catfish ~~species~~, also prey on CLH~~.~~ Larvae are probably eaten by Mississippi silversides. A detailed diet study of selected ~~n~~ introduced fishes is necessary to determine the extent of predation from introduced fishes but needs to be targeted at places where hitch and alien fishes come in the most contact (e.., mouths of streams). There is scientific information suggesting that predation by introduced fishes threatens the continued existence of CLH.

Comment [PM23]: What does this mean?

Competition

The extent of impacts on CLH from competition with other aquatic species is poorly understood. Studies conducted on diet analysis of CLH indicate that there is competition between CLH and other macroinvertebrate consuming fish species, primarily Mississippi ~~inland~~ silversides and threadfin shad. Observations by Department biologists and others indicate that CLH populations fluctuate on alternating cycles with inland silverside populations. CLH directly compete with other native and non-native fishes for juvenile rearing habitat. The majority of fishes in Clear Lake utilize near shore wetland habitat for juvenile rearing. With the decrease in wetland habitat over the past century, there is increased competition for the remaining habitat. Although no formal studies have been completed, it is likely that competition for resources threatens the continued existence of CLH.

Comment [PM24]: ? Most likely when both TFS and MSS are depressed.

Comment [PM25]: We don't actually know this. Competition is mre likely for food than space.

Comment [PM26]: They do? Reference?

Disease

There are no known diseases that are significant threats to the continued existence of CLH.

Other Natural Occurrences or Human-related Activities

Expected climate change impacts to California and the Clear Lake watershed will be significant during annual CLH spawning cycles. CLH require winter and spring storms that provide suitable spawning flows in the tributaries of Clear Lake. A shift in timing, temperature, and amount of runoff could significantly impact the ability of CLH to successfully spawn. A report on the projected effects of climate on California freshwater fishes determined CLH to be critically vulnerable to impacts from climate change.

Numerous recreational activities take place in Clear Lake each year. The majority of recreational activities pose no significant threat to the survival of CLH. However, it is believed that recreational and tournament anglers' capture CLH incidentally, at a low rate. The extent of impacts to CLH from angling is unknown, but likely do not threaten the continued existence of CLH.

SUMMARY OF KEY FINDINGS

At present time, the species can be found in portions of its historic habitat and qualitative surveys indicate a variable interannual population. Based on qualitative survey efforts to date a population estimate or index of CLH is not attainable. Without a current population or index for CLH it is necessary to estimate impacts not based on a set baseline but rather against trends seen in abundance and distribution in sampling efforts over the past half century.

It is ~~will be~~ imperative for the Department and the conservation community to study and monitor the population of CLH over the next decade. A review of the scientific determinations regarding the status of CLH indicates there are significant threats to the continued existence of the species, particularly related to historical and ongoing habitat modification, predation from introduced species, and competition. Many of these threats are currently or in the near future being addressed by existing management efforts. Monitoring impacts from existing management efforts will be imperative to assessing the future status of CLH.

RECOMMENDATION FOR PETITIONED ACTION

CESA directs the Department to prepare this report regarding the status of CLH in California based upon the best scientific information available. CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)). The Department includes and makes its recommendation in its status report as submitted to the Commission in an advisory capacity based on the best available science.

Based on the criteria described above, the scientific information available to the Department does/~~does not~~ indicate that CLH are threatened with extinction and likely to become an endangered species in the foreseeable future. The listing recommendation will be provided in this report after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

PROTECTION AFFORDED BY LISTING

It is the policy of the State to conserve, protect, restore and enhance any endangered or any threatened species and its habitat. (Fish & G. Code, § 2052.) If listed as an endangered or threatened species, unauthorized "take" of CLH will be prohibited, making the conservation, protection, and enhancement of the species and its habitat an issue of statewide concern. As noted earlier, CESA defines "take" as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill. (*Id.*, § 86.) Any person violating the take prohibition would be punishable under State law. The Fish and Game Code provides the Department with related authority to authorize "take" under certain circumstances. (*Id.*, §§ 2081, 2081.1, 2086, 2087 and 2835.) As authorized through an incidental take permit, however, impacts of the taking on CLH caused by the activity must be minimized and fully mitigated according to State standards.

Additional protection of CLH following listing would also occur with required public agency environmental review under CEQA and its federal counter-part, the National Environmental Policy Act (NEPA). CEQA and NEPA both require affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on endangered, rare, and threatened special status species. Under CEQA's "substantive mandate," for example, state and local agencies in California must avoid or substantially lessen significant environmental effects of their projects to the extent feasible. With that mandate and the Department's regulatory jurisdiction generally, the Department expects related CEQA and NEPA review will likely result in increased information regarding the status of CLH in California as a result of, among other things, updated occurrence and abundance information for individual projects. Where significant impacts are identified under CEQA, the Department expects project-specific required avoidance, minimization, and mitigation measures will also benefit the species. State listing, in this respect, and required consultation with the Department during state and local agency environmental review under CEQA, is also expected to benefit the species in terms of related impacts for individual projects that might otherwise occur absent listing.

If CLH are listed under CESA, it may increase the likelihood that State and federal land and resource management agencies will allocate additional funds towards protection and recovery actions. However, funding for species recovery and management is limited, and there is a growing list of threatened and endangered species.

MANAGEMENT RECOMMENDATIONS AND RECOVERY MEASURES

Current data on CLH suffers from being largely anecdotal and qualitative in nature. Studies designed to provide quantitative data on CLH populations and the factors that affect the ability of CLH to survive and reproduce are necessary for species management. The following management recommendations were generated by Department staff with considerations from local agencies, non-profits, and interested parties.

- Derive a statistically valid population estimate or index allowing assessment of impacts to the overall population and provide a baseline to maintain a sustainable population level. The best place to start is improvement of the stream spawning surveys, by hiring a full-time coordinator for citizen survey crews.
- Conduct a thorough assessment of barriers to fish movement on primary spawning streams and provide recommendations for restoration actions on substantial barriers.
- Complete a detailed analysis of spawning habitat in primary spawning streams and provide recommendations for restoration actions.
- Implement identified restoration activities to increase available spawning and rearing habitat for CLH.
- Conduct a review of reservoir operations at Highland Springs, Adobe Creek, and Kelsey Creek detention dams to assess water release operations that may be impacting CLH, development and implementation of guidelines for minimizing impacts.
- Conduct an in-stream flow analysis of primary spawning tributaries to determine impacts of water diversions on stream flows, particularly during spawning season.
- Coordinate with landowners, stakeholders, and permitting agencies on developing strategies for reducing in stream diversions during spawning season.
- Determine the value of wetland habitat in the watershed pertaining to survivorship of juvenile CLH and make appropriate recommendations on restoration or modification.
- Analyze food web interactions of CLH and non-native fish to determine potential impacts to CLH.
- Conduct a focused diet analysis of predatory fish species to determine the extent of their impact on CLH.
- Conduct creel surveys to gain a better understanding of CLH capture rates during both recreational and tournament angling.
- Develop a comprehensive monitoring program to assess both native and non-native fish populations and their distribution in the watershed.
- Identify habitats within the watershed that may be suitable for CLH translocations. In particular, develop ponds that can be used to create ‘back up’ populations of hitch in case the lake populations disappear.
- Coordinate the above research and restoration efforts with interested stakeholders in the watershed.
- Develop an outreach program to provide updates to stakeholders on recovery and management efforts.

Comment [PM27]: For hitch? This would be expensive & yield little data.

PUBLIC RESPONSE

Note to Reviewer: Public response will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

PEER REVIEW

Note to Reviewer: Peer review will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

LITERATURE CITED

Aguilar, A. and J. Jones. 2009. Nuclear and Mitochondrial Diversification in two Native California Minnows: Insights into Taxonomic Identity and Regional Phylogeography. Molecular Phylogenetics and Evolution 51 (2): 373-381.

Anderson, N.L., D.L. Woodward and A.E. Colwell. 1986. Pestiferous dipterans and two recently introduced aquatic species at Clear Lake. Proceedings of the California Mosquito Vector Control Association. 54:163-167.

Anderson, N.L., 1989. Letter to Rick Macedo containing notes and data from LCVCD sampling efforts.

Avise, J.C. and F.J. Ayala. 1976. Genetic differentiation in speciose versus depauperate phylads: Evidence from the California minnows. Evolution 30:46-58.

Barrett, S.A., 1906. The Ethno-Geography of the Pomo and Neighboring Indians. University of California Publications in American Archeology and Ethnology. Vol 6 No. 1.

Bairrington, P., 1999. CDFG Clear Lake Fishery Management Plan.

Bellucci, C. J., Becker, M., & Beauchene, M. (2011). Characteristics of macroinvertebrate and fish communities from 30 least disturbed small streams in Connecticut. *Northeastern Naturalist, 18*(4), 411-444.

Big Valley EPA, 2013. Hitch interview notes with families of Big Valley Rancheria and Elem Indian Colony.

Big Valley Rancheria, 2012. Hitch *Lavinia exilicauda* Chi Hopkirk ecology and water quality studies in Big Valley sub-basin creeks in 2012.

Big Valley Rancheria, 2013. Big Valley sub-basin creek water quality, quantity, and Hitch *Lavinia exilicauda* Chi Hopkirk ecology program. Spring, 2013.

Brown, A.V., M.M. Little, and K.B. Brown, 1998. Impacts of gravel mining on gravel bed streams. *Transactions of the American Fisheries Society*. 127:979-994.

Bunn, S.E., and A.H. Arthington, 2002. Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity. *Environmental Management*. Vol. 30:4. Pp 492-507.

California Climate Change Center, 2012. Our Changing Climate 2012 Vulnerability and Adaptation to the Increasing Risks from Climate Change in California.

California Department of Fish and Game, 1955-1956. Field notes on Kelsey and Seigler Creeks.

California Department of Fish and Game, 1961-2001. Commercial Catch data for Clear Lake

California Department of Fish and Game, 1969. News Release on Fish Dieoffs at Clear Lake.

California Department of Fish and Game, 1988. Clear Lake Electrofishing Survey, April 2, 1987 Memorandum.

California Department of Fish and Game, 2012. Electrofishing data, Memorandum in progress.

California Department of Fish and Wildlife, 2013. Report to the Fish and Game Commission Evaluation of the Petition from the Center for Biological Diversity to List Clear Lake Hitch (*Lavinia exilicauda chi*) as a Threatened Species under the California Endangered Species Act.

California Department of Fish and Wildlife, 2013. Commercial Fisheries Data from catch records.

California Department of Fish and Wildlife, 2013. Commercial Operators permit applications.

California Department of Fish and Wildlife, April 24, 2013. Press Release – CDFW Seeks Public Comment and Data Regarding Clear Lake Hitch.

California Department of Water Resources. 1975. Clear Lake Water Quality Data.

California Natural Resources Agency, 2009. California Climate Adaptation Strategy Discussion Draft.

California Environmental Protection Agency RWQCBCVR, 2002. Clear Lake TMDL for Mercury Staff Report.

California Environmental Protection Agency RWQCBCVR, 2008, Monitoring and Implementation Plan Clear Lake Mercury and Nutrient TMDL's.

California Environmental Protection Agency RWQCBCVR, 2010. Clear Lake Mercury Total Maximum Daily Load Update.

California Environmental Protection Agency RWQCBCVR, 2012. Clear Lake Nutrient Total Maximum Daily Load Control Program 5-year Update.

California Regulatory Notice Register, 2012. No. 41-Z. p.1501

California Regulatory Notice Register, 2013. No. 12-Z. p.488

Center for Biological Diversity, 2012. Petition to List Clear Lake Hitch (*Lavinia exilicauda chi*) as Threatened under the California Endangered Species Act. 58 pp.

Chi Council for the Clear Lake Hitch (CCCLH). 2013. Hitch spawning survey results, 2005-2013. Available at http://lakelive.info/chicouncil/

Clear Lake Integrated Watershed Management Plan, February 2010. Prepared for West Lake and East Lake Resource Conservation Districts.

Coleman, G.A. 1930. A biological survey of Clear Lake, Lake County. *Calif. Fish and Game* 16: 221-227.

Converse,Y.A., C.P. Hawkins and R. A. VALDEZ, 1998. Habitat Relationships of Subadult Humpback Chub in the Colorado River through Grand Canyon: Spatial Variability and Implications of Flow Regulation. *REGULATED RIVERS: RESEARCH & MANAGEMENT* **14**: 267–284

Cook, S. F., Jr., J. D. Connors, and R. L. Moore, 1964. The impact of the fishery on the midges of Clear Lake, Lake County, CA, *Annals of the Entomological Society of America*, Vol. 57, pp. 701-707.

Cott, P. A., Sibley, P. K., Somers, W. M., Lilly, M. R., & Gordon, A. M. (2008). A REVIEW OF WATER LEVEL FLUCTUATIONS ON AQUATIC BIOTA WITH AN EMPHASIS ON FISHES IN ICE-COVERED LAKES1. *Journal of the American Water Resources Association, 44*(2), 343-359.

Cox, B., 2007. CDFG Clear Lake Fishery Surveys Summary Report.

Curtis T.C. 1977. Pesticide Laboratory report. California Department of Fish and Game, E.P. No. P-133. 3pp.

Crump, KL and VL Trudeau, 2009. Mercury-induced reproductive impairment in fish. *Environmental Toxicology and Chemistry*. 28(5):895-907.

Deitch, M.J., G.M. Kondolf, and A.M. Merenlender. 2009. Hydrologic impacts of smallscale instream diversions for frost and heat protection in the California wine country. River Research and Applications, Volume 25, Issue 2, pages 118-134.

Dill, W. A., and A. J. Cordone. 1997. Fish Bulletin 178. History and Status of Introduced Fishes in California 1871-1996. California. Fish and Game. 414 pp.

Eagles-Smith, C.A., T.H. Suchanek, A.E. Colwell, N.L. Anderson, and P.B. Moyle. 2008. Changes in fish diets and food web mercury bioaccumulation induced by an invasive planktivorous fish. Ecological Applications 18(Supplement): A213–A226.

Ewing, B., 2013. Summary of the Clear Lake Hitch Population Estimate for Cole and Kelsey Creeks, Lake County.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller, 1999. *Confronting Climate Change in California: Ecological Impacts on the Golden State.* Union of Concerned Scientists, Cambridge, MA and Ecological Society of America, Washington, DC.

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

Forsgren Associates Inc, 2012. Clear Lake Watershed Sanitary Survey 2012 Update Final.

Franson, S. 2013. Summary of Spring 20-13 Field Monitoring with Locations chosen for observing egg and larval development of Clear Lake Hitch (*Lavinia exilicauda chi*).

Gafny, S., A. Gasith, and M. Goren 2006. Effect of water level fluctuation on shore spawning of *Mirogrex terraesanctae* (Steinitz), (Cyprinidae) in Lake Kinneret, Israel. Journal of Fish Biology vol 41:6 pages 863-871

Geary, R.E. 1978. Life history of the Clear Lake hitch *(Lavinia exilicauda chi).* Unpublished Master's Thesis, University of California, Davis. 27 pp.

Geary, R.E. and P.B. Moyle. 1980. Aspects of the ecology of the hitch, *Lavinia exilicauda* (Cyprinidae), a persistent native cyprinid in Clear Lake, California. Southwest. Nat. 25:385-390.

Giusti, G. 2009. Human Influences to Clear Lake, California A 20th Century History.

Harnly, M., S. Seidel, P. Rojas, R. Fornes, P. Flessel, D. Smith, R. Kreutzer, and L. Goldman. 1996. Biological monitoring for mercury within a community with soil and fish contamination. *Environmental Health Perspectives*, Vol. 105:4, 424-429.

Havens, K.E. 2008. Cyanobaterial Harmful Algal Blooms: State of the Science and Research Needs. Chapter 33: Cyanobacteria blooms: effects on aquatic ecosystems.

Hayhoe, K., D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider,K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S. Kalkstein, J. Lenihan, C.K.Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Science 101:12422-12427.

Hopkirk, J.D. 1973. Endemism in fishes of the Clear Lake region of central California. University of California Publications in Zoology 96: 160 pp.

Horne, A.J. 1975. The Effects of Copper, Major and Minor Nutrient Element Additions, and Lake Water Movements on Blue-Green Algal Bloom Development in Clear Lake.

Hudon, C., Armellin, A., Gagnon, P., & Patoine, A. (2010). Variations in water temperatures and levels in the St. Lawrence River (quebec, canada) and potential implications for three common fish species. *Hydrobiologia, 647*(1), 145-161.

Hunt, E.G. and A.I. Bischoff. 1960. Inimical effects on wildlife or periodic DDD applications to Clear Lake. California Fish and Game 46:91-106.

Jelks, H L., Stephen J. Walsh, Noel M. Burkhead, Salvador Contreras-Balderas, Edmundo

Diaz-Pardo, Dean A. Hendrickson, John Lyons, Nicholas E. Mandrak, Frank McCormick, Joseph S. Nelson, Steven P. Platania, Brady A. Porter, Claude B. Renaud, Juan Jacobo Schmitter-Soto, Eric B. Taylor & Melvin L. Warren Jr. (2008): Conservation Status of Imperiled North American Freshwater and Diadromous Fishes, Fisheries, 33:8, 372-407.

Jordan, D.S., and C.H. Gilbert. 1894. List of Fishes Inhabiting Clear Lake, California. Bulletin of the United States Fish Commission, Vol. XIV.

Kelsey Creek Watershed Assessment, February 2010. Prepared for East Lake and West Lake Resource Conservation Districts.

Kimsey, J.B. and L.O. Fisk. 1960. Keys to the freshwater and anadromous fishes of California. Calif. Fish Game 46:453-79.

Kniffen, F.B. 1939. Pomo Geography. University of California Publications in American Archaeology and Ethnology. Vol. 36 No. 6 pp. 353-400.

Kratville, D. October 7, 2013. Email correspondence on CESA MOU's issued for CLH.

Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen and I.A. Shiklomanov, 2007: Freshwater resources and their management. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210.

Lake County Department of Agriculture, 2011. Crop Report

Lake County Department of Public Works Water Resources Division, 2003. Clear Lake Wetlands Geographic Information Systems Data User Manual.

Lake County Vector Control District, 2013. Copy of verified Beach Seine 1987-2010 CL Hitch with notes.

Lindquist, A.W., C.D. Deonier, and J.E. Hanley. 1943. The relationship of fish to the Clear Lake gnat, in Clear Lake, California. Calif. Fish Game 29:196-202.

Lindquist, A.W. and A.R. Roth. 1950. Effect of dichlorodiphenyl dichloroethane on larva of the Clear Lake gnat in California. *Journal of Economic Entomology* 43:328-332.

Macclanahan, J., E. W. Danley, H. F. Dewitt, and W. Wolber. 1972[app]. Flood control project maintenance and repair, 1971 inspection report. California Department of Water Resources Bulletin 149-71.

Macedo, R., 1991. Creel Survey at Clear Lake, California March – June, 1988. CDFG Administrative Report No. 91-3.

Macedo, R. 1994. Swimming Upstream Without a Hitch. Outdoor California: January/February 1994.

Marchetti, M.P. and P.B. Moyle, 2001. Effects of flow regime on fish assemblages in a regulated California stream. *Ecological Applications*. 11(2). Pp. 530-539.

McGinnis, D. and E. Ringelberg. 2006. Lake County Fish Barrier Assessment. Technical Memo.

Middle Creek Watershed Assessment, February 2010. Prepared for West Lake Resource Conservation District.

Miller, R.R. 1945. A new cyprinid fish from Southern Arizona, and Sonora, Mexico, with description of a new subgenus of *Gila* and a review of related species. Copeia 1945:104-110.

Miller, R.R. 1963. Synonymy, characters and variation of *Gila crassicauda*, a rare California minnow, with an account of its hybridization with *Lavinia exilicauda*. California Fish and Game 49 (1): 20-29.

Mioni, C., R. Kudela, and D. Baxter. 2011. Harmful cyanobacteria blooms and their toxins in Clear Lake and the Sacramento-San Joaquin delta (California). Central Valley Regional Water Quality Control Board: 10-058-150.

Moyle, P.B. and M. Massingill. 1981. Hybridization between hitch, *Lavinia exilicauda*, and Sacramento blackfish, *Orthodon microlepidotus*, in San Luis Reservoir, California. California Fish Game 67:196-198.

Moyle, P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern in California, 2nd edition.

Moyle, P.B. and T. Light, 1996. Fish Invasions in California: Do Abiotic Factors Determine Success? Ecology 77:1666-1670.

Moyle, P. B. 2002. Inland Fishes of California. Berkeley: University of California Press.

Moyle, PB., JD Kiernam, PK Crain and RM Quinones, 2012. Projected Effects of Future Climates on Freshwater Fishes of California. A White Paper from the California Energy Commission's California Climate Change Center.

Moyle P.B., J.V Katz, and R.M. Quinones. In review. Fish Species of Special Concern for California. Prepared for California Department of Fish and Game, Sacramento

Murphy, G.I. 1948. Notes on the biology of the Sacramento hitch *(Lavinia e. exilicauda)* of Clear Lake, Lake County, California. Calif. Fish Game 34:101-110.

Murphy, G.I. 1951. The fishery of Clear Lake, Lake County, California. *Calif. Fish and Game* 37: 439-484.

National Oceanic and Atmospheric Administration, 2011. Table 2. Toxicity associated with mercury in tissues (ug/g) wet weight.

Nicola, S.J. 1974. The life history of the hitch, *Lavinia exilicauda* Baird and Girard, in Beardsley Reservoir, California. Inland Fish. Admin. Rep. 74-6:1-16.

Osleger, D.A., R.A. Zierenberg, T.H. Suchanek, J.S. Stoner, S. Morgan, and D.P. Adam. 2008. Clear Lake sediments: anthropogenic changes in physical sedimentology and magnetic response. Ecological Applications 18 (Supplement): A239-A256.

Puckett, L., 1972. CDFG Memorandum-Fisheries Survey Clear Lake, Lake County.

Richerson P.J., T.H. Suchanek, and S.J. Why. 1994. The Causes and Control of Algal Blooms in Clear Lake, Clean Lakes Diagnostic/Feasibility Study for Clear Lake, California. Prepared for USEPA Region IX.

Ridout, W.L. 1899. A Fish Jam on Kelsey Creek. *Overland Monthly and Out West Magazine.* Volume 34, Issue 202. p. 333.

Robinson Rancheria Environmental Center (RREC). 2011. Draft Adaptive Management Plan for the Clear Lake Hitch, *Lavinia exilicauda chi*. Available at http://www.robinsonrancheria.org/environmental/water.htm.

Rowan, J., 2008. CDFG Clear Lake, Lake County Memorandum.

Rudd, R.L. 1964. *Pesticides and the Living Landscape*. University of Wisconsin Press, Madison, WI.

Sandheinrich, MB. And KM Miller, 2006. Effects of dietary methylmercury on reproductive behavior of fathead minnows (*Pimephales promelas*). *Environmental Toxicology and Chemistry.* 25(11):3053-3057.

Scotts Creek Watershed Assessment, February 2010. Prepared for West Lake Conservation District.

Scotts Valley Band of Pomo Indians, 2013. Historical accounts provided to CDFW by Steve Elliott and Wanda Quitiquit.

State of California Fish and Game Commission, March 11, 2013. California Fish and Game Commission Notice of Findings

State of California Fish and Game Commission, October 2, 2012. California Fish and Game Commission Notice of Receipt of Petition

Suchanek, T.H., P.J. Richerson, L.A. Woodward, D.G. Slotton, L.J. Holts and C.E. Woodmansee. 1993. Ecological Assessment of the Sulphur Bank Mercury Mine Superfund Site, Clear Lake, California: A Survey and Evaluation of Mercury In:

Sediment, Water, Plankton, Periphyton, Benthic Invertebrates and Fishes Within the Aquatic Ecosystem of Clear Lake, California. Phase 1- Preliminary Lake Study Report. Prepared for EPA-Region IX, Superfund Program. 113 pp., plus 2 attachments.

Suchanek, T.H., P.J. Richerson, D.C. Nelson, C.A. Eagles-Smith, D.W. Anderson, J.J. Cech, Jr., G. Schladow, R. Zierenberg, J.F. Mount, S.C. McHatton, D.G. Slotton, L.B. Webber, A.L. Bern and B.J. Swisher. 2002. Evaluating and managing a multiply-stressed ecosystem at Clear Lake, California: A holistic ecosystem approach. “Managing For Healthy Ecosystems: Case Studies,” CRC/Lewis Press. pp. 1233-1265.

Swift, C. 1965. Early development of the hitch, *Lavinia exilicauda,* of Clear Lake, California. Calif. Fish Game 51:74-80.

Thompson, L.C., G.A. Giusti, K.L. Weber, and R.F. Keiffer. 2013. The native and introduced fishes of Clear Lake: a review of the past to assist with decisions of the future. California Fish and Game 99(1):7-41.

U.S. Army Corps of Engineers. 1974[app]. Flood plain information: Big Valley streams (Manning, Adobe, Kelsey, and Cole Creeks), Kelseyville, California. Department of the Army, Sacramento District, Corps of Engineers, Sacramento, California, USA.

U.S. Environmental Protection Agency, 2012. Sulphur Bank Mercury Mine News Release – EPA to Begin Construction of Test Covers in Clear Lake.

Week, L., 1982. Habitat Selectivity of Littoral Zone Fishes at Clear Lake, CDFG California. Administrative Report No. 82-7.

Wetzel, R.G., 2001. Limnology lake and River Ecosystems, 3rd ed. Pg. 834.

Winder, M., J. Reuter and G. Schladow, 2010. Clear Lake Report: Clear Lake Historical Data Analysis.

Appendix A. Summary graphs of spawning observations between 2005 and 2013

Appendix B. Figures depicting CLH observations on spawning tributaries

Appendix C. Description of barriers associated with CLH spawning tributaries

Highland Springs Creek: There is a flood control dam on Highland Springs Creek, a tributary to Adobe Creek, which is impassable to CLH.

Adobe Creek: There is a flood control dam on Adobe Creek above Bell Hill Road that is impassable to CLH. There are two culverts on Adobe Creek that are mitigation barriers to spawning CLH when the water flows and velocity are not too great, but these culverts block CLH migration.

Alley Creek: Alley Creek has been channeled and diverted into Clover Creek. Alley Creek historically supported CLH runs. During some time and under certain conditions migrating CLH can access Alley Creek via the Clover channel bypass, but not when the diversion has silt or sand obstructing it.

Clover Creek: There was a diversion barrier on Clover Creek, a tributary of Middle Creek, which prevented fish passage into Clover Creek and Alley Creek. In 2004 the Robinson Rancheria received a Tribal Wildlife Grant to mitigate the diversion barrier. The work has been completed and the barrier has been modified and no longer obstructs fish passage. However, CLH must pass a concrete diversion structure at the junction with Alley Creek to the northwest of Upper Lake to gain the upper reaches of Clover Creek. This diversion structure usually becomes a complete barrier when filled with gravel and sediment.

Forbes Creek: Forbes Creek has a concrete storm water diversion structure that impedes and at times blocks CLH passage.

Kelsey Creek: On Kelsey Creek, the main barriers to CLH migration are a detention dam 2 to 3 miles upstream of Clear Lake, and the Main Street Bridge in Kelseyville. The rock and concrete weir constructed at the base of the Main Street Bridge is a barrier to the passage of CLH (Peter Windrem, personnel communication, 2012). The structure has a fish ladder which is nonfunctional and the site is nonetheless a total barrier to CLH (McGinnis and Ringelberg, 2008). The Kelsey Creek detention structure below Dorn Crossing has retractable gates which can be opened during the CLH spawning season. However, altered flow patterns and slight increases in the slope of the streambed have been enough to reduce the number of spawning CLH that can pass through the detention structure and move upstream. Also, rock riprap situated below the retention dam seems to have impeded the upstream migration of CLH and needs to be modified to provide a clear channel for fish transit. A number of drop-structures in Kelsey Creek intended for gravel aggradation impede migration. Some of these do not seem to impede CLH passage under current conditions, but CLH navigate them with difficulty especially on the downstream passage. Further upstream, culverts that once tended to clog with debris and block fish migration at the Merritt Road crossing have been removed and replaced by a bridge that poses no impediment to CLH passage.

Lyons Creek: A high culvert on Lyons Creek at Lakeshore Drive prevents CLH from moving upstream. Lyons Creek also has a concrete barrier at the County's Juvenile Hall facility that completely prevents fish passage.

Manning Creek: A dam upstream of known CLH spawning areas in the lower reaches of Manning Creek may prevent CLH from spawning further upstream.

Middle Creek: On Middle Creek, a rock and concrete weir at the Rancheria Road Bridge has been a total fish passage barrier for CLH. Remedial work has been done downstream, with more weirs installed in an effort to elevate the gradient so that CLH could surmount the barrier and work was done to improve their stability after high flows, but it remains to be seen if this will allow CLH passage. Similar weirs to capture and hold gravel were installed many years ago in Adobe Creek and Kelsey Creek that do not impede CLH passage, but there is concern the installed weirs on Middle Creek may be potential barriers to CLH. A downstream weir at Rancheria Road is a partial barrier and improperly sized rip rap at this location acts as partial migration barrier (McGinnis and Ringelberg 2008). CLH were seen recently at Middle Creek Bridge and Highway 20 and although there are no obvious barriers, they did not appear to be able to navigate the swift currents there due to the lack of resting pools. If CLH could surmount Rancheria Bridge, many additional miles of spawning grounds would be accessible to CLH up to areas south of Hunter Bridge, where habitat suitability ends because the channel is braided and shallow due to gravel mining.

Scotts Creek: On Scotts Creek, a rock and concrete weir at the Decker Bridge is a total barrier to the passage of CLH. As water levels have been lower, a barrier at the lower end of Tule Lake is problematic for fish passage to Tule Lake and its tributary Mendenhall Creek, Scotts Creek and tributaries, Bachelor Valley/Witter Springs area tributaries, and Blue Lakes and tributaries. There is a one-way flow gate on the Blue Lakes outlet at Scotts Creek that prevents CLH from entering Blue Lakes.

Seigler Canyon Creek: There are two barriers to CLH migration into Seigler Canyon Creek, an exposed sewer pipe and a road crossing. The sewer pipeline which crosses Seigler Canyon Creek for Anderson Marsh State Park was modified in the 1990s and completely blocks CLH access to that creek, once a major spawning tributary.

Page	Line	Reviewer Comment	Department Response
9	4	suggested edit "to feed largely on water fleas"	Accepted
9	8	suggested edit "Chironomidae; planktonic crustaceans including the genera Bosmina and Daphnia;"	Accepted
9	20-21	suggested addition "Scale analysis indicates CLH live up to 6 years but it is likely that some individuals live longer (Moyle 2002)."	Accepted
9	23	suggested addition "CLH spawn in both lake tributaries and in the lake itself."	No Change- this information is provided further in the paragraph.
9	25-26	? which ones?	No Change- this is a general description of tributaries.
9	26	suggested edit "and nearly all have low gradients in their lower reaches."	Accepted
9	27-31	suggested edit "Some streams have flowing water year round, at least in headwaters. The lower reaches of tributary streams are seasonal with remnant pools occurring by late spring, and subsequently dry during summer months in most years."	No Change- The seasonality of tributaries is described.
9	31	suggested edit "CLH spawn in these low-gradient tributary streams and have spawning migrations"	Accepted
9	39-43	suggested edit "The success of these spawning events is not clearly understood and may be limited due to losses from predation on eggs and larvae, especially by alien fishes such as bluegill and Mississippi silverside"	Accepted- removed atypical and added events and predation on eggs and larvae. No Change- especially by alien fishes such as bluegill and Mississippi silversides as no reference was provided.
10	21-22	suggested edit "CLH are present in the littoral zone from April to July and are scarce in this habitat during other months"	Accepted
10	29-30	Are you sure? Bass fisherman use a hitch lure in the lake....	Accepted- The statement has been removed from the document.
10	39	suggested edit "tributaries or shallows of the lake during the following spring."	Accepted
10	42	suggested edit "Ideally, an assessment"	No Change
11	1	suggested addition "Glimpses into baseline numbers suggest that hitch were once very abundant. One of the oldest records is that of Livingston Stone (1876) who lived on the lake in 1872 and 1873. He states " They ran up the streams in spring to spawn in countless numbers. It is not unusual to see one or two acres of ground covered with hitch, which the Indians have dried for food." If you assume each drying fish is about 10 x 3 inches, this results in an estimate of about 200,000 fish per acre. Obviously, such numbers are at best 'ball park' estimates but they do suggest hitch were vastly more abundant then than they are today. "	No Change- Paragraph insertion. Historic information is provided later in the document. Accepted- Addition of Livingston Stone quote.
12	3	suggested edit "correlated to abundance of CLH"	Accepted
12	7	suggested edit "populations have at times been extremely low and at other times relatively high.	Accepted
14	20	suggested edit "CLH in 2005 is the likely"	Accepted
14	37	suggested edit "Based on this reports"	No Change
14	36-39	I disagree. Kelsey Creek presumably supported the largest run because of its size but there is no reason to think the fish did not use every available tributary as they do today.	Accepted- Sentence reworded to state the largest run occurred in Kelsey Creek.
14	43	suggested edit "the most important spawning tributary	No Change- The paragraph does not detail the importance of spawning tributaries only the importance of the CLH supply.
15	7	suggested edit "and Mississippi silversides (Menidia audens)"	Accepted
15	10-11	suggested edit "CLH populations as sampling varies significantly"	Accepted- Reworded based on other peer review comments
17	6	Using a boat electrofisher?	Accepted- Added sampling method to each survey.
17	7	Surveys found adult and juvenile (?) CLH	Accepted- Added adult.
17	15	would not? likely be found during this time period	No Change- "not" as CLH were the most abundant fish in the habitat they would be found in.
18	8-13	suggested edit "CLH were the second most abundant fish caught during various gill net surveys conducted between 1938 and 1941, for examination of fish and gnat interactions(Lindquist et al. 1943); runs of Sacramento splittail (Pogonichthys ciscoides) and CLH were described as numbering in the tens of thousands (Lindquist et al. 1943)."	Accepted- Clear Lake splittail scientific name. No Change- Paragraph rewording as original was clear on intent.
18	14	Hard to tell what species	Accepted- Sentence reworded.

18	Figure 6	suggested edit "Photo from 1890s depicting spawning fish, most likely CLH, being stranded in Kelsey Creek."	Accepted- Sentence reworded
19	35	Clear Lake is not a classic impoundment being a natural lake. One could argue that keeping lake levels higher in spring could benefit hitch (more littoral habitat for young).	Accepted- Information added on the amount of fluctuation seen in traditional reservoirs.
20	1-2	Results of the survey indicate all of the lower reaches? of the creeks had low Index of Biological Integrity (IBI) scores	Accepted- Sentence reworded
20	3	Not in references; would like to see a copy.	Accepted- Added to references
20	34	Good thing to do!	Noted
22	24-26	suggested addition "Cook et al (1966) noted the spittail "...underwent a drastic reduction in the 1940s" (p. 146) and feared it "...may disappear ... if increased demands upon the water further limit reproductive success." pg 147	Accepted
22	24-26	Cook SF, RL MOORE, and JD Connors. 1966. Status of the native fishes of Clear Lake, Lake County, California Wasmann Journal of Biology 24: 141-160.	Accepted
24	7	suggested edit "Primary producers such as epiphyton"	Accepted
24	9	suggested edit "As the cyanobacteria alter"	Accepted
24	11	suggested edit "cyanobacteria begin to deplete"	Accepted
24	25	suggested edit "marijuana culture"	Accepted
24	30	suggested edit "Clear Lake gnat, an important food source for juvenile CLH,"	Accepted
24	41-43	suggested edit "application of DDD in the Clear Lake watershed resulted in a major ecological disaster and the first records of pesticide bioaccumulation in the wildlife of the lake"	Accepted
24	42	Introduction of aliens, agriculture etc were also disasters from the lake perspective.	No Change- Sentence reworded to clarify first ecological disaster from pesticides.
24	47	petroleum product ????	Accepted- name added
25	3	suggested edit "Mississippi silversides"	Accepted
25	11	suggested edit "infestation of the lake"	Accepted
25	42	suggested edit "High levels of Mercury accumulation can lead to"	Accepted
25	48	What are the levels specifically in CLH? I suspect the higher levels are in bass, not hitch. Note; There is an entire issue of Ecological Applications (2008) devoted to Clear Lake mercury issues.	Accepted- Level for CLH added
25-26	48-1	suggested edit "), which have resulted in health advisories on their consumption, but are below acute toxicity thresholds"	Accepted
26	7	suggested edit "it is possible that"	Accepted
26	9	suggested addition "However, Hg levels are generally much lower in plankton feeding fish such as hitch than they are for other fishes in the lake (Eagles-Smith et al. 2008)."	No Change- The levels for CLH have been identified previously.
26	43	suggested edit "Two Pomo bands fought"	No Change
26	45	suggested edit "for the local native peoples"	No Change
27	13	suggested edit "to three bands to authorize"	No Change
27	25	Now aware of any records of hardhead from the lake or tributary streams. It is present in Cache Creek below the lake but the lake is not really suitable for it nor are the upstream tribs. If you believe the earliest accounts of the lake, CA roach were once abundant in shallow water; possible but identifications not strong. Check Hopkirk.	Accepted- Hardhead removed as reference in Thompson et al 2013 is unsubstantiated.
27	31	suggested edit "(largemouth and Florida bass (Micropterus spp)"	Accepted
27	36	Mississippi silverside (taxonomy has been reworked); the paper on the introduction of the silverside claims CDFG was a participant or at least did not discourage it.	No Change- According to Dill and Cordone the introduction into Clear Lake was not authorized be the Fish and Game Commission.
27	36	Doubt they are present in the lake; would like to see the proof.	No Change- The sentence states they were introduced. In the next sentence it is described that they never established.
27	37	Not present.	No Change- The sentence states they were introduced. In the next sentence it is described that they never established.
27	19-42	You need a table of all native and non-native species and their status	No Change- Species are discussed at length in document.
27	44	suggested edit "Non-native fish introductions have significant impacts on native fish species."	No Change - It is not within the references of this document to assert that all fish introductions have impacts to native fish species.

27	45	suggested edit "Mississippi silverside"	Accepted
27	46-47	suggested edit "compete directly with CLH for food resources and likely prey on larvae as well"	No Change- No reference provided to substantiate claim of "likely prey on larvae"
28	1	Could you make some?	Noted- The Department sought the LCVCD data on threadfin shad and Mississippi silverside abundance to make a comparison but the data was not provided to the Department.
28	5	suggested addition "Eagles-Smith et al. (2008) found that zooplankton populations declined precipitously as threadfin shad populations increased, causing other common plankton-feeding fishes (juvenile largemouth bass and bluegill, Mississippi silverside) to switch to benthic feeding. Hitch, being more specialized for zooplankton feeding may have been strongly affected by the threadfin shad (introduced in the 1980s), which undergoes boom-and-bust population cycles in the lake (Eagles-Smith et al (2008)."	Accepted- Information has been added on Mississippi silverside, threadfin shad, and CLH abundance.
28	13	suggested edit "rearing habitat and food has likely increased"	Accepted
28	18-19	Note that Florida bass (M. floridae) are regarded as a separate species from LMB. They apparently initially hybridized with LMB in the lake but now appear to be dominant. They grow larger than LMB so will be more inclined to eat adult CLH	Accepted- Florida bass added to sentence.
28	22	suggested edit "such as bullhead catfish (Ameiurus spp.)"	Accepted
28	23	suggested edit "introduction of white and channel catfish"	No Change- Changed to bullhead catfish
28	25	suggested edit "The introduction of white catfish (A. catus) was described"	Accepted
28	31-32	This is probably true, but Eagles-Smith et al. don't say this in relation to hitch or even fish predation.	Accepted- Sentence removed
28	34	suggested addition "Overall, alien species appear to be a major factor in contributing to hitch declines in Clear Lake. While fairly substantial runs of hitch have persisted into recent years, it is likely that the combination of introductions of Florida bass (1970s), Mississippi silverside (1967), and threadfin shad (1980s) have created an environment in which it is increasingly hard for hitch to persist. The voracious and large-sized bass will eat adults as well as juveniles. Threadfin shad deplete off shore plankton populations on which the hitch depend for much of their life. Silversides deplete inshore sources of food and presumably prey on larvae as they come out of the streams, as they have been shown to do for various fishes in the Sacramento San Joaquin Delta (ref.)	No Change- The same information has already been provided in the section.
29	27	suggested edit "likely to cause changes"	Accepted
29	33	suggested edit "amount of runoff will likely significantly"	Accepted
29	34-35	suggested edit "Climate driven anthropogenic change"	Accepted
29	41	This has now been published; Moyle, P.B., J. D. Kiernan, P. K. Crain, and R. M. Quiñones. 2013. Climate change vulnerability of native and alien freshwater fishes of California: a systematic assessment approach. PLoS One.http://dx.plos.org/10.1371/journal.pone.0063883	Accepted
30	1	suggested addition "). , Moyle et al. (2012. 2013) rated Clear Lake hitch as 'critically vulnerable' to extinction from the added effects of climate change, suggesting that CLH would be extinct by 2100 if steps were not taken to improve conditions for it.	No Change- Same info stated in first line of paragraph.
34	16-17	suggested edit "habitat restoration."	Accepted
36	3	suggested edit "Pomo bands"	No Change
36	12	This section is pretty weak.	Noted- This is a summary section of the threats to CLH by predation. A detailed account is found in Factors Affecting the Ability to Survive and Reproduce section.
36	14-15	suggested edit "mammals occurs"	No Change
36	17-18	suggested edits "modifications, especially flow reductions, described above"	No Change
36	19	suggested edits "CLH in all habitats"	No Change- Sentence reworded based on other peer review comments.
36	22-23	suggested edits "such as white and channel catfish"	No Change- Added bullhead catfish
36	23	suggested addition "Larvae are probably eaten by Mississippi silversides. "	No Change- No supporting documentation provided.
36	24	suggested edit "diet study of selected introduced"	Accepted

36	25-26	suggested addition "introduced fishes but needs to be targeted at places where hitch and alien fishes come in the most contact (e.., mouths of streams). "	No Change- A specific sample design would need to be created for the survey. That is out of the scope of this section.
36	27	What does this mean?	Accepted- Sentence reworded
36	34	suggested edit "Mississippi silverside"	Accepted
36	35	? Most likely when both TFS and MSS are depressed.	Accepted
36	36-37	We don't actually know this. Competition is more likely for food than space.	Noted- It is reasonable to assume that CLH compete for space in a system that is dominated by non-native species.
36	37-38	They do? Reference?	Accepted- Sentence reworded
37	28	suggested edit "It is imperative"	Accepted
38	5	suggested edit "Department does indicate"	Noted
39	10	The best place to start is improvement of the stream spawning surveys, by hiring a full-time coordinator for citizen survey crews.	No Change- The comment is outside the scope of this document.
39	19	suggested edit "spawning and rearing habitat"	Accepted
39	35	suggested edit "• Conduct a focused diet analysis"	No Change- Wording changed to reflect statements in previous sections.
39	37	For hitch? This would be expensive & yield little data.	No Change- Creel surveys provide information on all species including CLH.
39	41	suggested addition ". In particular, develop ponds that can be used to create 'back up' populations of hitch in case the lake populations disappear."	No Change- Statement is implied by management action.

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Fisheries Branch
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Sacramento, CA 95811
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EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

January 13, 2014

Thomas Taylor
Senior Consultant, Aquatic Biologist
Cardno ENTRIX
701 University Ave Suite 200
Sacramento, CA 95825

Dear Mr. Taylor

CLEAR LAKE HITCH (*LAVINIA EXILICAUDA CHI*); DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW STATUS REPORT

Thank you for agreeing to serve as a scientific peer reviewer for the Department of Fish and Wildlife (Department) Draft Status Report of the Clear Lake hitch (*Lavinia exilicauda chi*). A copy of the Department's peer review draft status report, dated January 2014, is enclosed for your use in that review. The Department seeks your expert analysis and input regarding the scientific validity of the report and its assessment of the status of Clear Lake hitch in California based on the best scientific information currently available. The Department is interested in and respectfully requests that you focus your peer review effort on the body of relevant scientific information and the Department's assessment of the required population and life history elements prescribed in the California Endangered Species Act (CESA). The Department would appreciate receiving your peer review input on or before February 10, 2014.

The Department seeks your review as part of formal proceedings pending before the California Fish and Game Commission under CESA. As you may know, the Commission is a constitutionally established entity distinct from the Department, exercising exclusive statutory authority under CESA to list species as endangered or threatened. The Department serves in an advisory capacity during listing proceedings, charged by the Fish and Game Code to focus on the best scientific information available to make related recommendations to the Commission.

The Commission first received the petition to list Clear Lake hitch as threatened on September 25, 2012. The Commission accepted the petition for further consideration and the species was formally designated as a candidate species on March 22, 2013 following publication of regulatory notice by the Office of Administrative Law. The Clear Lake hitch is currently protected under CESA in California in that capacity.

The peer review Status Report forwarded to you today reflects the Department's effort over the past year to identify and analyze the best scientific information available regarding the status of Clear Lake hitch in California. Headed into peer review, the Department believes the best available science indicates that listing the species as threatened under CESA is warranted at this time. To be clear, we ask that you focus

your review on the scientific information and the Department's related assessment of the required population and life history elements prescribed in CESA rather than focusing on the tentative conclusion we share as a matter of professional courtesy. We underscore, however, that scientific peer review plays a critical role in the Department's effort to develop and finalize its recommendation to the Commission as required by the Fish and Game Code.

Again, because of the importance of your effort, we ask you to focus your review on the best scientific information available regarding the status of Clear Lake hitch in California. As with our own effort to date, your peer review of the science and analysis regarding each of the population and life history categories prescribed in CESA (*i.e.*, present or threatened habitat modification, overexploitation, predation, competition, disease, and other natural occurrences or human-related activities that could affect the species) are particularly important as well as whether they indicate, in your opinion, that Clear Lake hitch is likely to become, in the foreseeable future, at serious risk of becoming extinct throughout all or a significant portion of its range in California.

We ask that you assess our work for quality and conduct a thorough and proper review. As with all peer review processes, the reviewer is not the final arbiter, but your comments will inform our final decision-making. Also, please note that the Department releases this peer review report to you solely as part of the peer review process, and it is not yet public.

For ease of review, I invite you to use "track changes" in WORD, or provide comments in list form by page and line number of the report. Please submit your comments electronically to Kevin Thomas at kevin.thomas@wildlife.ca.gov, or he may be reached by telephone at (916) 358-2845.

If there is anything the Department can do to facilitate your review, please let me know. Thank you again for your contribution to the status review effort and the important input it provides during the Commission's related proceedings.

Sincerely,

Stafford Lehr
Chief, Fisheries Branch

Enclosure(s)

cc: Tina Bartlett
CDFW-NCR

Thomas Gibson
CDFW-OGC

Katherine Hill
CDFW-NCR

Kevin Thomas
CDFW-NCR

Thomas, Kevin@Wildlife

From: Tom Taylor <thomas.taylor@cardno.com>
Sent: Monday, February 10, 2014 2:28 PM
To: Thomas, Kevin@Wildlife
Subject: CLH Status Report - Peer Review
Attachments: CLH Status review_peer review document_1-13-14_TT.docx

Dear Kevin,

Attached are my peer review comments and edits on the CLH Status Review document. Edits are in track changes and comments are included in the document. IN summary, I think the Status Review does an adequate job of vetting the breadth of potential causes that are active in the Clear Lake Basin on CLH, but it was less than definitive in establishing any long-term trends or solid linkages of cause and effect. I recognize that any census information on the species is usually an amalgamation of efforts to monitor other species that would not have targeted CLH. Outside of the relatively recent surveys of spawning runs by the CCCLH, all other population assessments are based on incidental catches of CLH. I have made three suggestions – two for additional analyses and one other to rectify an internal conflict in the document:

1) Hydrology and Spawning Access Analysis. This analysis would look at changes to spawning stream hydrology in combination with temporal changes to spawning habitat access from the lake AND access back to the lake for larvae. This issue seems to be at the heart of the CLH decline but the biological data is not strong enough to categorically conclude cause and effect. This analysis would examine the relationship of stream connectivity with the lake as a factor in population decline. Examine flow recession curves on key tributaries, or use indicator tributaries. This is more mechanistic than looking at rainfall. The analysis would test for reduced flows, flows of shorter duration (starting later or ending sooner) during the CLH spawning season. Also, if there is any information that would provide for a temporal perspective in the rate of decline of spawning tributary access either through documenting installation of barriers over time or a systematic reduction of access to spawning habitat (area reduction over time) this could provide stronger linkage to cause and effect. Operational info on the detention dam on Kelsey Creek might provide important data.

2) Analysis of threadfin shad and inland silversides juvenile abundance indices in the lake and association with CLH juvenile abundance and other lake factors. This would add some credibility to statements about this implied association between these species and perhaps vet the lake rearing habitat-related issue. Alternatively, while the report includes a statement of the reduction of marginal wetlands, it's treated as an on or off variable. Can wetland loss be quantified from available historical aerial photographs over the past 40 years?

3) Rectify or explain the counter intuitive nature between the stream connectivity theory (more CLH in wet years) and the graphics that appear to show higher CLH abundance in the lake associated with dry years.

Given the history of the CLH, I think it warrants listing at this time. We are at a key decision point because past efforts have failed to result in recovery, however, I don't think the Status Review, as written, leads one to reach that conclusion.

Please don't hesitate to give me a call if you have any questions.

I have not forgotten about your request to share some of my CLH images from late 1970s-early 1980s – I've just been too busy to move this to my active agenda.

Thomas L. Taylor
SENIOR CONSULTANT / AQUATIC BIOLOGIST
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State of California
Natural Resources Agency
Department of Fish and Wildlife

REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF CLEAR LAKE HITCH (*Lavinia exilicauda chi*)

January 2014 Preliminary Draft for Peer Review

Clear Lake hitch adult. Photo courtesy of Rick Macedo

Charlton H. Bonham, Director
Department of Fish and Wildlife

Report to the Fish and Game Commission

A STATUS REVIEW OF CLEAR LAKE HITCH

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EXECUTIVE SUMMARY

This status review report describes the current status of Clear Lake hitch (*Lavinia exilicauda chi*) (CLH) in California as informed by the scientific information available to the California Department of Fish and Wildlife (Department, CDFW, CDFG).

Background

- September 25, 2012: The Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity to list CLH as threatened under the California Endangered Species Act (CESA) (Center for Biological Diversity 2012).
- September 26, 2012: The Commission sent a memorandum to the Department, referring the petition to the Department for its evaluation.
- October 12, 2012: The Commission provided notice of the received petition from the Center for Biological Diversity to list CLH as threatened under CESA (Cal. Reg. Notice Register 2012, Vol. 41-Z, p.1502).
- December 12, 2012 the Commission granted a 30-day extension on the submission date for the Department's Initial Review of Petition to List the Clear Lake Hitch as threatened under CESA.
- January 31, 2013: The Department provided the Commission with an Initial Review of Petition to List the Clear Lake Hitch as Threatened under the California Endangered Species Act pursuant to Fish and Game Code, section 2073.5. The Department's review recommended that the petition provided sufficient information to indicate the petitioned action may be warranted, and the petition should be accepted and considered (CDFW 2013).
- March 6, 2013: At its scheduled public meeting in Mt. Shasta, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received by the Commission and found that the petition provided sufficient information to indicate the petitioned action may be warranted.
- March 22, 2013: The Commission published its Notice of Findings in the California Regulatory Notice Register (CA Reg. Notice Register 2013, Vol. 12-Z p. 488), stating the petition was accepted for consideration, and designated CLH as a candidate species.

Summary of Findings

Note to Reviewer: This Summary of Findings will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

Status

Threats

Petitioned Action

Management and Recovery Recommendations

INTRODUCTION

This status review report addresses the Clear Lake hitch (*Lavinia exilicauda chi*) (CLH), the subject of a petition to list the species as threatened under the California Endangered Species Act (CESA) (Fish & G. Code § 2050 *et seq*.).

Petition History

On September 25, 2012, the Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity (Petitioner) to list the CLH as a threatened species under CESA.

On September 26, 2012 the Commission sent a memorandum to the California Department of Fish and Wildlife (Department, CDFW, and CDFG) referring the petition to the Department for its evaluation.

On October 12, 2012, as required by Fish and Game Code, section 2073.3, notice of the petition was published in the California Notice Register (Cal. Reg. Notice Register 2012, Vol. 41-Z, p.1502).

On December 12, 2012 the Commission granted a 30-day extension on the submission date for the Department's Initial Review of Petition to List the CLH as threatened under CESA.

On January 31, 2013, the Department provided the Commission with its Initial Review of Petition to List the CLH as threatened under CESA. Pursuant to Fish and Game Code, section 2073.5, subdivision (a) (2), the Department recommended that the petition provided sufficient information to indicate the petitioned action may be warranted.

On March 6, 2013 at its scheduled public meeting in Mt. Shasta, California, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received, and found that sufficient information existed to indicate the petition may be warranted and accepted the petition for consideration.

Subsequently, on March 22, 2013 the Commission published its Notice of Findings for CLH in the California Regulatory Notice Register, designating the CLH as a candidate species (CA Reg. Notice Register 2013, Vol. 12-Z p. 488).

Department Review

Following the Commission's action to designate CLH as a candidate species, the Department notified affected and interested parties and solicited data and comments on the petitioned action, pursuant to Fish and Game Code, section 2074.4 (see also Cal. Code Regs., Title 14, § 670.1(f)(2)) (CDFW 2013). All comments received are included in Appendix D to this report. The Department commenced its review of the status of the species as required by Fish and Game Code section 2074.6.

This report reflects the Department's scientific assessment to date of the status of CLH in California. At this point, the report will undergo independent and competent peer review by scientists with acknowledged expertise relevant to the status of CLH. Once peer review is completed Appendix E will contain the specific input provided to the Department by the individual peer reviewers (Cal. Code Regs., Title 14, § 670.1(f) (2)).

BIOLOGY

Species Description

Clear Lake hitch is a member of the cyprinid family (Cyprinidae), growing to 35 centimeters (cm) standard length (SL), and with laterally compressed bodies, small heads and upward pointing mouths (Moyle et al. 1995). They are separated from other California minnows by their long anal fin consisting of 11 to 14 rays. The dorsal fin (10 to 12 rays) originates behind the origin of the pelvic fins. Juvenile CLH have a silver coloration with a black spot at the base of the tail. As CLH grow older the spot is lost and they appear yellow-brown to silvery-white on the back. The body becomes deeper in color as the length increases (Hopkirk 1973; Moyle 2002). CLH show little change in pigmentation during the breeding season (Hopkirk 1973). The deep, compressed body, small upturned mouth, and numerous long slender gill rakers (26 to 32) reflect the zooplankton-feeding strategy of a limnetic forager (Moyle 2002). This lake adapted subspecies also has larger eyes and larger scales than other hitch subspecies.

Taxonomy

Hopkirk (1973) described CLH as a lake-adapted subspecies based primarily on the greater number of fine gill rakers. CLH are distinguished from other subspecies of hitch by their deeper body, larger eyes, larger scales and more gill rakers (Hopkirk 1973). Recent research on 10 microsatellite loci supports Hopkirk's description of CLH as a distinct subspecies (Aguilar et al. 2009). However, mitochondrial DNA analysis has not been able to distinguish CLH as a distinct subspecies from other hitch in California. Yet, based upon the morphological and microsatellite analysis there is sufficient evidence to warrant the designation of CLH as a distinct subspecies of hitch (Hopkirk 1973; Moyle et al. 1995; Aguilar et al. 2009).

CLH can hybridize with other Cyprinidae species and hybridization is known to occur with the genetically similar California roach (*Lavinia symmetricus*) (Miller 1945b; Avise and Ayala 1976; Moyle and Massingill 1981; Moyle et al. *in review*). However, there is no documentation of these hybrids in Clear Lake. CLH were known to hybridize in Clear Lake with the now extinct thicktail chub (*Gila crassicauda*) (Moyle et al. *in review*).

Comment [TT1]: or in streams tributary to the Lake?

Range and Distribution

The entire CLH population is confined to Clear Lake, Lake County, California, and to associated lakes and ponds within the Clear Lake watershed such as Thurston Lake and Lampson Pond (Figure 1). Populations previously identified in the Blue Lakes, west of Clear Lake, have apparently been extirpated (Macedo 1994).

Comment [TT2]: Not shown in Fig 1.

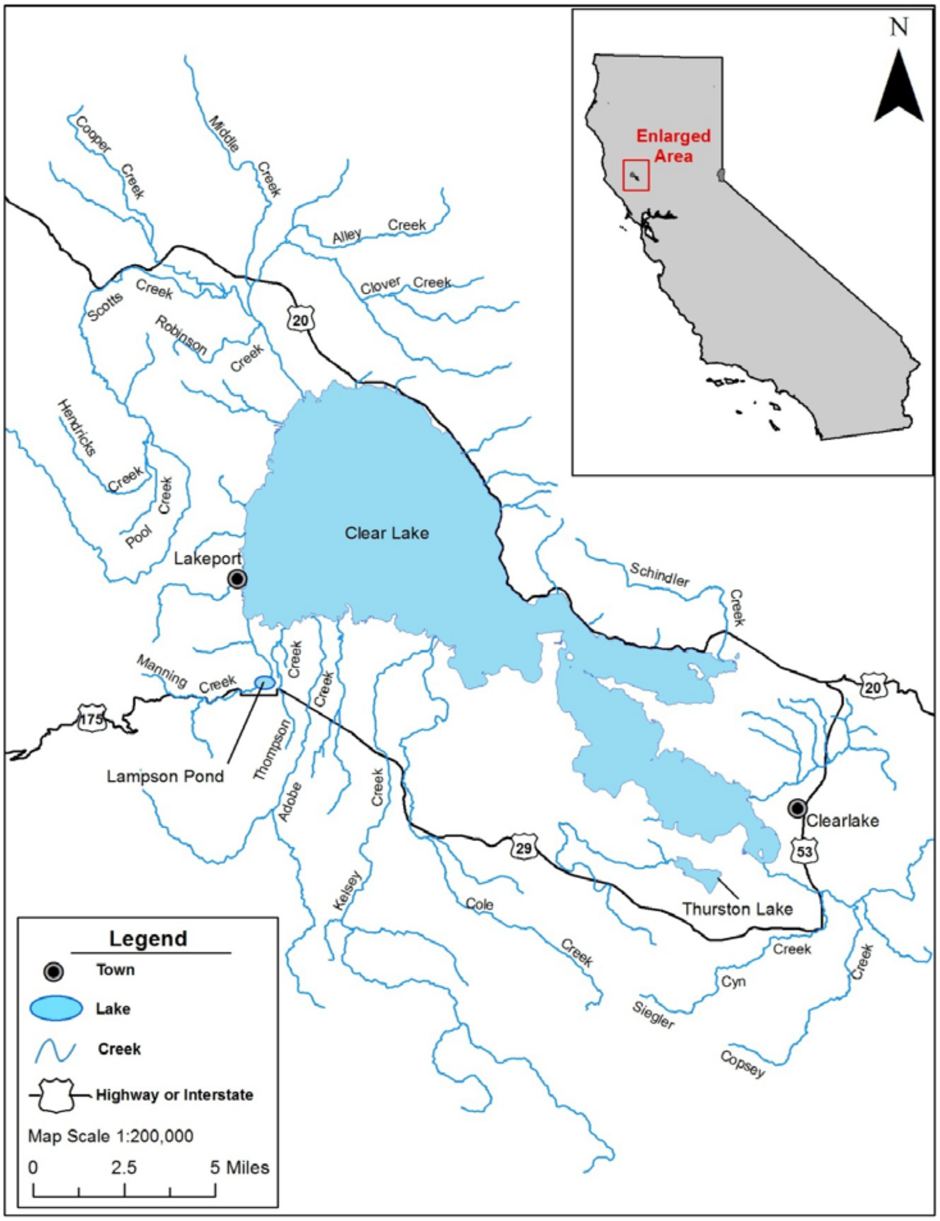

Figure 1. Map depicting the Clear Lake watershed.

Comment [TT3]: The map shows stream systems tributary to Clear Lake and does not include the entire watershed. Note that the Cache Creek outflow channel from Clear Lake is not labeled as such.

Life History

Physical adaptations to lake conditions allow CLH greater than 50 millimeters (mm) SL to feed almost exclusively on water fleas (*Daphnia* spp.) (Geary 1978; Geary and Moyle 1980; Moyle 2002). Stomach analysis indicates that CLH feed primarily in the day rather than at night (Geary 1978). Juveniles less than 50 mm SL are found in shallow, littoral zone (near-shore) waters and feed primarily on the larvae and pupae of chironomidae; planktonic crustaceans including the genera *Bosnia* and *Daphnia*; and historically on the eggs, larvae, and adults of Clear Lake gnat (*Chaoborus astictopus*) (Lindquist et al. 1943; Geary 1978; Geary and Moyle 1980). Growth in CLH is faster and total size greater than that of other hitch subspecies (Nicola 1974). By three months CLH have reached 44 mm SL and will continue to grow to between 80 to 120 mm by the end of their first year (Geary and Moyle 1980). Females become mature by their second or third year, whereas males tend to mature in their first or second year (Kimsey 1960). Females grow faster and are larger at maturity than males (Hopkirk 1973; Geary 1978; Ringelberg and McGinnis 2009). The larger size of CLH in comparison to hitch from other locations translates to greater fecundity. Accordingly, spawning females in Clear Lake average 36,000 eggs each year (Geary and Moyle 1980) compared to an average of 26,000 eggs for hitch in Beardsley Reservoir (Nicola 1974).

Clear Lake tributaries are numerous and located around the lake basin (Figure 1). Most streams have headwaters at higher elevations in the surrounding foothills; others have headwaters in lower elevations of the basin, and nearly all have low gradients. Some streams are more substantial than others with flowing water year round. Most are seasonal with remnant pools occurring by late spring, and subsequently dry during summer months. Those that retain water year round often have long stream reaches that are ephemeral. CLH spawn in these low-gradient tributary streams and form spawning migrations that resemble small scale salmon runs. Spawning migrations usually occur in response to heavy spring rains, from mid-February through May and occasionally into June (Murphy 1948b; Kimsey 1960; Swift 1965; Chi Council for Clear Lake Hitch (CCCLH) 2013 (unpublished data)). During wet years, CLH spawning migrations may also opportunistically extend into the upper reaches of various small tributaries, drainage ditches, and even flooded meadows (Moyle et al. *in review*). CLH have also been observed spawning along the shores of Clear Lake, over clean gravel in water 1 to 10 cm deep where wave action cleans the gravel of silt (Kimsey 1960). The success of these atypical spawning areas is not clearly understood and may be limited due to losses from egg desiccation and juvenile predation (Kimsey 1960; Rowan, J. personal communication, October 10, 2013, unreferenced).

CLH spawn at water temperatures of 14 to 18°C in the lower reaches of tributaries. Egg deposition occurs along the margins of streams in very shallow riffles over clean, fine-to-medium sized gravel (Murphy 1948b; Kimsey 1960). Eggs are fertilized by one to five males as they are released from the females (Murphy 1948b; Moyle 2002). Eggs are non-adhesive and sink to the bottom after fertilization, where they become lodged among the interstices in the gravel. The eggs immediately begin to absorb water and swell to more than double their original size. This rapid expansion provides a protective cushion of water between the outer membrane and the developing embryo (Swift 1965)

Comment [TT4]: I've observed spawning mid channel too – and some of these eggs will "eddy out" in the margins. Also note that large volumes of eggs may deplete stream margin areas of oxygen resulting in the mortality of large numbers of eggs and may help to secure eggs in gravel interstices. The embryos hatch after approximately 7 days, and larvae become free-swimming after another 7 days (Swift 1965). Larvae must then move downstream to the lake before stream flows become ephemeral (Moyle 2002).

Comment [TT5]: I would restate saying that larvae must move downstream to the lake before the stream flow disconnects with the lake (the stream may still be flowing at upstream locations).

Within Clear Lake, larvae remain near shore and are thought to depend upon stands of tules (*Schoenoplectus acutus*) and submerged weeds for cover until they assume a limnetic lifestyle (CDFG 2012). Juvenile CLH require rearing habitat with water temperatures of 15° C or greater for survival (Moyle 2002; Franson 2012 and 2013). Juveniles are found in littoral shallow-water habitats and move into deeper offshore areas after approximately 80 days, when they are between 40 to 50 mm SL (Geary 1978; CDFG 2012). Adult CLH are usually found in the limnetic zone (well-lit, surface waters away from shore) of Clear Lake. The limnetic feeding behavior of adult fish is supported by stomach analysis of CLH where very little content of benthic midges was found, even though the fish were collected in the profundal (deep-water) habitat during the survey (Cook et al. 1964). Additional data collected by the Department during the early 1980s indicates CLH are present in the littoral zone from April to July and are absent from this habitat during other months (Week 1982).

Adult CLH are vulnerable to predation during their spawning migration by mergansers (*Mergus* spp.), herons (*Ardea* spp.), bald eagles (*Haliaeetus leucocephalus*), and other birds, river otter (*Lontra canadensis*), northern raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*) (Bairrington 1999). In addition, CLH have been recovered from the stomachs of black bass (*Micropterus* spp.) caught in the lake (Bairrington 1999). Most predation by black bass likely occurs during spring staging periods as CLH congregate and begin to ascend tributaries to spawn (Rowan, J. personal communication, October 10, 2013, unreferenced).

Comment [TT6]: This is a strong statement of a cause-effect given it is an unreferenced P-C.

Habitat that May be Essential to the Continued Existence of the Species

At various life stages CLH utilize stream and lacustrine (lake) habitat present in the watershed (Figure 1). Adult fish spawn in the tributaries of the lake during the spring and juvenile fish emerge from the tributaries and utilize near shore habitats to continue growth and seek refuge from predators. As juveniles mature into adults they move to the main body of the lake and assume a limnetic lifestyle until returning to spawn in the tributaries the following spring.

Comment [TT7]: Not all tribs are of equal value to spawning. Some of the small channels will only flow during wet years (many of the short tribs on the east side) while others offer some spawning habitat nearly every year (these used to be Seigler, Kelsey, and Middle Cks)

SPECIES STATUS AND POPULATION TRENDS

An assessment of the status of CLH should include statistically valid population estimates conducted over time, to provide population data and trends. CLH studies to date have consisted primarily of qualitative sampling and are not suitable for deriving population estimates; however, these study results can provide insight into the current status of the species.

The population trends for this status review focus on three sets of data available to the Department for analysis. First, commercial catch records, submitted to the department by operators on Clear Lake, contain incidental catch information on CLH dating back to 1961. Operators were required to keep records of CLH caught incidentally while operations focused on other species in the lake. Second, the Lake County Vector Control District (LCVCD) has been conducting sampling efforts along the shoreline of Clear Lake since 1987. Although sampling efforts are not specific to CLH, LCVCD recorded incidental data on CLH captured during each sampling. Third, spawning observation data have been collected by volunteers with the CCCLH since 2005. Spawning observation data provide an estimate of the number of CLH in any given spawning tributary during the observation period. Results are summarized by the CCCLH each year following the completion of the spawning season. Information on population trends prior to 1961 is focused on small sampling efforts, published articles, and traditional ecological knowledge from tribal members. Although not quantifiable, this data provides an idea of the status and distribution of CLH prior to larger qualitative sampling efforts.

Environmental conditions required for successful spawning and biological impacts to the survivorship of CLH are highly variable from year to year and often result in multiple years with reduced spawning success or reduced recruitment into the population. The information presented in Figure 2 comes from the three qualitative sampling efforts conducted at Clear Lake and measured rainfall totals during the past 52 years in the watershed. Trend data in commercial catch records were represented for a given year by totaling the number of CLH captured per year and dividing by the number of days commercial operations occurred. Commercial catch data are comprised primarily of adult CLH. The CLH spawning trend data were calculated by totaling the number of CLH observed and dividing by the number of observation periods. LCVCD data on CLH captures represent the total number of CLH captured per year. LCVCD data is comprised primarily of juvenile CLH. The data represented from Table 6 of CDFG (1999) were calculated by using 20,000 as a total catch baseline for percent of total catch for CLH. Total rainfall data for January to June of each year was measured at the Clear Lake Highlands and U.S. Geological Survey rainfall gauges. Figure 2 does not reflect population numbers but rather trends in the abundance of CLH in any given year. As a proxy for changes ~~in~~ to an estimated ~~established~~ population size, biologists often use qualitative information as an indicator of population trends.

Comment [TT8]: Has rainfall been linked to streamflows that sustain CLH reproductive success? Are there other data to use besides rainfall (streamflow, lake level, number of passage flow days in representative creeks for adults migrating out of the lake and for larvae moving downstream)? The Status Review is lacking in analysis of hydrology.

The trends of all data show a highly variable population that responds both positively and negatively to environmental parameters and varies significantly from year to year. Rainf~~j~~all totals do not appear to be significantly correlated to the abundance of CLH during the timeframe. It is likely that a combination of environmental factors is impacting the CLH population. The fluctuating abundance trend has continued throughout the duration of the qualitative sampling efforts and indicates CLH populations have at times been extremely low and at other times relatively robust.

Comment [TT9]: This is conclusion jumping – Consider the factors at work here 1) there's the qualitative nature of the data, 2) some of the CLH data may not be linked to rainfall (juvenile or adult abundance may be lagged one or more years, or 3) there could be compensatory survival in years of high reproductive success, only so many larvae will survive to juvenile or adult life stages.

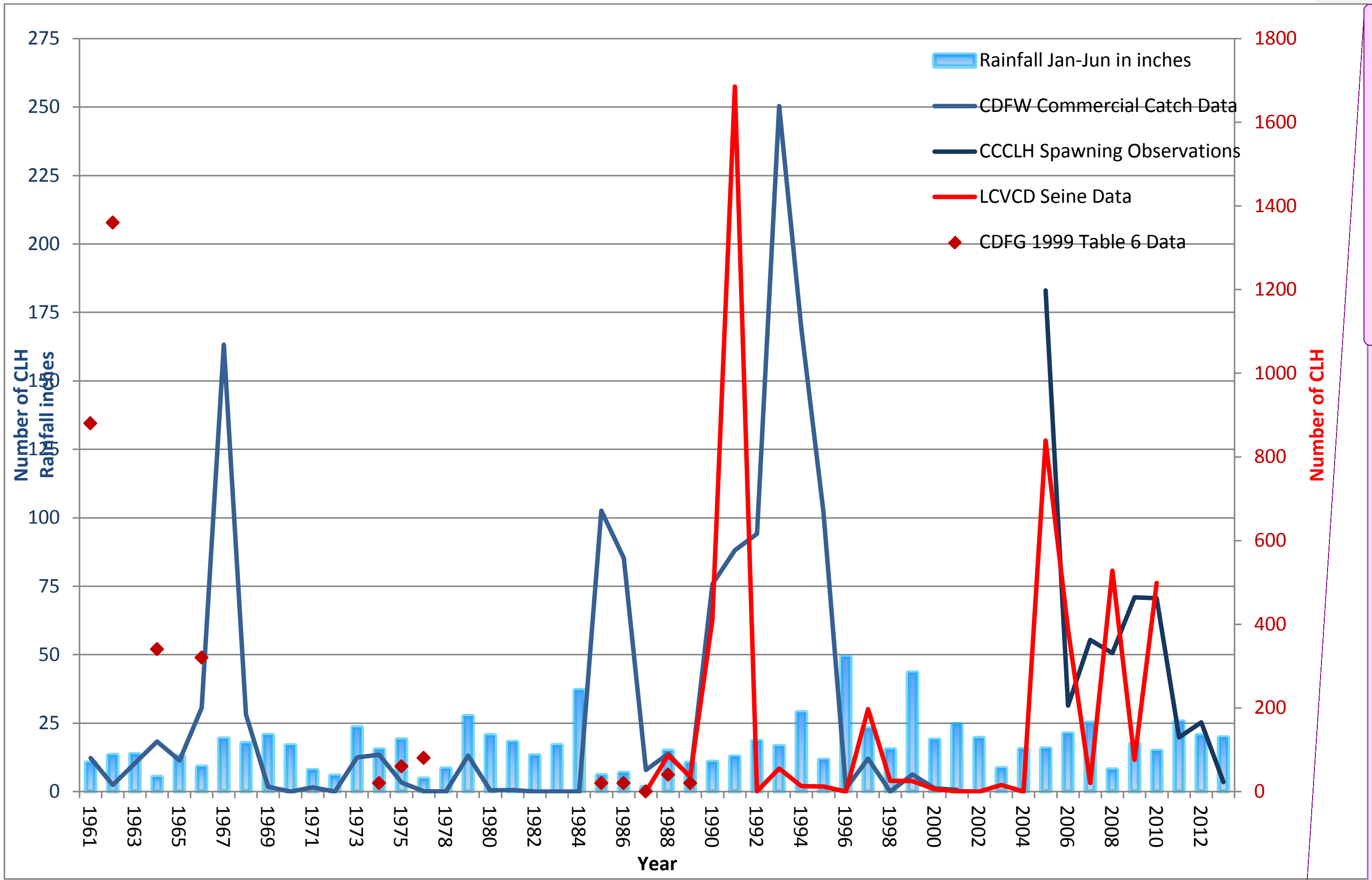

Figure 2. Clear Lake hitch population trends over the past 52 years as measured by three methods of qualitative sampling and spawning season rainfall totals as recorded at the Clear Lake Highlands and U.S. Geological Survey 385525122335501 rainfall gauges. Data in blue tones corresponds to the primary y axis and data in red tones corresponds to the secondary y axis.

Comment [TT10]: These data are all discrete and should be graphed with bars, not lines. I suggest not combining with rainfall it's too confusing in one graph. I question if total rainfall is a good measure for cause-effect. As an example, in 1997, all the rainfall came in January, so spawning conditions later were not that good. Are there other factors to examine in more detail such as lake level during the spawning period? Streamflow volume and persistence are other factors to examine in the individual streams or in index streams.

Also juvenile and adult fish should be lagged by an appropriate time step if you're looking at linkages between good spawning conditions relating to strong cohort years.

Comment [TT11]: Can you include other notable events, such as construction of the detention dam on Kelsey Creek, or other such known features?

In 2013 the Department conducted a mark-and-recapture study to gain a better understanding of the CLH spawning population in Cole and Kelsey creeks. Unfortunately, too few individuals were marked and recaptured to give a statistically valid population estimate (Ewing 2013). Electrofishing surveys in June 2012 identified thousands of young of year CLH in near shore habitats along the southwestern shoreline of Clear Lake (CDFG 2012). Volunteers with the CCCLH conducted direct observations of CLH in spawning tributaries of Clear Lake in 2013, and spawning observations identified less than 500 CLH present (CCCLH 2013). Of those fish, 300 to 400 CLH were found below the Kelsey Creek detention dam. No single day count totaled more than 70 fish in any spawning tributary in 2013 (CCCLH 2013).

CCCLH qualitative spawning observations between 2005 and 2013 indicated peak single day CLH counts of ~~spawning runs of~~ 1,000 to 5,000 fish (CCCLH 2013), and daily observation averages ranged from 3.5 to 183.1 fish (Figure 2). However, these observations make no distinction between previously counted fish, and it may be more prudent to look at fixed location single day counts from this time period. The highest number of CLH observations recorded was approximately 5,000 during 2005; concurring with beach seine data that demonstrate a higher than average number of CLH caught in 2005 as well (CCCLH 2013; LCVCD 2013). The increased number of juvenile CLH captured in the 2005 beach seine sampling is the likely reason for the increase in adult spawning observations between 2007 and 2009. Appendix A contains summary graphs and figures, prepared by CCCLH, for observations made between 2005 and 2013.

Comment [TT12]: As is wording implies the fish are only in the stream for a day, which is not the case.

There is sufficient information from these spawning observations to suggest the number of spawning tributaries being used by CLH decreased in 2013 compared to the average from 2005 to 2012 (Figure 3) (CCCLH 2013). However, the data limitations do not allow for quantification of observation time on each creek (survey effort) compared with the number of fish observed to aid in understanding the extent of use in each tributary. Appendix B contains figures depicting the decline in annual spawning runs in Clear Lake tributaries between 2005 and 2013 (CCCLH 2013). Historic accounts and habitat suitability predications suggest that CLH originally spawned, to some degree, in all the tributaries to Clear Lake (Robinson Rancheria Ecological Center (RREC) 2011). However, reports on Pomo geography speak of Pomo tribes in the area travelling to Kelsey Creek to capture CLH and even of war when a tribe tried to divert Kelsey Creek to gain control of the important CLH supply (Barrett 1906; Kniffen 1939). Based on the reports it is unclear to what extent CLH spawned in other tributaries to Clear Lake. It can be surmised the majority of CLH spawning occurred in Kelsey Creek during this period. Over the past eight years the number of occupied spawning tributaries has decreased from a high of 12 in 2006 to three in 2013 (CCCLH 2013). Currently, Adobe Creek seems to have the largest spawning run in the Clear Lake watershed while Kelsey and Cole creeks support smaller spawning runs. Based on historical accounts the primary spawning tributary has shifted from Kelsey Creek to Adobe Creek (Kniffen 1939; CCCLH 2013).

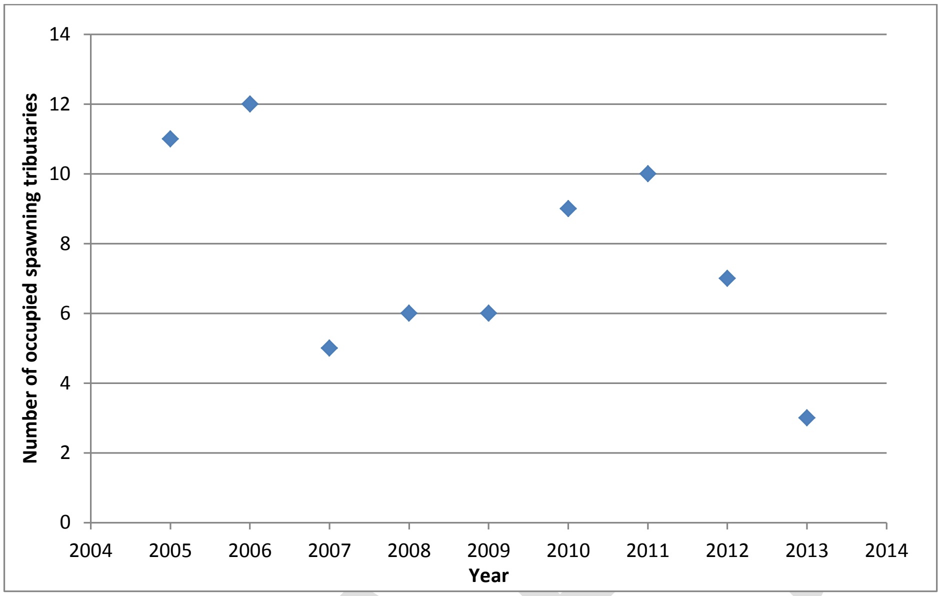

Figure 3. Number of occupied Clear Lake hitch spawning tributaries documented by CCCLH observers between 2005 and 2013.

LCVCD has been collecting beach seine data at various sites around the lake for more than two decades. The sampling is designed to measure abundance of threadfin shad (*Dorosoma petenense*) and inland silversides (*Menidia beryllina*) as part of a Clear Lake gnat (*Chaoborus astictopus*) surveillance program. Incidental captures of CLH are recorded during these surveys; however, the data collected are not appropriate for a statistically valid evaluation of CLH populations as the sample design varies significantly in timing, water quality conditions, and lake depth during surveys. Additionally, sample locations are in areas that contain open unvegetated beaches that are not preferred habitat for CLH. Although surveys were not conducted to assess CLH, capture data for these surveys is consistent with other data sources in demonstrating a population that has poor recruitment in many years interspersed with few years of high levels of recruitment (Figure 4) (LCVCD 2013). In most years less than 100 CLH are captured during the surveys (17 of 24 years). Four of the six years when more than 100 CLH were captured were between 2005 and 2010. The greatest numbers of CLH were captured in 1991, a year that was described by the Department as a boom for juvenile fish in the lake (Bairrington 1999). Commercial fisheries data from 1991 also indicate an increase in CLH numbers captured during operations; over 6,000 CLH were captured and released by commercial fishery operators between March and May in 1991 (CDFW Commercial Fisheries Data). Data from the early 1990s also indicate an increase in zooplankton and macroinvertebrate numbers resulting in increased available forage for CLH (Winder et al. 2010).

Comment [TT13]: Do TFS and Inland Silversides poulations show similar patterns in abundance to CLH? These are not stream spawners, so would reflect more lake conditions for larval/juv rearing, vs. conditions for spawning. Has this been examined?

Comment [TT14]: It is of interest that these high abundance years were drought years (1987-1992) in California

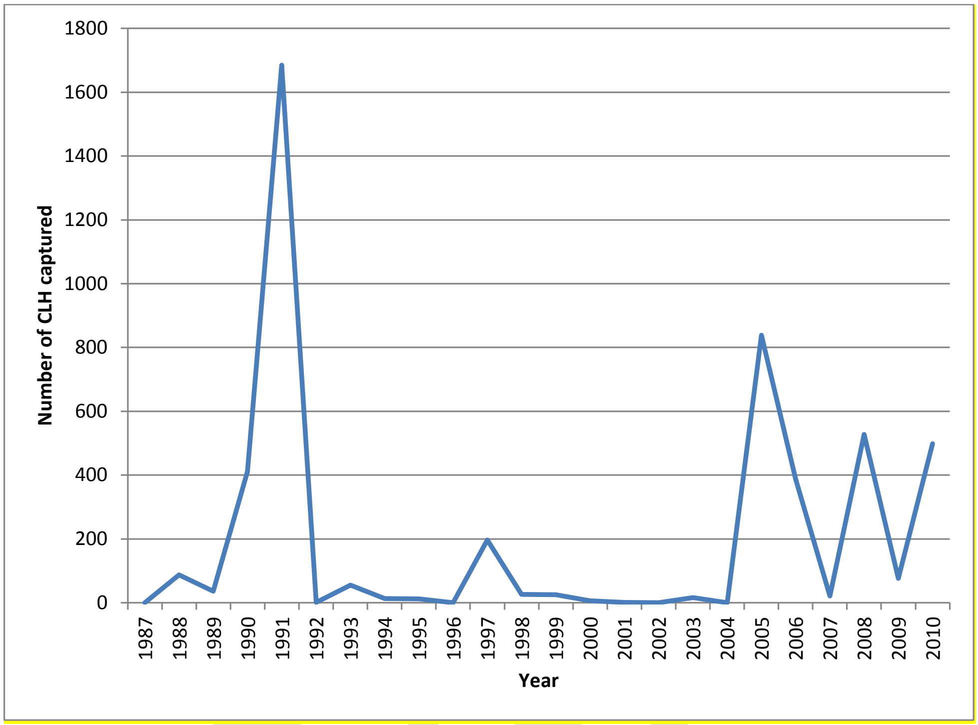

Figure 4. Summary of Clear Lake hitch captured during Lake County Vector Control District beach seine surveys conducted from 1987 to 2010.

The data available to the Department that cover the greatest timeframe come from commercial harvest records for Clear Lake. These data, 1961 to 2001, provide estimates of CLH numbers captured incidentally during operations (Figure 5). Multiple times throughout the past 50 years the number of CLH captured has surpassed 10,000 fish. There are also several years where CLH were almost or entirely absent from sample collections. These data suggest that CLH can sustain a population through multiple years of suppressed spawning or recruitment or both.

Comment [TT15]: Do we have metadata on seining dates,locations or methods that may influence the catch of CLH?

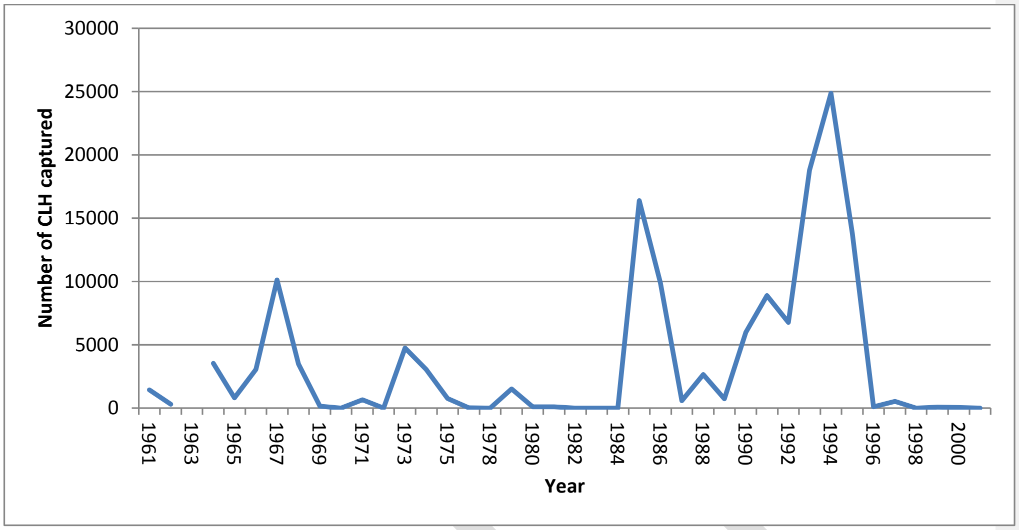

Figure 5. Number of Clear Lake hitch captured incidentally during commercial harvest operations between 1961 and 2001.

In the 1980s, the Department began sampling Clear Lake fishes to assess native and sport fish populations in the lake. Surveys found CLH occupying littoral habitats between April and July each year (Week 1982). The surveys were directed towards littoral zone use and provide no information on CLH outside of those months (Week 1982). An electrofishing survey was completed in April of 1987, and CLH was the most abundant fish sampled at locations around Rattlesnake Island and Clearlake Oaks subdivision; however, only a total of 52 CLH were captured during the survey (CDFG 1988). It must be noted that this sampling was on a very small scale, targeted black crappie (*Pomoxis nigromaculatus*), and occurred in habitats where CLH would likely be found during this time period. Additional spring and fall sampling between 1995 and 2006 found CLH to be the most abundant native fish, but the overall capture numbers were relatively low with a peak catch per unit effort (CPUE) of only 0.087 for juvenile fish in the fall of 2000 and 0.169 for adult fish in the spring of 1999. CPUE's were based on the number of fish caught per minute of electrofishing (Cox 2007). Electrofishing surveys conducted during late June 2007 reported low numbers of CLH recorded during the survey (Rowan 2008). The low numbers of CLH may be attributed to the sampling timeframe in late June. As noted in Cook et al. 1964, CLH were absent from littoral zone sampling following the start of summer. In an effort to reduce impacts to CLH while sampling, the Department's Clear Lake surveys between 2008 and 2012 were all confined to the timeframe of late June and July when CLH numbers are greatly reduced in the littoral zone.

Comment [TT16]: I don't mean to sound critical, but when we're trying to assess the status of a population, not sampling it is not a sound approach. ++

As late as 1972, CLH and other nongame fish were described as comprising the bulk of the Clear Lake fishery (Puckett 1972). The Lake County Mosquito Abatement District conducted surveys between 1961 and 1963 examining the relationship between fish and midges. These surveys identified CLH as the third most abundant fish in the lake.

The majority of CLH were captured in the littoral and profundal zones using gill nets. However, the limnetic zone was not sampled since midges do not occur in this area. A total of 1,229 fish was taken during these surveys (Cook et al. 1964).

Field notes from CDFG biologists in 1955 note CLH runs with large numbers in Kelsey Creek (CDFG 1955). Similar notes from 1956 indicate spawning CLH in Kelsey Creek as numbering in the hundreds and Seigler Creek containing 400 CLH for every 100 feet of stream above the Anderson Brothers ford (CDFG 1956). CLH were the second most abundant fish caught during various gill net surveys in the lake at that time (Lindquist et al. 1943). Surveys conducted between 1938 and 1941, for examination of fish and gnat interactions, describe the runs of Sacramento splittail (*Ptychocheilus grandis*) and CLH as numbering in the tens of thousands (Lindquist et al. 1943). A photograph from 1890 depicts a spawning run so thick that CLH formed a blanket across the creek (Figure 6). Early stories from the area describe fish runs so thick that streams were difficult to ford by horses and wagons, and residents shoveled spawning fish to bring home for hog feed (Rideout 1899). The volume of dead fish found during spawning runs on Clear Lake tributaries created a stench that was intolerable to lakeshore residents (Dill and Cordone 1997). It is not entirely clear if spawning runs such as those depicted in Figure 6 occurred every year or fluctuated based on tributary flows, but it is likely they fluctuated in a similar fashion to what was observed during the past decade of CCCLH spawning surveys. Regardless, the body of evidence lends support for claims of CLH as common and the most abundant fish in Clear Lake during the late nineteenth and early twentieth centuries (Coleman 1930; Jordan and Gilbert 1894).

Figure 6. Photo from 1890s depicting spawning CLH being stranded in Kelsey Creek.

FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE

Present or Threatened Modification or Destruction of Habitat

Wetland Habitat Loss

Wetlands provide critical rearing habitat for juvenile fishes native to Clear Lake (Geary 1978; CDFG 2012). Prior to the arrival of European settlers in the mid-1800s, Clear Lake was surrounded by large tracts of wetlands. Throughout the expansion of European settlements around the lake, the wetland habitat was drained and filled to provide urban and agricultural lands. Currently, the Clear Lake watershed contains over 16,000 acres of land dedicated to agricultural production (Lake County Department of Agriculture 2011; Forsgen Associates Inc. 2012). Comparisons of historical versus current wetland habitat reveal a loss of approximately 85%, from 9,000 acres in 1840 to 1,500 acres by 1977 (Week 1982; Bairrington 1999; Suchanek et al. 2002; ; Lake County Department of Public Works 2003; Giusti 2009; CEPA 2012). Loss of wetland habitat coupled with competition for existing habitat with introduced fishes has led to a decline in available rearing habitat for juvenile CLH (Week 1982).

Spawning Habitat Exclusion and Loss

Dams, Barriers, and Diversions

Cache Creek Dam was constructed at the outlet of Clear Lake in 1915, and Yolo County Flood Control and Water Conservation District (YCFCWCD) manipulates the lake water level several feet seasonally to allow for diversions for irrigation (CDWR 1975). Clear Lake is allowed to fluctuate on a yearly basis, a maximum of 7.56 feet above a mean level plane referred to as the “Rumsey gage” (CDWR 1975). The effects of lake water manipulations on CLH populations have not been quantified. Manipulation of water levels in the Clear Lake watershed likely results in decreased water quality, a reduction in spawning and rearing habitat, and increased risk of predation (Converse et al. 1998; Wetzel 2001; Gafny et al. 2006; Cott et al. 2008; Hudon et al 2009). All of these impacts can lead to the extinction of native species that evolved in lakes free of habitat modifications resulting from impoundment structures (Wetzel 2001). Impounded systems also tend to be dominated by non-native species (Moyle and Light 1996).

CLH spawn in low-gradient tributary streams to Clear Lake. All of the tributary streams to Clear Lake have been altered (Appendix C) to various degrees by dams, barriers, and diversions. Stream alterations can block migratory routes and impeded passage~~decrease stream flows~~ necessary for adults to reach spawning areas and for larval fish to gain access to the lake~~for spawning~~. The result can be direct loss of spawning and rearing habitat, loss of nursery areas or loss of access to these areas, increases in predation, competition from non-native aquatic species, and decreased water quality (Murphy 1948 and 1951; Moyle 2002;). A limited physical habitat analysis survey was conducted in 2013 on Adobe, Kelsey, Manning, Middle, and Scotts creeks. Results of the survey indicate all of the creeks had low Index of Biological Integrity (IBI)

Comment [TT17]: All these factors don't have strong links to CLH decline. What are the physical functional links to each one?

Comment [TT18]: flood control, highway construction, groundwater use and vegetation.

Comment [TT19]: How is this linked in the tributary streams?

Comment [TT20]: How does a physical habitat survey end up with an IBI score? This would be a biological survey.

scores and are either partially or not supportive of aquatic life (Mosley 2013). Examples of alterations to Clear Lake tributaries that have impacted CLH include agricultural irrigation pumps and diversions, aggregate mining activity, flood control structures, road crossings, bridge aprons, and off-highway vehicle (OHV) use (McGinnis and Ringelberg 2008).

Adobe Creek, Highland Creek, Middle Creek, Clover Creek, and Kelsey Creek have experienced a reduction in fish spawning habitat since the installation of dams and increased irrigation (Murphy 1951; Macedo 1994; McGinnis and Ringelberg 2006). A barrier assessment was completed in 2006 for Middle Creek and the Kelsey Creek fish ladder (McGinnis and Ringelberg 2006). The assessment found physical barriers to fish migration were associated with bridge aprons and weirs as well as habitat barriers from historical gravel operations (McGinnis and Ringelberg 2006). The Kelsey Creek fish ladder was found unsuitable for passage of CLH. The jump heights and velocities at the ladder were determined to be too great for CLH (McGinnis and Ringelberg 2006). Spawning observations by CCCLH from 2005 to 2013 witnessed fish stranded below multiple barriers within the watershed (CCCLH 2013).

Many Clear Lake tributaries are no longer used for spawning or have reduced spawning runs as a result of artificial structures that continue to impede spawning migrations (Figure 7). While some operational and physical modifications to these structures have been implemented over the years, they continue to ~~adversely impact~~prevent migrating~~spawning~~ CLH from accessing spawning habitat, especially during dry years when spring stream flows are low.

In preparation of this report, the Department estimated the loss of CLH spawning and rearing habitat due to constructed barriers and impediments within the tributaries to Clear Lake (Figure 7). The barrier assessment determined the approximate locations of barriers and estimated miles of stream habitat as determined from the California Native Diversity Database, CDFW Geographic Information System, CDFW Fish Passage Assessment Database, California GIS street layer, and Google Earth Maps. Using that data, the Department estimated 180 ~~river~~ stream miles were historically available to spawning CLH and that barriers have eliminated or reduced access to ~~greater~~ more than 92% of the historically available spawning habitat. Physical barriers, such as the footings of bridges, low water crossings, dams, pipes, culverts, and water diversions in Kelsey, Scotts, Middle, Clover, and other creeks interrupt or eliminate migration to spawning areas (McGinnis and Ringelberg 2008). Appendix C contains a list of several tributaries and some of their associated barriers.

Comment [TT21]: A reduction in habitat or a reduction in access to habitat – or both? This distinction is critical to the analysis.

Comment [TT22]: Define habitat barriers vs. physical barriers. The Kelsey Creek fish ladder was known not to pass hitch in the 1970s – or is this a different ladder than what was present then?

Comment [TT23]: The channels shown on Figure 7 include segments of many creeks that would not have been used by CLH because they are either too far from the lake or are not low gradient streams. What criteria were used to screen for potential access?

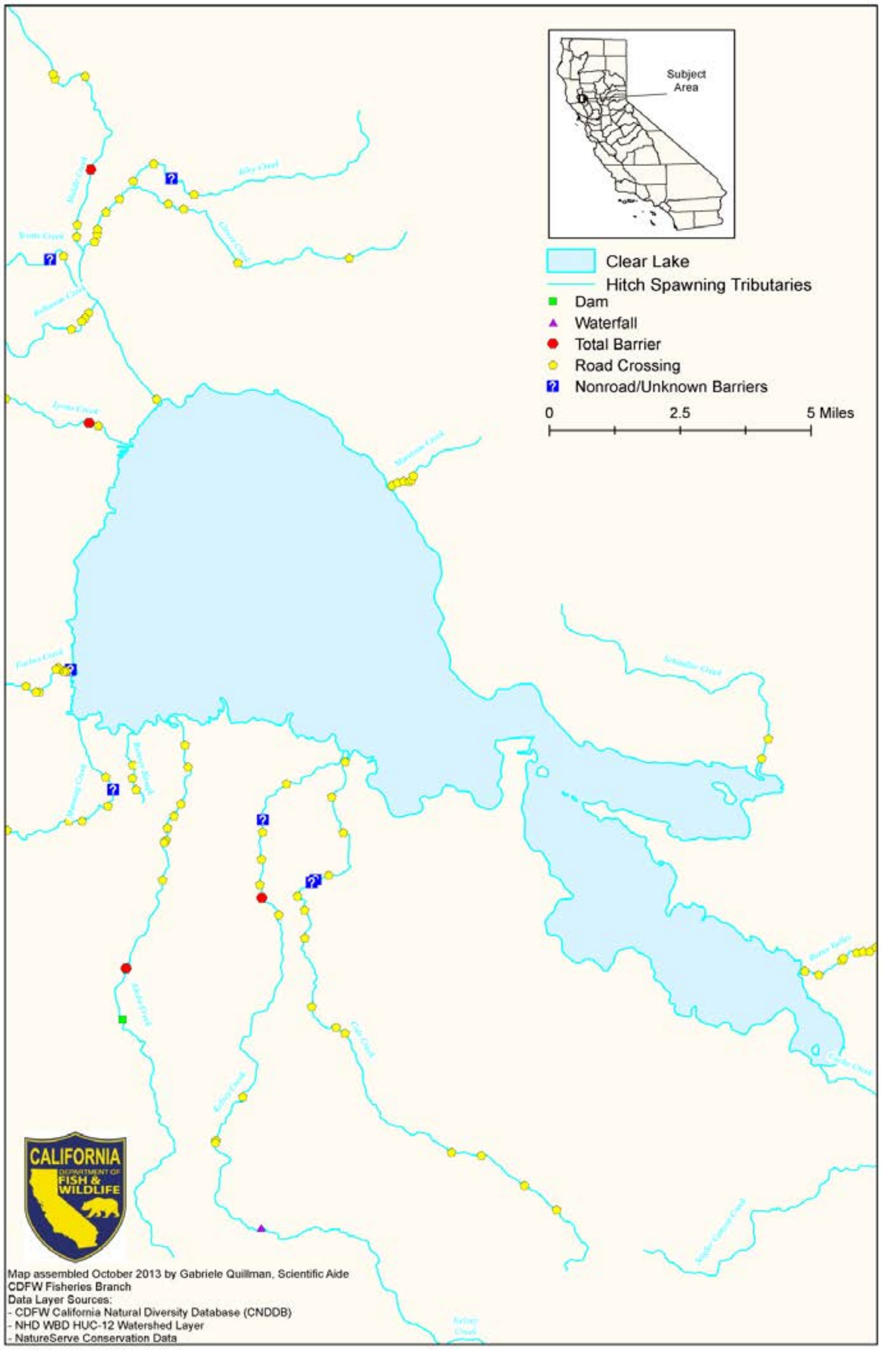

Figure 7. Clear Lake hitch spawning barriers located on tributaries throughout the watershed.

Water is frequently diverted from Clear Lake tributaries, during the CLH spawning season, under riparian rights associated with land ownership in the watershed. These water diversions consist of direct diversion from surface water intake pumps and from shallow off-channel wells that capture ~~groundwater~~ underflow from adjacent channels~~s~~. The primary purpose of water diversions from Clear Lake tributaries is for agricultural production and frost protection. Water diversions for frost protection have been shown to temporarily reduce in-stream flow by as much as 95% (Deitch et al. 2009). Natural flow regimes are thought to favor the success of native fishes over non-native fishes (Marchetti and Moyle 2001). The impact of diversion on CLH spawning tributaries is poorly understood. In some tributaries, water diversion has contributed to early drying of stream reaches and desiccation of CLH eggs masses and newly hatched juveniles (Macedo, R., personal communication, November 25, 2013, unreferenced). Additionally, significant flow reductions can lead to increased water temperatures, reduced available aquatic habitat, altered or decreased biodiversity, increases in non-native species, and alterations to fish assemblages (Marchetti and Moyle 2001; Bunn and Arthington 2002; Bellucci et al. 2011).

The impacts of spawning habitat alterations to CLH may be inferred by the fate of another native Clear Lake fish that required tributaries for spawning; the Clear Lake splittail was last recorded in 1972 (Puckett 1972). The Clear Lake splittail formerly spawned later in the season than did CLH, and the drying up of tributaries contributed to their demise (Moyle 2002). All stream spawners had “declined precipitously” by 1944 (Murphy 1951). Therefore, earlier drying of tributaries by both natural and anthropogenic processes likely impacts the CLH population.

Comment [TT24]: This is a key piece of information that should be used to structure an analysis around flow persistence in the tributaries. It is buried here and should be brought forward as a key concern earlier in the document and revisted here.

Dredging and Mining

Since the first European settlers arrived at Clear Lake and began gravel mining and dredging operations, there have been documented deleterious effects on the watershed (Suchanek et al. 2002). Field notes from CDFG personnel conducting stocking assessments documented Kelsey Creek so loaded with silt from gravel operations that creek visibility was zero (CDFG 1955). Smaller scale mining and dredging in tributary streams has occurred since early settlement and has altered the amount, quality? and distribution of stream gravels (Thompson et al. 2013). In some tributaries, gravel extraction has resulted in the incising and channelizing of the streams and stream level changes by as much as 15 feet (Suchanek et al. 2002; Eutenier, D. April 17, 2013 comment letter). After 1965 about one million metric tons of gravel products per year were removed from the watershed until the partial moratorium on aggregate mining in 1981 (Richerson et al. 1994). Gravel was removed from Clear Lake tributaries to provide road base for new roads created to accommodate the expanding population of the area (Suchanek et al. 2002). Currently, approximately 58 acres in the Clear Lake watershed are used for mining purposes (Forsgren Associates Inc. 2012).

Comment [TT25]: How much is in-stream mining?

Many areas along the tributaries to Clear Lake were channelized in response to frequent flooding during the late winter and early spring (Maclanahan et al. 1972; U.S. Army Corps of Engineers 1974). As a result of gravel extraction and channelization, some areas were covered with riprap or confined by levees to prevent further erosion and flooding. Erosion problems have contributed to sediment entering Clear Lake and providing increased phosphorous loads that impair water quality (Richerson et al. 1994). Gravel extraction results in channelization and down cutting of the stream bank, a decrease in suitable spawning habitat, and increasing flow velocity and amount of coarse material that passes through the system (Brown et al. 1998).

Comment [TT26]: Levees can also result in downcutting by increasing stage and shear stress on the bed during floods.

Water Quality Impacts

Comment [TT27]: This section is large and discusses many attributes related to WQ. I suggest some subheadings as appropriate.

The Clear Lake watershed has seen a significant increase in the amount of contaminants entering the lake over the past 75 years (Richerson et al. 1994). An increase in agriculture and mining, and a shift to an urban environment, has resulted in adverse water quality impacts in the lake (Mioni et al. 2011; California Environmental Protection Agency [CEPA] 2012).

Sediment and Nutrients

Erosion from construction, dredging, mining, agriculture, OHV use, grazing, and urbanization has resulted in increased sediment loads to the Clear Lake watershed (Forsgren Associates Inc. 2012). Increased sediment loads transport nutrient rich soil, particularly phosphorous, into Clear Lake. Increased sediment loads also ~~and~~ reduce spawning habitat quality by increasing substrate “embeddedness” (Mosley 2013). During the late 1990s and early 2000s soil erosion and sedimentation became an increasing problem as existing agricultural lands were converted to vineyards (Forsgren Associates Inc. 2012). From 2002 to 2011 vineyard acreage in the Clear Lake watershed increased from approximately 5,500 acres to 8,000 acres (Lake County Department of Agriculture 2011).

Development and expansion of extensive agriculture in the Clear Lake watershed during the late 1890s until present day reclaimed the lake’s natural wetland filtration system for agricultural use. An increase in agricultural production and a decrease in wetland filtration increased nutrient flows into Clear Lake. Wetland reclamation projects altered the transport of sediment and nutrients, particularly phosphorous, into Clear Lake, resulting in an increase in noxious cyanobacteria blooms that cover the lake in warmer months (Suchanek et al. 2002). As a result of continued water quality issues, Clear Lake was added to the Clean Water Act Section 303(d) list of impaired water bodies in 1988 (CEPA 2010 and 2012). In recent years, noxious cyanobacteria blooms have at a minimum remained constant and may have increased (CEPA 2012).

Food Web

Cyanobacteria blooms have occurred at Clear Lake since the mid-1900s. Studies indicate an increase in phosphorous was the driver behind water quality impairments and noxious cyanobacteria blooms (Horne 1975; Richerson et al. 1994; CEPA 2012). The blooms originally consisted primarily of *Microcystis*, but in recent years the blooms have been attributed to both *Microcystis* and *Lyngbya.* These taxa represent both non-nitrogen fixing (*Microcystis*) and nitrogen fixing (*Lyngbya*) cyanobacteria and raise concerns that both phosphorous and nitrogen entering the lake need to be controlled

(Mioni et al. 2011; CEPA 2012). Cyanobacteria blooms have the ability to both directly and indirectly impact CLH by direct interference with the growth of *Daphnia*, a limnetic organism that is a food source for adult CLH, and interference with food web efficiency. No studies have been conducted at Clear Lake to quantify the impact of cyanobacteria blooms on the ecosystem, but studies conducted at other water bodies with varying degrees of cyanobacteria blooms provide information on their impacts to the aquatic environment. Cyanobacteria blooms reduce the amount of light penetration in the water column and cause a reduction in producers that are unable to reposition themselves to gain more light (Havens 2008). Organisms such as epiphyton, benthic algae, and rooted vascular plants have a reduced ability to function in the ecosystem as a result of cyanobacteria blooms. As the bacteria alter the nutrient cycle of the lake they replace the producers in space and mass. The expanding bacteria begin to deplete CO_2 from the water body, which increases pH and reduces growth of other producers (Havens 2008). The decreased CO_2 and increased pH can create surface scums and result in mortality of fishes, including CLH. In the summer of 1969, a large fish die off, due to heavy cyanobacteria growth and low oxygen levels, was reported at Clear Lake. An estimated 170,000 fish died, consisting primarily of carp, CLH, and blackfish (CDFG News Release 1969). Sub lethal and lethal effects of toxins released during cyanobacteria blooms are also seen in fish and their associated food web (Havens 2008).

Comment [TT28]: Some parallels with the Delta on food web dynamics here?

On September 19, 2007, the U.S. Environmental Protection Agency (EPA) approved a control program as a nutrient Total Maximum Daily Load (TMDL) for Clear Lake with the goal of reducing point and non-point source phosphorous entering the lake (CEPA 2012). Sources for phosphorous entering the lake include agricultural and urban runoff, timber harvest, road maintenance, construction, gravel mining, dredging, and fire. Additional amounts of nutrients from home fertilizers, marijuana grows, sewer, and septic systems cannot be quantified.

Pesticides and Herbicides

To allow for increased yields on agricultural land and to prevent nuisance insect species around the lake, pesticides became commonplace during the early and mid-1900s. For many decades the Clear Lake gnat, a primary food source for CLH, was targeted with pesticides to reduce its population. Between 1949 and 1957, the Clear Lake gnat was targeted with the pesticide dichlorodiphenyldichloroethane (DDD). During these years it is estimated that 99 percent of the gnat larvae in the lake were killed. Concentrations of DDD were magnitudes higher in invertebrates, fish, and birds than in the surrounding water in which they were found (Lindquist and Roth 1950; Rudd 1964). Sampling conducted during the late 1950s identified CLH, as well as other fish species, contaminated with DDD (Hunt and Bischoff 1960). Contamination levels ranged from 5.27 to 115 parts per million (ppm) for edible flesh of sampled fishes (Hunt and Bischoff 1960). CLH were at the lower level of DDD contamination for Clear Lake fishes at 10.9 to 28.1 ppm for edible flesh content (Hunt and Bischoff 1960). The results of DDD in the Clear Lake watershed resulted in the first major ecological disaster at the lake and the first records of pesticide bioaccumulation in the wildlife of the lake (Suchanek et al. 2002).

Following the resurgence of gnat populations in response to growing resistance to DDD, two additional measures were taken to reduce the gnat population. Gnat eggs were targeted with a petroleum product, and adult gnats were targeted at roosting locations with Malathion. Additional applications of methyl parathion were also made in 1962 (Suchanek et al. 2002). Clear Lake gnats are still present at the lake, but populations are significantly reduced from historical levels. The likely cause of the reduced population of gnats is introduced fishes, primarily inland silversides (Suchanek et al. 2002). In 2010 and 2012 Clear Lake gnat populations reached levels not seen in decades. These gnat population booms appeared to coincide with years of low population levels of inland silversides (Scott, J. 2013 personal communication, Aug 1, 2013, unreferenced). Qualitative sampling data on CLH does not allow for a direct comparison of CLH numbers in years with increases in the gnat population.

In recent years, two herbicides, Komeen™ (copper sulfate) and SONAR™ (fluridone), have been used extensively to manage the *Hydrilla verticillata* infestation at the lake. Applied concentrations of Komeen™ do not kill fish directly; however, the impacts to macroinvertebrates may indirectly impact CLH populations (Bairrington 1999). These systemic herbicides also pose a threat to non-target vascular aquatic plants, such as tules and submerged vegetation, which juvenile CLH require for rearing habitat. As noted previously, there has already been a significant reduction in wetland habitat around the lake, and any additional reductions would further limit the amount of habitat available for CLH. Initial studies indicate a reduction in tule habitat following SONAR™ applications (Bairrington 1999). Environmental monitoring of eradication activities in 1996 and 1997 found that invertebrate species declined within the treatment area but rebounded quickly following the toxicity decay of the herbicide (Bairrington 1999). Post-treatment electrofishing surveys noted an increase in the number and abundance of fish species (Bairrington 1999).

Mercury

Mining operations within the watershed contributed to sulphur and mercury contamination in Clear Lake. The Sulphur Bank Mercury Mine began operations in 1865 and ended in 1957 (Osleger et al. 2008; Giusti 2009) Originally the mine focused on extracting sulphur, but as operations continued into the late 1920s and the sulphur was found to be contaminated with mercury sulfide, operations switched to extracting mercury from the large-scale open-pit mine (Giusti 2009). As a result of contamination, the mine was classified as an EPA Superfund Site in 1990 (Suchanek et al. 1993). The mine is thought to have contaminated the lake with both mercury and arsenic (Suchanek et al. 1993). Studies have found the mercury concentrations in sediment to be high (over 400 ppm) in the vicinity of the mine, decreasing as distance from the mine increases (Suchanek et al. 2002). The mine continues to produce low pH acid mine drainage that delivers sulfate to the lake. Over the past decade, the EPA has taken several actions to remediate contamination from the mine. These include erosion control measures, removal of contaminated soil, storm water diversion, and well capping (U.S. Environmental Protection Agency 2012).

During the 1970s, elevated concentrations of mercury were found in the fish of the lake (Curtis 1977). Mercury contamination can lead to significant impacts to the reproductive success of fishes and can result in reduced brain function, altered size and function of gonads and reduced gamete production (Sandheinrich and Miller 2006; Crump and Trudeau 2009). In 2003, a mercury TMDL was developed for Clear Lake to reduce methylmercury in fish by reducing overall mercury loads to Clear Lake (CEPA 2010). Levels of mercury found in fish, including CLH, are between 0.06 and 0.32 µg/g (CEPA 2002). Concentrations of mercury present in Clear Lake fishes have resulted in health advisories on their consumption, but are below acute toxicity thresholds (Harnly et al. 1997). Mercury levels are close to or within the effect thresholds for reproduction and growth for fathead minnow (0.32 to 0.62 µg/g) and rainbow trout (National Oceanic and Atmospheric Administration [NOAA] 2011). Concentrations with no effect on rainbow trout growth and development are 0.02 to 0.09 µg/g (NOAA 2011). Lacking specific studies on CLH, based on surrogate effect levels for fathead minnows and rainbow trout, it is reasonable to suspect that CLH may be experiencing sub lethal chronic and reproductive effects from mercury contamination.

Overexploitation

Commercial Harvest

Commercial fish harvest at Clear Lake ~~has been~~ occurred~~ing~~ from ~~since~~ the early 1900 through 2001. ~~s.~~ Harvested fish were distributed to fish markets in California for sale for human consumption and animal feed. Prior to 1941, the majority of commercial operations centered on harvesting catfish (*Ictalurus* or *Ameiurus* spp.) from the lake. Although exact numbers are unavailable, it is likely that large numbers of catfish were taken during this period (Bairrington 1999). In 1942 commercial harvest of catfish was banned at Clear Lake. Beginning in the 1930s commercial harvest focused on Sacramento blackfish (*Orthodon microlepidotus*), a native species, and common carp (*Cyprinus carpio*), a non-native species. From 1932 to 1962 the annual average catch rate was 295,000 pounds for the commercial fishery (Bairrington 1999). A ratio of 1.33:1 for blackfish to carp was the average during commercial fishing operations (Bairrington 1999). In 1976 the only recorded capture and sale of CLH for commercial purposes was submitted to the Department, a total of 1,550 pounds was reported captured and sold at market that year (CDFW Commercial Fisheries Data). This is the only instance in the records of CLH being captured for commercial sale, primarily due to lack of interest and low sale price for the species (CDFW Commercial Fisheries Data). By 1960 commercial fishing operators were required to count and release all bycatch from commercial operations. CLH were found in large numbers some years and were recorded and returned to the lake when captured (Figure 5; CDFW Commercial Fisheries Data). The Department has received no commercial permit applications for operations on Clear Lake over the past several years. The lack of permit applications indicates that at this time commercial fishing operations at Clear Lake have ceased (CDFW Commercial Fishing Permit Data).

Cultural Harvest

Clear Lake hitch are culturally significant to several Pomo tribes that inhabit the Clear Lake watershed. Two Pomo tribes fought a war over Kelsey Creek and its important CLH supply (Barrett 1906; Kniffen 1939). Historically, large runs of CLH provided a staple food source for the local tribes (RREC 2011). During spawning runs, CLH were captured by constructing a series of dams in the creeks from which the fish were then scooped with baskets. The fish were cured to provide a food source throughout the year (Kniffen 1939). Historical accounts from tribal members speak of CLH being easy to find as they spawned in large numbers in the tributaries to the lake (Scotts Valley Band of Pomo Indians historical accounts 2013). There are no estimates of the number of CLH that were taken for cultural harvest during any specific timeframe. However, an account from a tribal member indicates that, historically, a single family may have taken a couple thousand fish during the spawning runs (Big Valley EPA 2013). Tribal accounts indicate the harvest of CLH continued until the decline in spawning runs in the mid-1980s (Big Valley EPA 2013). Prior to designation of CLH as a candidate species for listing, regulations in the Clear Lake watershed allowed for the harvest of CLH in spawning tributaries by hand or hand-held dip net. In 2013 the Department issued CESA Memoranda of Understanding (Fish and Game Code, § 2081(a)) to three tribes to authorize collection of CLH for scientific research and public education (Kratville, D. personal communication, October 7, 2013, unreferenced).

Predation and Competition

Non-native fish introductions into Clear Lake date back as far as the late 1800s (Dill and Cordone 1997). Prior to the introduction of non-native fish species, between 12 and 14 native fish species occupied Clear Lake (Bairrington 1999; Moyle 2002; Thompson et al. 2013). Currently, approximately ten native species and 20 non-native species inhabit the lake (Bairrington1999; Thompson et al. 2013). Over the past 100 years one native species, thicktail chub (*Gila crassicauda*), has gone extinct and two native species, hardhead (*Mylopharodon concephalus*), and Clear Lake splittail, have been extirpated from the lake. Sacramento perch (*Archoplites interruptus*), has not been captured in sampling efforts since 1996 (Bairrington 1999; CDFW Commercial Fisheries Data; Thompson et al. 2013). The majority of non-native species introductions have been conducted by the Department, various local agencies, and angling groups in an effort to increase sport fishing opportunities. Introductions of fish at Clear Lake have been warmwater sport fish (black bass, sunfish (*Lepomis* spp.), catfish, etc.) or forage species for piscivorous sport fish. The Department has not stocked fish in Clear Lake in the past decade. The four fish species listed below were introduced without authorization from the Department (Bairrington 1999; Rowan J. personal communication, October 10, 2013, unreferenced). Inland silverside, threadfin shad, smallmouth bass (*Micropterus dolomieu*), and pumpkinseed (*Lepomis gibbosus*) were introduced to provide forage for other game fishes, provide Clear Lake gnat control, or as part of a new sport fishery (Anderson et al. 1986; Dill and Cordone 1997; Bairrington 1999). Non-native game fishes comprise nearly 100 percent of the sport catch from the lake. Incidental captures of native species occur infrequently and are rarely recorded during creel and tournament surveys (Rowan J. personal communication, October 10, 2013, unreferenced).

Comment [TT29]: I found no hardhead in the stream surveys conducted in the basin in 1975-76.

Comment [TT30]: But what's happened to the black bass population over the past 10 years – are their more, large bass compared to pre-2000?

Non-native fish introductions can have significant impacts on native fish species. Inland silverside and threadfin shad are thought to compete directly with CLH for food resources (Geary and Moyle 1980; Anderson et al. 1986; Bairrington 1999). All three species are limnetic foragers that rely on macroinvertebrates for food. There are no direct comparisons, but years with declines in threadfin shad and inland silverside are thought to coincide with increases in CLH numbers, and years with decreased threadfin shad and inland silverside result in increased young of year recruitment for other native and non-native species (Rowan J. personal communication, October 10, 2013, unreferenced). Competition for juvenile rearing habitat has increased with the reduction in wetland habitat and increase in non-native fish species. Rearing habitat is essential for CLH recruitment to any year class. A reduction in recruitment leads to a decrease in spawning adults in the following years. A species with highly fluctuating population trends, such as CLH, is particularly vulnerable to population level impacts in years with reduced recruitment. Piscivorous fish species such as largemouth bass (*Micropterus salmoides*) prey directly on both juvenile and adult CLH. Although no comprehensive diet studies have been done, incidental data indicate that CLH are found in the stomachs of piscivorous species in the lake (Moyle et al. in progress). Omnivorous species such as catfish (*Ameiurus* spp.) are known to prey on various life stages of native fishes. It is suggested that the introduction of catfish to Clear Lake may have played a role in the decline of native fish species (Dill and Cordone 1997). The introduction of catfish was described, by Captain J.D. Dondero of the Division of Fish and Game, as having solved the problem of large spawning runs of fish dying in tributaries to Clear Lake and that the population of nongame fish diminished following their introduction (Dill and Cordone 1997). Jordan and Gilbert (1894) also describe catfish as being destructive to the spawn of other species. The rates at which CLH are consumed in relation to other prey species and the amount of CLH consumed are unknown. It is likely that during years when alternative prey abundance is low, CLH predation increases (Eagles-Smith et al. 2008).

Comment [TT31]: Could this be done for this report?

Comment [TT32]: This statement needs a reference.

Comment [TT33]: Are we looking at a species similar to splittail in the Central Valley, where it goes along at low levels in many years, then has a good spawn and really booms for several years, before returning to background numbers? This is the key question – is it a boom and bust fish or something different.

Disease and Parasites

Disease outbreaks in fishes have been known to occur at Clear Lake. The outbreaks are primarily koi herpes virus (KHV) and it affects introduced carp and goldfish. Native minnows, including CLH, show no effects from KHV. Fish fungi (*Saprolegnia* spp.) have been observed on fishes captured in Clear Lake and results from physical injury or infection. CLH are susceptible to fish fungi but it is not readily observed in captured fish. All fish in Clear Lake are susceptible to anchor worms (*Lernaea* spp.) and heavy infestations can lead to mortality. No CLH with heavy anchor worm infestations have been observed during CDFW fishery surveys at Clear Lake (Rowan J. personal communication, October 10, 2013, unreferenced). The Big Valley Rancheria Band of Pomo Indians has documented light loads of anchor worms occurring on CLH (Big Valley Rancheria 2012 and 2013).

Other Natural Occurrences or Human Related Activities

Climate Change

It is likely that native fishes in California will be vulnerable to physical and chemical changes as a result of climate change (Moyle et al. 2012). Research has shown that the annual mean temperature in North America has increased between 1955 and 2005 and is predicted to continue increasing in the future (Field et al. 1999; Hayhoe et al. 2004); however, it varies across North America, is more pronounced in spring and winter, and has affected daily minimum temperatures more than daily maximum temperatures (Field et al. 2007). In general, climate change models for California indicate an increase in overall air temperature, decreased and warmer rainfall, and an increase in overall water temperatures (California Climate Change Center [CCCC] 2012). Cold storms are expected to decrease, giving way to warmer storms that create earlier run-off and less water storage capabilities (Field et al. 1999; Hayhoe et al. 2004; CCCC 2012). Climate change in the Clear Lake watershed is likely to cause some changes to the interannual variability in rainfall. The change in rainfall variability would likely increase the occurrence of drought and flood years (Clear Lake Integrated Watershed Management Plan [CLIWMP] 2010). Expected climate change impacts to California and the Clear Lake watershed will be significant during annual CLH spawning cycles. CLH require winter and spring storms that provide suitable spawning flows in the tributaries of Clear Lake. A shift in timing, temperature, and amount of runoff could significantly impact the ability of CLH to successfully spawn. A climate driven change in the Clear Lake watershed could result in the loss of spawning habitat, reduced access to spawning habitat, stranding of spawning and juvenile fish, and egg desiccation.

A report on the projected effects of climate on California freshwater fishes, prepared for the California Energy Commission's California Climate Change Center, determined CLH to be critically vulnerable to impacts from climate change (Moyle et al. 2012). The report evaluated criteria such as population size, population trends, range, lifespan, and vulnerability to stochastic events to identify the degree of vulnerability of each fish species. The Intergovernmental Panel on Climate Change has stated that of all ecosystems, freshwater ecosystems will have the highest proportion of species threatened with extinction due to climate change (Kundzewicz et al. 2007). Freshwater lake species are more susceptible to extirpation because they are unable to emigrate should habitat changes occur (CA Natural Resources Agency 2009).

Recreational Activities

The natural resources of the Clear Lake watershed are a tremendous recreational resource for residents and visitors to Lake County. As the largest freshwater lake wholly in California, with opportunities for multiple aquatic recreational activities, the lake receives tens of thousands of visitors per year. According to 2008 data acquired from Lake County quagga mussel (*Dreissena rostriformis*) inspection sticker application forms; there were 11,230 boats that visited the lake that year. Jet skis and pleasure boats accounted for 41 percent of the boating activity at the lake (CLIWMP 2010).

Permanent structures, associated with boat docks, boat ramps, and swimming beaches, have reduced littoral zone habitat around the lake. These structures require clearing of littoral zone habitat to maintain access for recreational boaters and swimmers. It is estimated that there are over 600 private boat docks and boat ramps on the lake shoreline. In addition to reducing littoral zone habitat these structures provide additional habitat for non-native sport fish, such as largemouth bass, that prey on CLH.

Recreational and tournament angling generate a significant amount of the activity in the Clear Lake aquatic environment. In 2008, 18 percent of all boats entering the lake identified their recreational activity as angling (CLIWMP 2010). In a single year creel survey conducted in 1988 by the Department, CLH comprised two percent of the recreational sport catch (Macedo 1991).

The number of angling tournaments, primarily targeting largemouth bass, has drastically increased over the last three decades in response to Clear Lake's reputation as a premiere sport fishery. Between 2001 and 2008 the number of angling tournaments increased from 98 to 208 per year (Rowan J. personal communication, October 10, 2013, unreferenced). It is believed that recreational and tournament anglers' capture CLH incidentally while angling. The impact to CLH from the increase in angling tournaments is unknown, but is likely negligible because tournament anglers do not target CLH and bycatch would be an inadvertent snagging on an artificial lure, a rare occurrence.

REGULATORY AND LISTING STATUS

Federal

On September 25, 2012 the Center for Biological Diversity petitioned the U.S. Fish and Wildlife Service (USFWS) to list CLH as endangered or threatened under the federal Endangered Species Act (ESA). As of the publication of this status review there has been no action taken on the petition by USFWS.

The U.S. Forest Service (USFS) lists CLH as a sensitive species. USFS sensitive species are those plant and animal species identified by a regional forester that are not listed or proposed for listing under the federal ESA for which population viability is a concern.

State

The Department designated CLH as a Species of Special Concern (SSC) in 1994. A SSC is a species, subspecies, or distinct population of an animal native to California that currently satisfies one or more of the following (not necessarily mutually exclusive) criteria:

- Is extirpated from the State or, in the case of birds, in its primary seasonal or breeding role;
- Is listed as Federally, but not State, threatened or endangered;
- Is experiencing, or formerly experienced, serious (noncyclical) population declines or range restrictions (not reversed) that, if continued or resumed, could qualify it for State threatened or endangered status;
- Has naturally small populations exhibiting high susceptibility to risk from any factor(s) that if realized, could lead to declines that would qualify it for State threatened or endangered status.

The intent of designating a species as a SSC is to:

- Focus attention on animals at conservation risk by the Department, other State, local and Federal government entities, regulators, land managers, planners, consulting biologists, and others;
- Stimulate research on poorly known species;
- Achieve conservation and recovery of these animals before they meet California Endangered Species Act criteria for listing as threatened or endangered.

There are no provisions in the Fish and Game Code that specifically prohibit take of CLH or protect its habitat.

Other Rankings

The American Fisheries Society ranks CLH as vulnerable, meaning the taxon is in imminent danger of becoming threatened throughout all or a significant portion of its range (Jelks et al. 2011).

EXISTING MANAGEMENT EFFORTS

Resource Management Plans

An increase in resource management efforts throughout the Clear Lake watershed has benefitted CLH, and several plans and strategies are in place to assist in reducing the threats to CLH.

The Clear Lake Integrated Watershed Management Plan (2010) was prepared by two resource conservation districts and provides details of past and current resource management within the Clear Lake watershed. The plan seeks to identify opportunities to improve and protect the health and function of the watershed and identifies specific implementation actions to improve and protect watershed resources. Recommended actions are prioritized on a timeline. As funding allows, implementation of these actions will be undertaken by various non-governmental organizations (NGO) and local, state, and federal agencies that share an interest in promoting the health and function of the watershed. Multiple action items listed in the plan would benefit CLH and their habitats. Several tributaries to Clear Lake have completed Watershed Assessment plans as well. These include Kelsey Creek Watershed Assessment (2010), Middle Creek Watershed Assessment (2010), and Scotts Creek Watershed Assessment (2010). These plans were all completed by Lake County Water Resources Division for West and East Lake Resource Conservation Districts.

With adoption of the TMDL for Clear Lake, several projects are in process or have been completed to reduce the amount of phosphorous entering the lake. Specifically, the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project seeks to reduce the amount of phosphorous entering the lake by 40 percent (CEPA 2012). Lake County and the California Department of Transportation have implemented several best management practices (BMPs) for managing storm water runoff to reduce the amount of phosphorous and other contaminants that enter the lake. Both the USFS and Bureau of Land Management (BLM) have undertaken projects to reduce nutrients entering the lake as a result of off-highway vehicles and other land uses. BLM, in coordination with Scotts Valley Band of Pomo Indians, received a grant to implement the Eightmile Valley Sediment Reduction and Habitat Enhancement Project Design. Controlling sediment from Eightmile Valley is crucial to controlling the amount of nutrients entering the lake. Many of these projects are still in design or early implementation and it will be several years before changes in nutrient loads within the lake can be observed and studied.

The adverse effects from an increase in sedimentation as a result of conversion of various types of agricultural land to vineyard resulted in the formation of the Erosion Prevention and Education Committee (EPEC). The EPEC is a group of county agencies and private entities that provide educational outreach regarding erosion control and water quality protection. In addition, the Lake County Grading Ordinance was approved in 2007 and requires grading permits and Erosion Control and Sediment Detention Plans for projects with the probability of resulting in increased sedimentation (Forsgren Associates, Inc. 2012).

Concerns over the reduction in habitat quality resulting from gravel mining prompted Lake County to adopt an Aggregate Resources Management Plan in 1994. The plan called for a moratorium on gravel mining in several tributaries to Clear Lake. The implementation of gravel mining regulations has resulted in reduced in-stream and bank erosion and increased riparian habitat along the creeks (CEPA 2008).

To prevent further destruction of wetland habitat along the lake shoreline, in 2000 and 2003 amendments, Lake County adopted Section 23-15 of the Clear Lake Shoreline Ordinance that prohibits the destruction of woody species and tules. In addition to the ordinance, there is a no net-loss requirement for commercial, resort, and public properties that seek to clear vegetation from areas along the shoreline (CLIWMP 2010).

RREC produced an Adaptive Management Plan (HAMP) for the Clear Lake Hitch, *Lavinia exilicauda chi* (RREC 2011). The HAMP describes the current status of CLH habitat and problems for habitat recovery. The habitat assessments are included in a management plan that identifies action items, issues of uncertainty, stakeholder involvement, sustainability, and plan amendment procedures. The RREC is currently in the process of revising the HAMP.

The Department has created or approved two Conceptual Area Protection Plans (CAPP) for the Clear Lake Watershed. The creation of a CAPP for an area allows the Department, as well as local and federal agencies, and NGOs, to apply for land acquisition funding from the Wildlife Conservation Board. The first, the Clear Lake CAPP, was approved in 2002 and addresses land acquisition needs in the area of Middle Creek. The plan focuses on protecting wetland and riparian habitat for the benefit of natural resources. The second CAPP, Big Valley Wetlands, is currently in development with possible approval in 2014. The Big Valley Wetlands CAPP focuses on land acquisitions in the western portion of the Clear Lake watershed for the purpose of protecting wetland and riparian habitat. Both CAPP's will benefit CLH in the protection of riparian and wetland habitat critical for spawning and rearing CLH. Land acquisitions that seek to protect and restore existing CLH habitat should create a stable environment for CLH populations.

The Department published a Clear Lake Fishery Management Plan in 1999 (Bairrington 1999). The plan provides a review of past and present biological information for Clear Lake. The primary focus of the plan is to maintain fishery resources of the lake and enhance recreational fishing opportunities. The plan identifies areas of controversy between various stakeholder groups in the watershed, and states that "adapting to the biological and social settings at Clear Lake involves a variety of compromises between these groups and the non-angling groups who wish to ensure the well-being of Clear Lake's native fish species." The plan identifies the decline in native fish species at Clear Lake as being detrimental both socially and biologically. No specific guidelines are given for addressing impacts to native species, but restoration of spawning habitat and natural flow regimes are discussed as critical for native species survival.

Monitoring and Research

In 2013 the Department attempted to conduct a status assessment of the CLH population present in Cole and Kelsey creeks. Sampling produced too few fish to facilitate a statistically valid mark and recapture study. As a result, a population estimate was not completed. The Department has proposed additional funding in 2014 to begin a multi-year mark-recapture study to determine a statistically valid population estimate or index of CLH.

The CCCLH has been conducting annual spawning observations since 2005. A simple protocol is followed that identifies the time, observer, and number of CLH observed. Volunteers have put in hundreds of hours monitoring CLH spawning runs during this time period. Although not quantitative, the surveys provide a glimpse into the number of spawning CLH and how successful spawning is in a particular season. Results of these surveys are included in Appendices A and B and summarized in Section 4.1 and 4.2 above.

Habitat Restoration Projects

In recent years, local, state, and federal agencies have begun implementing actions to aid in the protection and restoration of Clear Lake wetland habitat. The Middle Creek Flood Damage Reduction and Ecosystem Restoration Project will restore up to 1,400 acres of wetland habitat around Middle Creek and Rodman Slough, essentially doubling the amount of existing wetland habitat in the watershed (CLIWMP 2010).

Impacts of Existing Management Efforts

To date, existing management efforts have focused on CLH habitat restoration in the watershed. Wetland restoration projects that would significantly benefit CLH have been proposed and have been or will be implemented through the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project and the two CAPPs that cover portions of the watershed. Wetland restoration is expected to aid in increasing spawning success and juvenile recruitment into the population. Increased wetland acreage would enhance filtration of tributary waters resulting in decreased amounts of nutrients entering the lake and an increase in the water table. The increased water table will help maintain surface flow in tributaries, resulting in suitable spawning habitat being maintained throughout the spawning season. The Clear Lake Shoreline Ordinance has resulted in a "no net loss" of shoreline wetland habitat around the lake since its enactment. However, because these wetland restoration projects are either recent or yet to be implemented, a thorough assessment of direct and indirect impacts to CLH populations cannot be included in this status review.

Comment [TT34]: Linkages to cause/effect are unclear. Increased groundwater elevations would only help to maintain surface flows if they were located at sites where flows are limiting access. Seems that a different approach to management of the lake level would do the same thing.

Establishment of TMDLs for mercury and nutrients has led to a reduction in inputs and an increase in monitoring efforts in the Clear Lake watershed. Past and future steps by the federal government will reduce mercury contamination resulting from the Sulphur Bank Mercury Mine. Most of the identified initial actions for cleanup have been implemented. The focus will now be on two long-term projects to address waste pile and lake sediment cleanup, which should result in significant reductions in mercury contamination in the watershed. Nutrient loads entering Clear Lake have been addressed by several measures including wetland restoration, BMPs for storm water runoff, and erosion control measures. Many of these projects are in the early stages of implementation, and a thorough assessment of impacts to CLH is yet to be been completed. It is likely that reduced mercury and nutrient loads in Clear Lake will result in a significant benefit to CLH.

SCIENTIFIC DETERMINATIONS REGARDING THE STATUS OF CLEAR LAKE HITCH IN CALIFORNIA

CESA directs the Department to prepare this report regarding the status of CLH based upon the best scientific information available to the Department. CESA's implementing regulations identify key factors that are relevant to the Department's analyses. Specifically, a "species shall be listed as endangered or threatened ... if the Commission determines that its continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities." (Cal. Code Regs., tit. 14, § 670.1 (i)(1)(A)).

The definitions of endangered and threatened species in the Fish and Game Code provide guidance to the Department's scientific determination. An endangered species under CESA is one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, over exploitation, predation, competition, or disease." (Fish & G. Code, § 2062). A threatened species under CESA is one "that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [CESA]." (*Id.*, § 2067).

The preceding sections of this status review report describe the best scientific information available to the Department, with respect to the key factors identified in the regulations. The Department's scientific determinations regarding these factors as peer review begins are summarized below.

Present or Threatened Modification or Destruction of Habitat

Beginning with the arrival of European settlers in the mid-1800s, alterations to habitats in the watershed have directly impacted the ability of CLH to survive. Habitats necessary for both spawning and rearing have been reduced or severely decreased in suitability in the past century resulting in an observable decrease in the overall abundance of CLH and its habitat. Spawning tributaries have been physically altered by a combination of dams, diversions, and mining operations that have altered the course and timing of spring flows and the amount and quality of spawning habitat available for CLH. Dams create barriers to CLH passage that reduce the amount of available spawning habitat while altering the natural flow regime of tributaries. Water diversions in tributaries have resulted in decreased flows during critical spawning migrations for CLH. Loss of eggs, juvenile, and adult fish due to desiccation and stranding from water diversions are likely a significant impact on CLH populations. Gravel mining removed large amounts of spawning substrate during peak operations in the mid-1900s. Spawning substrate has been restored slowly after gravel mining was discontinued in the majority of the watershed. Water quality impacts to the watershed have resulted in Clear Lake being listed as an impaired water body and led to the establishment of TMDLs for both mercury and nutrients for the lake. It is unclear to what extent the water quality impacts are affecting CLH populations. The Department considers modification and destruction of habitat a significant threat to the continued existence of CLH.

Overexploitation

Harvest of CLH has occurred by both Pomo tribes and commercial fishery operators at Clear Lake. Historic accounts from tribal members indicate that significant amounts of CLH were harvested during spawning runs. In recent years, the amount of harvest by the Pomo has been minimal, and the CLH are used strictly for educational and cultural reasons. Since the early 1990s commercial fishery operations have been required to return all CLH captured to the lake. Prior to that, CLH had not been regularly harvested for sale. It is likely that incidental catch during commercial harvest operations resulted in mortality of some CLH. However, there is no information indicating that overexploitation threatens the continued existence of CLH.

Predation

Direct predation of CLH by fish, birds, and mammals is known to occur in suitable habitats within the watershed. Spawning runs are vulnerable to predation from birds and mammals as fish migrate upstream and become stranded at various locations. Stranding occurs both naturally and as a result of habitat modifications described above. Non-native fishes prey directly on different life stages of CLH in all occupied habitats. CLH have been found during stomach content analyses of largemouth bass. Incidental observations indicate that largemouth bass may target CLH as the CLH stage at the entrance to ascend spawning tributaries in early spring. Other introduced fishes, such as catfish species, also prey on CLH. A detailed diet study on introduced fishes is necessary to determine the extent of predation from introduced fishes. There is scientific information suggesting that predation by introduced fishes threatens the continued existence of CLH.

Competition

The extent of impacts on CLH from competition with other aquatic species is poorly understood. Studies conducted on diet analysis of CLH indicate that there is competition between CLH and other macroinvertebrate consuming fish species, primarily inland silversides and threadfin shad. Observations by Department biologists and others indicate that CLH populations fluctuate on alternating cycles with inland silverside populations. CLH directly compete with other native and non-native fishes for juvenile rearing habitat. The majority of fishes in Clear Lake utilize near shore wetland habitat for juvenile rearing. With the decrease in wetland habitat over the past century, there is increased competition for the remaining habitat. Although no formal studies have been completed, it is likely that competition for resources threatens the continued existence of CLH.

Comment [TT35]: Let's be clear on what we're calling this habitat – Is this inundated shallow water with emergent vegetation? Does it meet the definition of a wetland for regulatory purposes or is it permanently inundated shallow water habitat?

Disease

There are no known diseases that are significant threats to the continued existence of CLH.

Other Natural Occurrences or Human-related Activities

Expected climate change impacts to California and the Clear Lake watershed will be significant during annual CLH spawning cycles. CLH require winter and spring storms that provide suitable spawning flows in the tributaries of Clear Lake. A shift in timing, temperature, and amount of runoff could significantly impact the ability of CLH to successfully spawn. A report on the projected effects of climate on California freshwater fishes determined CLH to be critically vulnerable to impacts from climate change.

Numerous recreational activities take place in Clear Lake each year. The majority of recreational activities pose no significant threat to the survival of CLH. However, it is believed that recreational and tournament anglers' capture CLH incidentally, at a low rate. The extent of impacts to CLH from angling is unknown, but likely do not threaten the continued existence of CLH.

Comment [TT36]: I think this is a weak summary statement. The document refers to OHV use in the Middle Creek and Scotts Creek watersheds as a source of sediment yet discounts what could be more watershed wide impacts while focusing on the relatively inconsequential bycatch from sport anglers. I don't think too many hitch will take a bass lure.

SUMMARY OF KEY FINDINGS

At present time, the species can be found in portions of its historic habitat and qualitative surveys indicate a variable interannual population. Based on qualitative survey efforts to date a population estimate or index of CLH is not attainable. Without a current population or index for CLH it is necessary to estimate impacts not based on a set baseline but rather against trends seen in abundance and distribution in sampling efforts over the past half century.

It will be imperative for the Department and the conservation community to study and monitor the population of CLH over the next decade. A review of the scientific determinations regarding the status of CLH indicates there are significant threats to the continued existence of the species, particularly related to historical and ongoing habitat modification, predation from introduced species, and competition. Many of these threats are currently or in the near future being addressed by existing management efforts. Monitoring impacts from existing management efforts will be imperative to assessing the future status of CLH.

RECOMMENDATION FOR PETITIONED ACTION

CESA directs the Department to prepare this report regarding the status of CLH in California based upon the best scientific information available. CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)). The Department includes and makes its recommendation in its status report as submitted to the Commission in an advisory capacity based on the best available science.

Based on the criteria described above, the scientific information available to the Department does/does not indicate that CLH are threatened with extinction and likely to become an endangered species in the foreseeable future. The listing recommendation will be provided in this report after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

PROTECTION AFFORDED BY LISTING

It is the policy of the State to conserve, protect, restore and enhance any endangered or any threatened species and its habitat. (Fish & G. Code, § 2052.) If listed as an endangered or threatened species, unauthorized "take" of CLH will be prohibited, making the conservation, protection, and enhancement of the species and its habitat an issue of statewide concern. As noted earlier, CESA defines "take" as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill. (*Id.*, § 86.) Any person violating the take prohibition would be punishable under State law. The Fish and Game Code provides the Department with related authority to authorize "take" under certain circumstances. (*Id.*, §§ 2081, 2081.1, 2086, 2087 and 2835.) As authorized through an incidental take permit, however, impacts of the taking on CLH caused by the activity must be minimized and fully mitigated according to State standards.

Additional protection of CLH following listing would also occur with required public agency environmental review under CEQA and its federal counter-part, the National Environmental Policy Act (NEPA). CEQA and NEPA both require affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on endangered, rare, and threatened special status

Comment [TT37]: To summarize:

1)Pretty sound evidence for substantial physical habitat changes to the lake and surrounding stream system. Greatly reduced access to spawning habitat, altered and diminished stream flows reduce ability for fish to successfully spawn or transport larvae back to the lake This could be more strongly demonstrated by looking a flow records where they are available and plotting the first date of some index flow that would relate to disconnection with the lake. Can an index to lake level be developed as an indicator of connectivity between streams and the lake. I think this evidence would be very valuable in establishing a change in physical habitat. Also, some basic biology on CLH is needed to identify how long spawners are in the stream before they either return to the lake or die. This info would then be used to quantify run abundance.
2) Also it's clear that shallow water shoreline habitat has been reduced in acreage and quality around the lake, and there are some links to larval rearing and this habitat, but it's not strong as presented. Examination of historic aerial photographs may provide hard evidence of trends in reduction of shoreline habitat. One item that needs explanation is that both of these habitat issues (stream connectivity and shorelines habitats) have been long-occurring issues – so, why are they now becoming critical? The stream connectivity issue is decades old, but has yet to be resolved. The largest single piece of evidence for listing under CESA is the long term decline in the size of the adult spawning runs.
3)There is some evidence that the lake rearing habitat has been altered – through the introduction of predators and competitors – and possible alteration of the food web, but this is difficult to tie down to specifics.
4)It doesn't look like exploitation has necessarily been an issue – the commercial catch data, in fact, shows no downward trend through 2001. Excessive harvest could limit recovery in the future.
5) Contaminants are questionable as there are no smoking guns and no solid evidence that links contaminants to CLH decline. Mercury is not a recent contaminant to the lake and CLH have persisted, sometimes in abundance, during this exposure.

I think the Status Review does an adequate job of vetting the breadth of potential causes that are active in the lake basin on CLH but it doesn't do as good a job as possible in nailing down specific cause/effect relationships. I recommend looking at flow recession curves on itributaries and seeing if this data provides any evidence for flows/spawning relationships either being less flow, flow of shorter duration (starting later and/or ending sooner). How do these new flows relate to the access issues? Can these two factors be used to develop better linkages to population level effects?

species. Under CEQA's "substantive mandate," for example, state and local agencies in California must avoid or substantially lessen significant environmental effects of their projects to the extent feasible. With that mandate and the Department's regulatory jurisdiction generally, the Department expects related CEQA and NEPA review will likely result in increased information regarding the status of CLH in California as a result of, among other things, updated occurrence and abundance information for individual projects. Where significant impacts are identified under CEQA, the Department expects project-specific required avoidance, minimization, and mitigation measures will also benefit the species. State listing, in this respect, and required consultation with the Department during state and local agency environmental review under CEQA, is also expected to benefit the species in terms of related impacts for individual projects that might otherwise occur absent listing.

If CLH are listed under CESA, it may increase the likelihood that State and federal land and resource management agencies will allocate additional funds towards protection and recovery actions. However, funding for species recovery and management is limited, and there is a growing list of threatened and endangered species.

MANAGEMENT RECOMMENDATIONS AND RECOVERY MEASURES

Current data on CLH suffers from being largely anecdotal and qualitative in nature. Studies designed to provide quantitative data on CLH populations and the factors that affect the ability of CLH to survive and reproduce are necessary for species management. The following management recommendations were generated by Department staff with considerations from local agencies, non-profits, and interested parties.

- Derive a statistically valid population estimate or index allowing assessment of impacts to the overall population and provide a baseline to maintain a sustainable population level.
- Conduct a thorough assessment of barriers to fish movement on primary spawning streams and provide recommendations for restoration actions on substantial barriers.
- Complete a detailed analysis of spawning habitat in primary spawning streams and provide recommendations for restoration actions.
- Implement identified restoration activities to increase available spawning habitat for CLH.
- Conduct a review of reservoir operations at Highland Springs, Adobe Creek, and Kelsey Creek detention dams to assess water release operations that may be impacting CLH, development and implementation of guidelines for minimizing impacts.
- Conduct an in stream flow analysis of primary spawning tributaries to determine impacts of water diversions on stream flows, particularly during spawning season.
- Coordinate with landowners, stakeholders, and permitting agencies on developing strategies for reducing in stream diversions during spawning season.

- Determine the value of wetland habitat in the watershed pertaining to survivorship of juvenile CLH and make appropriate recommendations on restoration or modification.
- Analyze food web interactions of CLH and non-native fish to determine potential impacts to CLH.
- Conduct a diet analysis of predatory fish species to determine the extent of their impact on CLH.
- Conduct creel surveys to gain a better understanding of CLH capture rates during both recreational and tournament angling.
- Develop a comprehensive monitoring program to assess both native and non-native fish populations and their distribution in the watershed.
- Identify habitats within the watershed that may be suitable for CLH translocations.
- Coordinate the above research and restoration efforts with interested stakeholders in the watershed.
- Develop an outreach program to provide updates to stakeholders on recovery and management efforts.

PUBLIC RESPONSE

Note to Reviewer: Public response will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

PEER REVIEW

Note to Reviewer: Peer review will be finalized after the Department receives, evaluates, and incorporates peer-review comments as appropriate.

LITERATURE CITED

Aguilar, A. and J. Jones. 2009. Nuclear and Mitochondrial Diversification in two Native California Minnows: Insights into Taxonomic Identity and Regional Phylogeography. Molecular Phylogenetics and Evolution 51 (2): 373-381.

Anderson, N.L., D.L. Woodward and A.E. Colwell. 1986. Pestiferous dipterans and two recently introduced aquatic species at Clear Lake. Proceedings of the California Mosquito Vector Control Association. 54:163-167.

Anderson, N.L., 1989. Letter to Rick Macedo containing notes and data from LCVCD sampling efforts.

Avise, J.C. and F.J. Ayala. 1976. Genetic differentiation in speciose versus depauperate phylads: Evidence from the California minnows. Evolution 30:46-58.

Barrett, S.A., 1906. The Ethno-Geography of the Pomo and Neighboring Indians. University of California Publications in American Archeology and Ethnology. Vol 6 No. 1.

Bairrington, P., 1999. CDFG Clear Lake Fishery Management Plan.

Bellucci, C. J., Becker, M., & Beauchene, M. (2011). Characteristics of macroinvertebrate and fish communities from 30 least disturbed small streams in Connecticut. *Northeastern Naturalist, 18*(4), 411-444.

Big Valley EPA, 2013. Hitch interview notes with families of Big Valley Rancheria and Elem Indian Colony.

Big Valley Rancheria, 2012. Hitch *Lavinia exilicauda* Chi Hopkirk ecology and water quality studies in Big Valley sub-basin creeks in 2012.

Big Valley Rancheria, 2013. Big Valley sub-basin creek water quality, quantity, and Hitch *Lavinia exilicauda* Chi Hopkirk ecology program. Spring, 2013.

Brown, A.V., M.M. Little, and K.B. Brown, 1998. Impacts of gravel mining on gravel bed streams. *Transactions of the American Fisheries Society*. 127:979-994.

Bunn, S.E., and A.H. Arthington, 2002. Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity. *Environmental Management*. Vol. 30:4. Pp 492-507.

California Climate Change Center, 2012. Our Changing Climate 2012 Vulnerability and Adaptation to the Increasing Risks from Climate Change in California.

California Department of Fish and Game, 1955-1956. Field notes on Kelsey and Seigler Creeks.

California Department of Fish and Game, 1961-2001. Commercial Catch data for Clear Lake

California Department of Fish and Game, 1969. News Release on Fish Dieoffs at Clear Lake.

California Department of Fish and Game, 1988. Clear Lake Electrofishing Survey, April 2, 1987 Memorandum.

California Department of Fish and Game, 2012. Electrofishing data, Memorandum in progress.

California Department of Fish and Wildlife, 2013. Report to the Fish and Game Commission Evaluation of the Petition from the Center for Biological Diversity to List Clear Lake Hitch (*Lavinia exilicauda chi*) as a Threatened Species under the California Endangered Species Act.

California Department of Fish and Wildlife, 2013. Commercial Fisheries Data from catch records.

California Department of Fish and Wildlife, 2013. Commercial Operators permit applications.

California Department of Fish and Wildlife, April 24, 2013. Press Release – CDFW Seeks Public Comment and Data Regarding Clear Lake Hitch.

California Department of Water Resources. 1975. Clear Lake Water Quality Data.

California Natural Resources Agency, 2009. California Climate Adaptation Strategy Discussion Draft.

California Environmental Protection Agency RWQCBCVR, 2002. Clear Lake TMDL for Mercury Staff Report.

California Environmental Protection Agency RWQCBCVR, 2008, Monitoring and Implementation Plan Clear Lake Mercury and Nutrient TMDL's.

California Environmental Protection Agency RWQCBCVR, 2010. Clear Lake Mercury Total Maximum Daily Load Update.

California Environmental Protection Agency RWQCBCVR, 2012. Clear Lake Nutrient Total Maximum Daily Load Control Program 5-year Update.

California Regulatory Notice Register, 2012. No. 41-Z. p.1501

California Regulatory Notice Register, 2013. No. 12-Z. p.488

Center for Biological Diversity, 2012. Petition to List Clear Lake Hitch (*Lavinia exilicauda chi*) as Threatened under the California Endangered Species Act. 58 pp.

Chi Council for the Clear Lake Hitch (CCCLH). 2013. Hitch spawning survey results, 2005-2013. Available at http://lakelive.info/chicouncil/

Clear Lake Integrated Watershed Management Plan, February 2010. Prepared for West Lake and East Lake Resource Conservation Districts.

Coleman, G.A. 1930. A biological survey of Clear Lake, Lake County. *Calif. Fish and Game* 16: 221-227.

Converse,Y.A., C.P. Hawkins and R. A. VALDEZ, 1998. Habitat Relationships of Subadult Humpback Chub in the Colorado River through Grand Canyon: Spatial Variability and Implications of Flow Regulation. *REGULATED RIVERS: RESEARCH & MANAGEMENT* **14**: 267–284

Cook, S. F., Jr., J. D. Connors, and R. L. Moore, 1964. The impact of the fishery on the midges of Clear Lake, Lake County, CA, *Annals of the Entomological Society of America*, Vol. 57, pp. 701-707.

Cott, P. A., Sibley, P. K., Somers, W. M., Lilly, M. R., & Gordon, A. M. (2008). A REVIEW OF WATER LEVEL FLUCTUATIONS ON AQUATIC BIOTA WITH AN EMPHASIS ON FISHES IN ICE-COVERED LAKES1. *Journal of the American Water Resources Association, 44*(2), 343-359.

Cox, B., 2007. CDFG Clear Lake Fishery Surveys Summary Report.

Curtis T.C. 1977. Pesticide Laboratory report. California Department of Fish and Game, E.P. No. P-133. 3pp.

Crump, KL and VL Trudeau, 2009. Mercury-induced reproductive impairment in fish. *Environmental Toxicology and Chemistry*. 28(5):895-907.

Deitch, M.J., G.M. Kondolf, and A.M. Merenlender. 2009. Hydrologic impacts of smallscale instream diversions for frost and heat protection in the California wine country. River Research and Applications, Volume 25, Issue 2, pages 118-134.

Dill, W. A., and A. J. Cordone. 1997. Fish Bulletin 178. History and Status of Introduced Fishes in California 1871-1996. California. Fish and Game. 414 pp.

Eagles-Smith, C.A., T.H. Suchanek, A.E. Colwell, N.L. Anderson, and P.B. Moyle. 2008. Changes in fish diets and food web mercury bioaccumulation induced by an invasive planktivorous fish. Ecological Applications 18(Supplement): A213–A226.

Ewing, B., 2013. Summary of the Clear Lake Hitch Population Estimate for Cole and Kelsey Creeks, Lake County.

Field, C.B., G.C. Daily, F.W. Davis, S. Gaines, P.A. Matson, J. Melack, and N.L. Miller, 1999. *Confronting Climate Change in California: Ecological Impacts on the Golden State.* Union of Concerned Scientists, Cambridge, MA and Ecological Society of America, Washington, DC.

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

Forsgren Associates Inc, 2012. Clear Lake Watershed Sanitary Survey 2012 Update Final.

Franson, S. 2013. Summary of Spring 20-13 Field Monitoring with Locations chosen for observing egg and larval development of Clear Lake Hitch (*Lavinia exilicauda chi*).

Gafny, S., A. Gasith, and M. Goren 2006. Effect of water level fluctuation on shore spawning of *Mirogrex terraesanctae* (Steinitz), (Cyprinidae) in Lake Kinneret, Israel. Journal of Fish Biology vol 41:6 pages 863-871

Geary, R.E. 1978. Life history of the Clear Lake hitch *(Lavinia exilicauda chi).* Unpublished Master's Thesis, University of California, Davis. 27 pp.

Geary, R.E. and P.B. Moyle. 1980. Aspects of the ecology of the hitch, *Lavinia exilicauda* (Cyprinidae), a persistent native cyprinid in Clear Lake, California. Southwest. Nat. 25:385-390.

Giusti, G. 2009. Human Influences to Clear Lake, California A 20th Century History.

Harnly, M., S. Seidel, P. Rojas, R. Fornes, P. Flessel, D. Smith, R. Kreutzer, and L. Goldman. 1996. Biological monitoring for mercury within a community with soil and fish contamination. *Environmental Health Perspectives*, Vol. 105:4, 424-429.

Havens, K.E. 2008. Cyanobaterial Harmful Algal Blooms: State of the Science and Research Needs. Chapter 33: Cyanobacteria blooms: effects on aquatic ecosystems.
Hayhoe, K., D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider,K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S. Kalkstein, J. Lenihan, C.K.Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Science 101:12422-12427.

Hopkirk, J.D. 1973. Endemism in fishes of the Clear Lake region of central California. University of California Publications in Zoology 96: 160 pp.

Horne, A.J. 1975. The Effects of Copper, Major and Minor Nutrient Element Additions, and Lake Water Movements on Blue-Green Algal Bloom Development in Clear Lake.

Hudon, C., Armellin, A., Gagnon, P., & Patoine, A. (2010). Variations in water temperatures and levels in the St. Lawrence River (quebec, canada) and potential implications for three common fish species. *Hydrobiologia, 647*(1), 145-161.

Hunt, E.G. and A.I. Bischoff. 1960. Inimical effects on wildlife or periodic DDD applications to Clear Lake. California Fish and Game 46:91-106.

Jelks, H L., Stephen J. Walsh, Noel M. Burkhead, Salvador Contreras-Balderas, Edmundo, Diaz-Pardo, Dean A. Hendrickson, John Lyons, Nicholas E. Mandrak, Frank McCormick, Joseph S. Nelson, Steven P. Platania, Brady A. Porter, Claude B. Renaud, Juan Jacobo Schmitter-Soto, Eric B. Taylor & Melvin L. Warren Jr. (2008): Conservation Status of Imperiled North American Freshwater and Diadromous Fishes, Fisheries, 33:8, 372-407.

Jordan, D.S., and C.H. Gilbert. 1894. List of Fishes Inhabiting Clear Lake, California. Bulletin of the United States Fish Commission, Vol. XIV.

Kelsey Creek Watershed Assessment, February 2010. Prepared for East Lake and West Lake Resource Conservation Districts.

Kimsey, J.B. and L.O. Fisk. 1960. Keys to the freshwater and anadromous fishes of California. Calif. Fish Game 46:453-79.

Kniffen, F.B. 1939. Pomo Geography. University of California Publications in American Archaeology and Ethnology. Vol. 36 No. 6 pp. 353-400.

Kratville, D. October 7, 2013. Email correspondence on CESA MOU's issued for CLH.

Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen and I.A. Shiklomanov, 2007: Freshwater resources and their management. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210.

Lake County Department of Agriculture, 2011. Crop Report

Lake County Department of Public Works Water Resources Division, 2003. Clear Lake Wetlands Geographic Information Systems Data User Manual.

Lake County Vector Control District, 2013. Copy of verified Beach Seine 1987-2010 CL Hitch with notes.

Lindquist, A.W., C.D. Deonier, and J.E. Hanley. 1943. The relationship of fish to the Clear Lake gnat, in Clear Lake, California. Calif. Fish Game 29:196-202.

Lindquist, A.W. and A.R. Roth. 1950. Effect of dichlorodiphenyl dichloroethane on larva of the Clear Lake gnat in California. *Journal of Economic Entomology* 43:328-332.

Macclanahan, J., E. W. Danley, H. F. Dewitt, and W. Wolber. 1972[app]. Flood control project maintenance and repair, 1971 inspection report. California Department of Water Resources Bulletin 149-71.

Macedo, R., 1991. Creel Survey at Clear Lake, California March – June, 1988. CDFG Administrative Report No. 91-3.

Macedo, R. 1994. Swimming Upstream Without a Hitch. Outdoor California: January/February 1994.

Marchetti, M.P. and P.B. Moyle, 2001. Effects of flow regime on fish assemblages in a regulated California stream. *Ecological Applications*. 11(2). Pp. 530-539.

McGinnis, D. and E. Ringelberg. 2006. Lake County Fish Barrier Assessment. Technical Memo.

Middle Creek Watershed Assessment, February 2010. Prepared for West Lake Resource Conservation District.

Miller, R.R. 1945. A new cyprinid fish from Southern Arizona, and Sonora, Mexico, with description of a new subgenus of *Gila* and a review of related species. Copeia 1945:104-110.

Miller, R.R. 1963. Synonymy, characters and variation of *Gila crassicauda*, a rare California minnow, with an account of its hybridization with *Lavinia exilicauda*. California Fish and Game 49 (1): 20-29.

Mioni, C., R. Kudela, and D. Baxter. 2011. Harmful cyanobacteria blooms and their toxins in Clear Lake and the Sacramento-San Joaquin delta (California). Central Valley Regional Water Quality Control Board: 10-058-150.

Moyle, P.B. and M. Massingill. 1981. Hybridization between hitch, *Lavinia exilicauda*, and Sacramento blackfish, *Orthodon microlepidotus*, in San Luis Reservoir, California. California Fish Game 67:196-198.

Moyle, P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern in California, 2nd edition.

Moyle, P.B. and T. Light, 1996. Fish Invasions in California: Do Abiotic Factors Determine Success? Ecology 77:1666-1670.

Moyle, P. B. 2002. Inland Fishes of California. Berkeley: University of California Press.

Moyle, PB., JD Kiernam, PK Crain and RM Quinones, 2012. Projected Effects of Future Climates on Freshwater Fishes of California. A White Paper from the California Energy Commission's California Climate Change Center.

Moyle P.B., J.V Katz, and R.M. Quinones. In review. Fish Species of Special Concern for California. Prepared for California Department of Fish and Game, Sacramento

Murphy, G.I. 1948. Notes on the biology of the Sacramento hitch *(Lavinia e. exilicauda)* of Clear Lake, Lake County, California. Calif. Fish Game 34:101-110.

Murphy, G.I. 1951. The fishery of Clear Lake, Lake County, California. *Calif. Fish and Game* 37: 439-484.

National Oceanic and Atmospheric Administration, 2011. Table 2. Toxicity associated with mercury in tissues (ug/g) wet weight.

Nicola, S.J. 1974. The life history of the hitch, *Lavinia exilicauda* Baird and Girard, in Beardsley Reservoir, California. Inland Fish. Admin. Rep. 74-6:1-16.

Osleger, D.A., R.A. Zierenberg, T.H. Suchanek, J.S. Stoner, S. Morgan, and D.P. Adam. 2008. Clear Lake sediments: anthropogenic changes in physical sedimentology and magnetic response. Ecological Applications 18 (Supplement): A239-A256.

Puckett, L., 1972. CDFG Memorandum-Fisheries Survey Clear Lake, Lake County.

Richerson P.J., T.H. Suchanek, and S.J. Why. 1994. The Causes and Control of Algal Blooms in Clear Lake, Clean Lakes Diagnostic/Feasibility Study for Clear Lake, California. Prepared for USEPA Region IX.

Ridout, W.L. 1899. A Fish Jam on Kelsey Creek. *Overland Monthly and Out West Magazine.* Volume 34, Issue 202. p. 333.

Robinson Rancheria Environmental Center (RREC). 2011. Draft Adaptive Management Plan for the Clear Lake Hitch, *Lavinia exilicauda chi*. Available at http://www.robinsonrancheria.org/environmental/water.htm.

Rowan, J., 2008. CDFG Clear Lake, Lake County Memorandum.

Rudd, R.L. 1964. *Pesticides and the Living Landscape*. University of Wisconsin Press, Madison, WI.

Sandheinrich, MB. And KM Miller, 2006. Effects of dietary methylmercury on reproductive behavior of fathead minnows (*Pimephales promelas*). *Environmental Toxicology and Chemistry.* 25(11):3053-3057.

Scotts Creek Watershed Assessment, February 2010. Prepared for West Lake Conservation District.

Scotts Valley Band of Pomo Indians, 2013. Historical accounts provided to CDFW by Steve Elliott and Wanda Quitiquit.

State of California Fish and Game Commission, March 11, 2013. California Fish and Game Commission Notice of Findings

State of California Fish and Game Commission, October 2, 2012. California Fish and Game Commission Notice of Receipt of Petition

Suchanek, T.H., P.J. Richerson, L.A. Woodward, D.G. Slotton, L.J. Holts and C.E. Woodmansee. 1993. Ecological Assessment of the Sulphur Bank Mercury Mine Superfund Site, Clear Lake, California: A Survey and Evaluation of Mercury In: Sediment, Water, Plankton, Periphyton, Benthic Invertebrates and Fishes Within the Aquatic Ecosystem of Clear Lake, California. Phase 1- Preliminary Lake Study Report. Prepared for EPA-Region IX, Superfund Program. 113 pp., plus 2 attachments.

Suchanek, T.H., P.J. Richerson, D.C. Nelson, C.A. Eagles-Smith, D.W. Anderson, J.J. Cech, Jr., G. Schladow, R. Zierenberg, J.F. Mount, S.C. McHatton, D.G. Slotton, L.B. Webber, A.L. Bern and B.J. Swisher. 2002. Evaluating and managing a multiply-stressed ecosystem at Clear Lake, California: A holistic ecosystem approach. “Managing For Healthy Ecosystems: Case Studies,” CRC/Lewis Press. pp. 1233-1265.

Swift, C. 1965. Early development of the hitch, *Lavinia exilicauda,* of Clear Lake, California. Calif. Fish Game 51:74-80.

Thompson, L.C., G.A. Giusti, K.L. Weber, and R.F. Keiffer. 2013. The native and introduced fishes of Clear Lake: a review of the past to assist with decisions of the future. California Fish and Game 99(1):7-41.

U.S. Army Corps of Engineers. 1974[app]. Flood plain information: Big Valley streams (Manning, Adobe, Kelsey, and Cole Creeks), Kelseyville, California. Department of the Army, Sacramento District, Corps of Engineers, Sacramento, California, USA.

U.S. Environmental Protection Agency, 2012. Sulphur Bank Mercury Mine News Release – EPA to Begin Construction of Test Covers in Clear Lake.

Week, L., 1982. Habitat Selectivity of Littoral Zone Fishes at Clear Lake, CDFG California. Administrative Report No. 82-7.

Wetzel, R.G., 2001. Limnology lake and River Ecosystems, 3rd ed. Pg. 834.

Winder, M., J. Reuter and G. Schladow, 2010. Clear Lake Report: Clear Lake Historical Data Analysis.

Appendix A. Summary graphs of spawning observations between 2005 and 2013

Appendix B. Figures depicting CLH observations on spawning tributaries

Appendix C. Description of barriers associated with CLH spawning tributaries

Highland Springs Creek: There is a flood control dam on Highland Springs Creek, a tributary to Adobe Creek, which is impassable to CLH.

Adobe Creek: There is a flood control dam on Adobe Creek above Bell Hill Road that is impassable to CLH. There are two culverts on Adobe Creek that are mitigation barriers to spawning CLH when the water flows and velocity are not too great, but these culverts block CLH migration.

Alley Creek: Alley Creek has been channeled and diverted into Clover Creek. Alley Creek historically supported CLH runs. During some time and under certain conditions migrating CLH can access Alley Creek via the Clover channel bypass, but not when the diversion has silt or sand obstructing it.

Clover Creek: There was a diversion barrier on Clover Creek, a tributary of Middle Creek, which prevented fish passage into Clover Creek and Alley Creek. In 2004 the Robinson Rancheria received a Tribal Wildlife Grant to mitigate the diversion barrier. The work has been completed and the barrier has been modified and no longer obstructs fish passage. However, CLH must pass a concrete diversion structure at the junction with Alley Creek to the northwest of Upper Lake to gain the upper reaches of Clover Creek. This diversion structure usually becomes a complete barrier when filled with gravel and sediment.

Forbes Creek: Forbes Creek has a concrete storm water diversion structure that impedes and at times blocks CLH passage.

Kelsey Creek: On Kelsey Creek, the main barriers to CLH migration are a detention dam 2 to 3 miles upstream of Clear Lake, and the Main Street Bridge in Kelseyville. The rock and concrete weir constructed at the base of the Main Street Bridge is a barrier to the passage of CLH (Peter Windrem, personnel communication, 2012). The structure has a fish ladder which is nonfunctional and the site is nonetheless a total barrier to CLH (McGinnis and Ringelberg, 2008). The Kelsey Creek detention structure below Dorn Crossing has retractable gates which can be opened during the CLH spawning season. However, altered flow patterns and slight increases in the slope of the streambed have been enough to reduce the number of spawning CLH that can pass through the detention structure and move upstream. Also, rock riprap situated below the retention dam seems to have impeded the upstream migration of CLH and needs to be modified to provide a clear channel for fish transit. A number of drop-structures in Kelsey Creek intended for gravel aggradation impede migration. Some of these do not seem to impede CLH passage under current conditions, but CLH navigate them with difficulty especially on the downstream passage. Further upstream, culverts that once tended to clog with debris and block fish migration at the Merritt Road crossing have been removed and replaced by a bridge that poses no impediment to CLH passage.

Lyons Creek: A high culvert on Lyons Creek at Lakeshore Drive prevents CLH from moving upstream. Lyons Creek also has a concrete barrier at the County's Juvenile Hall facility that completely prevents fish passage.

Manning Creek: A dam upstream of known CLH spawning areas in the lower reaches of Manning Creek may prevent CLH from spawning further upstream.

Middle Creek: On Middle Creek, a rock and concrete weir at the Rancheria Road Bridge has been a total fish passage barrier for CLH. Remedial work has been done downstream, with more weirs installed in an effort to elevate the gradient so that CLH could surmount the barrier and work was done to improve their stability after high flows, but it remains to be seen if this will allow CLH passage. Similar weirs to capture and hold gravel were installed many years ago in Adobe Creek and Kelsey Creek that do not impede CLH passage, but there is concern the installed weirs on Middle Creek may be potential barriers to CLH. A downstream weir at Rancheria Road is a partial barrier and improperly sized rip rap at this location acts as partial migration barrier (McGinnis and Ringelberg 2008). CLH were seen recently at Middle Creek Bridge and Highway 20 and although there are no obvious barriers, they did not appear to be able to navigate the swift currents there due to the lack of resting pools. If CLH could surmount Rancheria Bridge, many additional miles of spawning grounds would be accessible to CLH up to areas south of Hunter Bridge, where habitat suitability ends because the channel is braided and shallow due to gravel mining.

Scotts Creek: On Scotts Creek, a rock and concrete weir at the Decker Bridge is a total barrier to the passage of CLH. As water levels have been lower, a barrier at the lower end of Tule Lake is problematic for fish passage to Tule Lake and its tributary Mendenhall Creek, Scotts Creek and tributaries, Bachelor Valley/Witter Springs area tributaries, and Blue Lakes and tributaries. There is a one-way flow gate on the Blue Lakes outlet at Scotts Creek that prevents CLH from entering Blue Lakes.

Seigler Canyon Creek: There are two barriers to CLH migration into Seigler Canyon Creek, an exposed sewer pipe and a road crossing. The sewer pipeline which crosses Seigler Canyon Creek for Anderson Marsh State Park was modified in the 1990s and completely blocks CLH access to that creek, once a major spawning tributary.

Page	Line	Reviewer Comment	Department Response
7	37	or in streams tributary to the Lake?	Accepted- The Department has not found any evidence of hybrids in tributaries.
7	44	Not shown in Fig 1.	Accepted- Figure 1 has been corrected.
8	Figure 1	The map shows stream systems tributary to Clear Lake and does not include the entire watershed. Note that the Cache Creek outflow channel from Clear Lake is not labeled as such.	Accepted- Figure 1 has been corrected.
9	41-43	I've observed spawning mid channel too – and some of these eggs will "eddy out" in the margins. Also note that large volumes of eggs may deplete stream margin areas of oxygen resulting in the mortality of large numbers of eggs	Accepted- Spawning mid-channel has been added to document.
10	3-4	I would restate saying that larvae must move downstream to the lake before the stream flow disconnects with the lake (the stream may still be flowing at upstream locations).	Accepted
10	25-27	This is a strong statement of a cause-effect given it is an unreferenced P-C.	Accepted- Statement was removed based on multiple peer review comments.
10	28-35	Not all tribs are of equal value to spawning. Some of the small channels will only flow during wet years (many of the short tribs on the east side) while others offer some spawning habitat nearly every year (these used to be Seigler, Kelsey, and Middle Cks)	Accepted- Clarification on spawning tributaries added to paragraph.
11	29-30	Has rainfall been linked to streamflows that sustain CLH reproductive success? Are there other data to use besides rainfall (streamflow, lake level, number of passage flow days in representative creeks for adults migrating out of the lake and for larvae moving downstream)? The Status Review is lacking in analysis of hydrology.	Accepted- Information on lake levels and stream flows has been added to the document.
11	37-38	This is conclusion jumping – Consider the factors at work here 1) there's the qualitative nature of the data, 2) some of the CLH data may not be linked to rainfall (juvenile or adult abundance may be lagged one or more years, or 3) there could be compensatory survival in years of high reproductive success, only so many larvae will survive to juvenile or adult life stages.	Accepted- Rainfall information was removed and additional information on stream flows and lake levels was added.
12	Figure 2	These data are all discrete and should be graphed with bars, not lines. I suggest not combining with rainfall it's too confusing in one graph. I question if total rainfall is a good measure for cause-effect. As an example, in 1997, all the rainfall came in January, so spawning conditions later were not that good. Are there other factors to examine in more detail such as lake level during the spawning period? Streamflow volume and persistence are other factors to examine in the individual streams or in index streams. Also juvenile and adult fish should be lagged by an appropriate time step if you're looking at linkages between good spawning conditions relating to strong cohort years.	Accepted- Figure revised
12	Figure 2	Can you include other notable events, such as construction of the detention dam on Kelsey Creek, or other such known features?	No Change- Figure would be to difficult to understand with more information in it. Data will be analyzed to see if additional figures are necessary.
13	8-9	suggested edit "Of those fish, 300 to 400 CLH were found below the Kelsey Creek detention dam."	Accepted
13	12-13	As is wording implies the fish are only in the stream for a day, which is not the case. Suggest edit "CLH counts of 1,000 to 5,000 fish"	Accepted
14	6-8	Do TFS and Inland Silversides populations show similar patterns in abundance to CLH? These are not stream spawners, so would reflect more lake conditions for larval/juv rearing, vs. conditions for spawning. Has this been examined?	Accepted- Information has been added on Mississippi silverside, threadfin shad, and CLH abundance.
14	23-24	It is of interest that these high abundance years were drought years (1987-1992) in California	Noted.
15	5-11	Do we have metadata on seining dates,locations or methods that may influence the catch of CLH?	Noted- The dataset is being evaluated for further use. Information on times, locations, sample methods, etc. was not consistently provided over the duration of harvest.
16	23-26	I don't mean to sound critical, but when we're trying to assess the status of a population, not sampling it is not a sound approach. ++	Noted- The sample design was for general fish surveys not CLH surveys.
18	27-30	All these factors don't have strong links to CLH decline. What are the physical functional links to each one?	Rejected- All of these factors are discussed in the Factors Affecting the Ability to Survive and Reproduce section as impacting CLH.
18	37-38	flood control, highway construction, groundwater use and vegetation.	Accepted- Paragraph reworded
18	38-40	suggested edit "Stream alterations can block migratory routes and impeded passage necessary for adults to reach spawning areas and for larval fish to gain access to the lake."	Accepted- Paragraph reworded

18	41	suggested edit "The result can be direct loss of spawning and rearing habitat, loss of nursery areas or loss of access to these areas,"	Accepted- Paragraph reworded
18	42	How is this linked in the tributary streams?	Accepted- Wording removed.
18	43-45	How does a physical habitat survey end up with an IBI score? This would be a biological survey.	Accepted- Sentence reworded
19	8	A reduction in habitat or a reduction in access to habitat – or both? This distinction is critical to the analysis.	Accepted- Sentence reworded
19	11-17	Define habitat barriers vs. physical barriers. The Kelsey Creek fish ladder was known not to pass hitch in the 1970s – or is this a different ladder than what was present then?	Accepted- Sentence reworded, it is the same ladder with minor modifications.
19	22-24	suggested edit "they continue to prevent migrating CLH from accessing spawning habitat,"	Accepted
19	31-34	The channels shown on Figure 7 include segments of many creeks that would not have been used by CLH because they are either too far from the lake or are not low gradient streams. What criteria were used to screen for potential access?	Noted- The analysis was conducted based on the Departments best knowledge of what could have been historically occupied by CLH. As recommended later by the Department a complete habitat analysis of tributaries needs to be conducted.
19	32-34	suggested edit "the Department estimated 180 stream miles were historically available to spawning CLH and that barriers have eliminated or reduced access to more than 92% of the historically available spawning habitat .	Accepted
21	5	suggested edit "wells that capture underflow from adjacent channels."	Accepted
21	19-25	This is a key piece of information that should be used to structure an analysis around flow persistence in the tributaries. It is buried here and should be brought forward as a key concern earlier in the document and revisited here.	No Change- The previous paragraph describes impacts to CLH and concludes with a comparison to Clear Lake splittail.
21	34	suggested edit "has altered the amount, quality, and distribution of stream gravels"	No Change- The Department has no documentation for the quality of stream gravels.
21	42-43	How much is in-stream mining?	Accepted- Additional information added.
22	4-6	Levees can also result in downcutting by increasing stage and shear stress on the bed during floods.	Noted.
22	7	This section is large and discusses many attributes related to WQ. I suggest some subheadings as appropriate.	Accepted.
22	20-21	suggested edit "Increased sediment loads also reduce spawning habitat quality by increasing substrate “embeddedness” (Mosley 2013).	Accepted.
23	1-7	Some parallels with the Delta on food web dynamics here?	Noted.
25	20-21	suggested edit "Commercial fish harvest at Clear Lake occurred from the early 1900s through 2001."	Accepted
26	29	I found no hardhead in the stream surveys conducted in the basin in 1975-76.	Accepted- Hardhead removed based on peer review comments
26	35-38	But what’s happened to the black bass population over the past 10 years – are their more, large bass compared to pre-2000?	Noted- The black bass population at Clear Lake goes through cycles of many smaller fish to fewer larger fish on regular cycles.
27	4-8	Could this be done for this report?	Noted- Data on Mississippi silverside and threadfin shad numbers was not provided to the Department.
27	9-10	This statement needs a reference.	Accepted- Sentence reworded to remove definitive nature of statement.
27	11-14	Are we looking at a species similar to splittail in the Central Valley, where it goes along at low levels in many years, then has a good spawn and really booms for several years, before returning to background numbers? This is the key question – is it a boom and bust fish or something different.	Noted- Although historical data does not support a boom and bust lifestyle for CLH it appears based on recent trends that they have become that way based on impacts to survival.
32-33	46-5	Linkages to cause/effect are unclear. Increased groundwater elevations would only help to maintain surface flows if they were located at sites where flows are limiting access. Seems that a different approach to management of the lake level would do the same thing.	Noted- Lake levels are a function of deliveries downstream of the outlet dam. Wetland restoration would be a permanent action that would result in long term benefits.
35	14	Let’s be clear on what we’re calling this habitat – Is this inundated shallow water with emergent vegetation? Does it meet the definition of a wetland for regulatory purposes or is it permanently inundated shallow water habitat?	Accepted- Wetlands are described at first mention in the wetlands section.

35	32-36	I think this is a weak summary statement. The document refers to OHV use in the Middle Creek and Scotts Creek watersheds as a source of sediment yet discounts what could be more watershed wide impacts while focusing on the relatively inconsequential bycatch from sport anglers. I don't think too many hitch will take a bass lure.	No Change- Sedimentation is covered in the water quality section even for those activities that are human related.
36	24-26	1) Pretty sound evidence for substantial physical habitat changes to the lake and surrounding stream system. Greatly reduced access to spawning habitat, altered and diminished stream flows reduce ability for fish to successfully spawn or transport larvae back to the lake This could be more strongly demonstrated by looking a flow records where they are available and plotting the first date of some index flow that would relate to disconnection with the lake. Can an index to lake level be developed as an indicator of connectivity between streams and the lake. I think this evidence would be very valuable in establishing a change in physical habitat. Also, some basic biology on CLH is needed to identify how long spawners are in the stream before they either return to the lake or die. This info would then be used to quantify run abundance.	Noted.
36	24-26	2) Also it's clear that shallow water shoreline habitat has been reduced in acreage and quality around the lake, and there are some links to larval rearing and this habitat, but it's not strong as presented. Examination of historic aerial photographs may provide hard evidence of trends in reduction of shoreline habitat. One item that needs explanation is that both of these habitat issues (stream connectivity and shorelines habitats) have been long-occurring issues – so, why are they now becoming critical? The stream connectivity issue is decades old, but has yet to be resolved. The largest single piece of evidence for listing under CESA is the long term decline in the size of the adult spawning runs.	Noted.
36	24-26	3) There is some evidence that the lake rearing habitat has been altered – through the introduction of predators and competitors – and possible alteration of the food web, but this is difficult to tie down to specifics.	Noted.
36	24-26	4) It doesn't look like exploitation has necessarily been an issue – the commercial catch data, in fact, shows no downward trend through 2001. Excessive harvest could limit recovery in the future.	Noted.
36	24-26	5) Contaminants are questionable as there are no smoking guns and no solid evidence that links contaminants to CLH decline. Mercury is not a recent contaminant to the lake and CLH have persisted, sometimes in abundance, during this exposure.	Noted.
36	24-26	I think the Status Review does an adequate job of vetting the breadth of potential causes that are active in the lake basin on CLH but it doesn't do as good a job as possible in nailing down specific cause/effect relationships. I recommend looking at flow recession curves on tributaries and seeing if this data provides any evidence for flows/spawning relationships either being less flow, flow of shorter duration (starting later and/or ending sooner). How do these new flows relate to the access issues? Can these two factors be used to develop better linkages to population level effects?	Noted.