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REPORT

EVALUATION OF THE OWENS TUI CHUB HABITAT

LONG VALLEY CALDERA MONO COUNTY, CALIFORNIA

For
County of Mono
Department of Economic
Development and Special Projects

By
geologica

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-EXECUTIVE SUMMARY

This evaluation of the Owens tui chub habitat was performed to assess the current understanding of the habitat requirements of the Owens tui chub. The Owens tui chub is a federally listed endangered species due to species invasion and habitat degradation. The remaining genetically pure Owens tui chub populations only exist in habitats that are isolated from non-native fish. The isolation is necessary to protect the Owens tui chub from the Lahontan tui chub, a subspecies with which it readily interbreeds and hybridizes, as well as predatory exotic fish such as brown trout and largemouth bass.

Critical habitat has been designated as "high quality, cool water with adequate cover in the form of rocks, undercut banks, or aquatic vegetation, and a sufficient insect food base." Aspects of critical habitat include the following:

Vegetation and Water Flow – Owens tui chub are observed in low velocity waters, typically associated with well-developed beds of aquatic vegetation. Vegetation is used for predator avoidance, reproduction, water velocity displacement, and feeding.

Temperature and Water Quality – Owens tui chub are found both in habitats of consistent temperatures, such as the Hot Creek Headsprings and the Little Hot Creek waterfowl impoundment, and habitats with fluctuating seasonal temperatures such as Lower Owens Gorge, White Mountain Research Station, and Mule Spring. At the Hot Creek Headsprings, water temperatures in the past 15 years have ranged from roughly 14.5 to 18.0 °C. At the White Mountain Research Station, annual temperatures fluctuate from 2 °C in winter up to 25 °C in the summer. Most species of chub spawn at temperatures between 13 and 17 °C.

Food Sources – Like other chubs, the Owens tui chub is an omnivore which feeds mainly by gleaning and grazing among the vegetation. Important food sources appear to be the chironomid larvae, micro caddisfly larvae, and detritus, mostly algae and plankton.

Reproduction – Tui chubs typically spawn from late winter to early summer over aquatic vegetation or gravel bottom. Vegetation is considered important for the survival of the young larvae.

Predators – As mentioned above, non-native fish are predators of the Owens tui chub. The Lahontan tui chub readily interbreeds with the Owens tui chub resulting in hybridized, non-genetically pure offspring. Other predatory exotics such as brown trout and largemouth bass consume the smaller tui chub. The genetically pure Owens tui chub only exists where there are physical barriers to migration of the non-native fishes.

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LONG VALLEY CALDERA
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1.0 Purpose and Scope of Services

This report has been prepared by Geologica, Inc., for Mono County in accordance with our scope of work (Attachment A2, Agreement between County of Mono and Geologica dated August 15, 2003).

An evaluation of the Owens tui chub habitat is important to the ongoing monitoring of the Long Valley Hydrological System to understand the range of water quality, flow and temperatures in surface features of the Long Valley Hydrological System that the Owens Tui Chub inhabits. This evaluation was accomplished by, and limited to, a review of research and information on the Owens Tui Chub available in the public domain and telephone interviews of appropriate individuals at regulatory agencies responsible for monitoring of this endangered species.

1.1 Available Data

Few studies have been conducted specifically on the habitat requirements of the Owens tui chub. An overview of the life history of the tui chub species, in general, is provided by Moyle's classic textbook, Inland Fishes of California (2002). Absent specific habitat information regarding the Owens tui chub subspecies, one might infer that the Owens tui chub habitat lies within the generalized information provided about the species. Many of the environmental assessment documents cite McEwan's detailed study of Owens tui chub inhabiting the Hot Creek Headsprings (1989). Similarly, Jenkins (1990) describes the Owens tui chub at the Owens River Gorge.

Ongoing monitoring of the remaining Owens tui chub populations and habitats has been performed by the California Department of Fish and Game (Steve Parmenter, personal communication, 2003). The most recent report available is the 1999 Monitoring of Sensitive Aquatic Animals in The Owens Basin (Malengo, 1999). The 2002 monitoring report has not yet been completed but should be available soon. Other recent studies on the Owens tui chub have focused on genetics and systematics. References are provided in Section 6.0.

2.0 Introduction

The Owens Tui Chub (*Siphateles bicolor snyderi*) is a sub-species of tui chub. The tui chub is a minnow (*Cyprinidae*), typically small silvery fish. In California, tui chubs are native mostly to interior drainages, except the Central Valley, and

absent from all coastal drainages, except where introduced. Tui chubs occur in many habitats: isolated springs, large desert lakes, sloughs, meadow streams, sluggish rivers, and backwaters of swift creeks (Moyle, 2002). Ten subspecies of tui chub are recognized in California, although further taxonomic work may change the current status. The tui chub subspecies include: Klamath; Cowhead Lake; Goose Lake; Pit River; Lahontan; Eagle Lake; High Rock Springs; Owens; and Mohave.

Early fish collections from the Owens Basin at the beginning of the 20th century suggest that the Owens tui chub were common and occupied a variety of aquatic habitats of the Owens River basin in Inyo and Mono counties (Miller, 1973). Since then, their survival has been imperiled by species invasion and habitat degradation. By 1974, the number of Owens tui chubs had declined so precipitously that the state of California added it to their endangered species list. In 1985, the fish became listed as "endangered" under the federal endangered species act (USFWS, 1998).

Tui chub currently occupy many valley-floor habitats in the Owens River and its tributaries, however, few of these populations are genetically pure Owens tui chub. Non-hybridized Owens tui chub appear to exist only where suitable habitat is isolated from non-native fishes. The isolation protects the Owens tui chub not only from predatory exotic fish such as brown trout and largemouth bass, but more importantly, from the Lahontan tui chub with which it readily interbreeds and hybridizes. The Lahontan tui chubs were presumably introduced as fish bait and spread throughout the Owens River basin.

The remaining genetically pure Owens tui chub populations exist in the following isolated habitats: 1) the AB and CD springs at Hot Creek Fish Hatchery; 2) the uppermost reach of the Owens River Gorge downstream of Crowley Lake; 3) an introduced population at a waterfowl impoundment on Little Hot Creek; 4) a newly rewatered section of the Lower Owens River Gorge (identified in 1995, current existence unknown); 5) University of California's White Mountain Research Station near Bishop (transfers from the Lower Owens Gorge and their progeny); 6) irrigation ditches and spring at Cabin Bar Ranch on Owens Lake (current existence unknown); 7) an impoundment at Mule Spring established in 1990 with rescued fish from Cabin Bar; and 8) Sotcher Lake, Madera County (Middle Fork San Joaquin River drainage). Based on a recent genetic study, the Cabin Bar/Mule Spring tui chubs could merit distinction as a separate subspecies (Chen and May, 2003). The non-hybridized Owens tui chub population at Sotcher Lake occurs outside of its native range. Other hybridized tui chubs are located in the Mono Lake and Mammoth Lakes basin. The origin of these extralimital chub populations is unknown, but may result from the use of tui chubs as live bait for sportfishing or the incidental stocking of trout (Chen and May, 1993).

3.0 Habitat Requirements

While the Owens tui chub was historically present in a variety of habitats within the Owens River basin, the remaining populations are confined to limited areas that are isolated from non-native fishes. Information is provided below about the habitats of these areas. Based on its historical distribution, however, it is likely that the Owens tui chub could flourish at a wider range of conditions than currently exist in these sanctuaries, provided that non-native fishes were not present.

Critical habitat has been designated at two sites for the Owens tui chub: 1) 8 miles of the Owens River and 50 feet of riparian vegetation on either side of the river, encompassing a total of 97 acres in the Owens River Gorge; and two spring provinces and 50 feet of riparian vegetation on either side of spring brooks encompassing approximately 5 acres at Hot Creek Fish Hatchery. Constituent elements of Critical Habitat include high quality, cool water with adequate cover in the form of rocks, undercut banks, or aquatic vegetation, and a sufficient insect food base (50 CFR 17.95 (e)). In addition, the designation identified activities that could adversely modify the critical habitat of the tui chub to include " activities that decrease available water or cause significant change in the physical or chemical properties (e.g. temperature, pH, or dissolved gases of the water).

3.1 Vegetation and Water Flow

The "typical" tui chub habitat is quiet water with well-developed beds of aquatic plants and bottoms of sand or other fine materials (Moyle, 2002). McEwan observed a close affinity of the Owens tui chubs for aquatic vegetation in the Hot Creek Headsprings. He attributed it to four reasons: predator avoidance, reproduction, water velocity displacement, and feeding (McEwan, 1989). Under natural conditions, the aquatic vegetation in both springs covers 75% of the stream surface area, growing out from the sides of the channel. The substrate is a fairly uniform gravel/sand/silt mixture with a high degree of embeddedness. McEwan recommended limiting vegetation removal for hatchery operations to the center one-third of the channel, and only during the non-spawning period.

Morphology, swimming ability, and behavior all suggest that the tui chub as a species is not a stream adapted fish, yet it occurs in many moderate velocity streams, such as the Owens River, Hot Creek and Mammoth Creak. Beds of aquatic vegetation probably create suitable habitat in these streams. Water velocities in the beds of aquatic vegetation at the Fish Hatchery AB and CD springs was essentially zero. Velocities in the surrounding open water were recorded at 0.15m/s (0.5 ft/s). Chubs were observed darting across areas of relatively high velocity to move from one vegetation bed to another, but sustained swimming was not observed in these areas (McEwan, 1989). Water velocities in the waterfowl impoundment and holding ponds are presumed to be low as well.

The CD springs were virtually devoid of vegetation at the time of the 1999 annual monitoring and no tui chub were observed.

In Jenkins' study of the Owens River Gorge fish community, he observed that Owens tui chub were fairly abundant in pools and absent from riffles throughout the stream. The entire population of chubs probably numbered fewer than 5,000, most of which lived in the first kilometer of stream or in rare pool-like areas distributed sparsely along its length. Young-of-year chubs were found only at two sites, both of which were artificially constructed. One was a pond created by a concrete weir, and the other was an abandoned beaver pond. The water was deeper and slower in these areas, and encroached by aquatic vegetation on all sides (Jenkins, 1990).

3.2 Temperature and Water Quality

Information regarding temperature and water quality is presented below for the tui chub species in general, and specifically for the different Owens tui chub habitats.

3.2.1 Tui chubs in general

Waters containing abundant tui chubs usually have summer water temperatures in excess of 20 degrees C and are alkaline, but do well under many conditions from the cold, clear waters of Lake Tahoe to the cool, productive waters of Pyramid Lake, Nevada where total dissolved solids are greater than 4,700 ppm, approximately 75% sodium chloride. Mohave tui chubs, the southernmost representative of the species can survive temperatures from 2 to 36 °C, but optimal temperatures are between 15 to 30 °C. The range of alkalinities tolerated is considerably greater. Tui chubs are regularly found at pH values greater than 9 and can tolerate pH levels of around 11. Tui chubs are also tolerant of low dissolved oxygen levels. In Pyramid Lake they are regularly found at oxygen levels less than 50% saturation, and when the water is cold, they will survive at less than 25% saturation, or 4 mg/L (Moyle, 2002).

3.2.2 Owens Tui Chub

The remaining Owens tui chub habitats vary significantly with respect to water temperature and quality. Table 1 summarizes water temperature and quality information at these Owens tui chub habitats.

Hot Creek Springs (Fish Hatchery AB and CD Springs)

Several studies of the Fish Hatchery AB and CD spring temperatures suggest that temperatures have been fairly constant over the past 15 to 20 years.

McEwan measured temperature and some water quality parameters during his study from 1986 to 1988 at the Hot Creek springs. His results suggested that temperatures in the two springs were quite constant, ranging from 14.5 to 16.0 °C during this period. Dissolved oxygen concentrations varied from 5.4 to 7.0 mg/L and pH ranged from 6.6 to 7.0. Alkalinity varied from 68.0 to 88.4 mg/L (McEwan 1989).

During 1988 to 1997, the mean monthly temperature at the AB spring ranged from 16.3 to 18.0 °C, while the CD spring ranged from 14.5 to 16.8 °C (California Department of Fish and Game, 1998). The temperatures increased during the drought years (1987-1992) with low spring flows.

The 1999 California Department of Fish and Game monitoring (Malengo, 1999) measured the following water chemistry values: dissolved oxygen 5-6 mg/L; conductivity 230-255 Mmhos; pH 7.6; temperatures 14.6 °C (CD spring) and 16.7 (AB spring).

Results of the Long Valley Hydrological Monitoring Program summarized in the Hydrological Interpretive Report on the Geothermal System in Long Valley, Draft dated December 17, 2003 by Geologica, also indicate that temperatures in Fish Hatcher Springs AB and CD have varied over a narrow range between 1997 and 2002. While Fish Hatchery Spring AB ranged from >18 to 15.5 °C, temperatures in the CD springs were lower, ranging from 14 to almost 17°C over this time period (Figure 1).

Little Hot Creek Waterfowl Impoundment

Water in Little Hot Creek cools significantly by the time it reaches the waterfowl impoundment. Steve Parmenter, California Department of Fish and Game) recalls that temperatures range from 21 to 25 °C (personal communication, November 26, 2003) in the waterfowl impoundment.

Upper Owens River Gorge

Water temperature in the Upper Owens Gorge is much cooler than in Hot Creek without the thermal contribution of the springs, and due to the high elevation and summer shade. Jenkins reports that chubs live in water temperatures below 8 °C from December through February (with extremes of 3.5 °C) and at temperatures from 12 to 19 °C for the rest of the year (Jenkins, 1990).

Basic water chemistry values for the Upper Gorge areas measured in 1980 were as follows: 106 total alkalinity (as CaCO3, mg/L); 250 mg/L total dissolved solids; 274 Mmhos/cm specific conductance; 53 mg/L dissolved hardness (as CaCO3); and 7.8 pH (Jenkins, 1990). The 1999 annual monitoring water chemistry data

were: dissolved oxygen from 5.2 to 6.9 mg/L; conductivity from 300 to 340 Mmhos; pH between 8.1 and 8.6; and temperatures from 11 to 14.4 °C.

White Mountain Research Station

Three experimental ponds approximately, 18m x 18m in size, and one smaller decorative pond have been constructed by the University of California for research projects. Temperatures fluctuate greatly in the holding ponds.. In winter, the ponds reportedly have a skin of ice on top and temperatures of 2-3 °C. Temperatures up to 25 °C were recorded in summer (Parmenter, personal communication, 2003). The 1999 monitoring, performed in September, recorded the following water chemistry values: dissolved oxygen 5.6–9.3 mg/L; conductivity 430-660 Mmhos; pH 7.8-8.9; and temperature14.2-19.6 °C.

Cabin Bar Ranch

The 1999 annual monitoring, was performed on June 28, 1999. Water chemistry readings were as follows: dissolved oxygen 2.8-3.2 mg/L; conductivity 202 to 207 Mmhos; pH 7.7 to 8.2; and temperatures of 20.1-20.2 °C. These small ponds would presumably be close to freezing in winter.

Mule Spring

Fish habitat at Mule Spring consists of a rectangular-shaped pond measuring 13m by 9.5m. The 1999 annual monitoring reported the following water chemistry values at the pond inlet: dissolved oxygen 5.8 mg/L; conductivity 870 Mmhos; ph 8.2; temperature 21.1 °C As in the above small ponds, water temperatures in winter would likely be close to freezing.

Sotcher Lake

One would expect distinct seasonal variations in water temperature at Sotcher Lake. We are attempting to locate this data.

3.3 Food Sources

Like other chub subspecies, Owens tui chub is an opportunistic omnivore which feeds mainly by gleaning and grazing amongst the vegetation. A diet analysis of the chub in the AB and CD springs (McEwan, 1989) indicated a diversity of food items (up to ten items in summer) and that chironomid larvae appeared to be the most important food item. They were present in 77.1% of the digestive tracts examined. Other important items were micro caddisfly larvae and detritus, mostly algae and plankton. The constant temperature of the springs promotes year-round growth and production of aquatic plants, algae, and invertebrate food base, allowing the Owens tui chub to remain active year-round.

3.4 Reproduction

Some aspects of tui chub life history can be surmised from studies of other species. In general, tui chubs congregate from late winter to early summer to spawn over aquatic vegetation or gravel substrate (Kimsey, 1954). Females may produce a large number of eggs. A female from Eagle Lake measuring 28 cm contained 11,200 ripe eggs, females from an Oregon population measuring 15-28 cm contained 4,140-25,000 eggs, and Mohave tui chubs measuring 10-22 cm contained 3,800-50,000 eggs. Spawning in most places occurs at temperatures between 13 and 17 °C, although Mohave tui chubs have been recorded spawning at 26 °C. Newly fertilized eggs are 1.5-1.9 mm in diameter and adhere to aquatic plants or bottom. Embryos hatch in three to six days and larvae start feeding soon after hatching (Moyle, 2002).

In McEwan's study Owens tui chub at the Hatchery headsprings, he found a long spawning season, from February until July. Because the water temperature remains constant year-round, it was unclear what environmental stimulus triggered spawning. While he did not observe the Owens tui chub eggs in the vegetation, he noted the adhesive quality of the eggs and observed larval and young chubs in the aquatic vegetation. Aquatic vegetation is presumed to be essential to its reproductive success (McEwan, 1989)

3.5 Predators

As noted above, the greatest predator to the reproduction of the genetically pure Owens tui chub subspecies, is the non-native Lahontan tui chub with which it readily interbreeds. As it is virtually impossible to eradicate the Lahontan tui chub from the Owens River basin, the Owens tui chub exists only in isolated refugia where there are physical barriers to migration of the non-native fishes.

As there are no native fish in the Owens River drainage that eat other fish (McEwan, 1989), the Owens tui chub has not co-evolved with a fish predator and may not have learned predator avoidance. Therefore, it has declined with the introduction of other predatory exotic fish, including brown trout and largemouth bass.

No predation, however, was observed by fingerling rainbow trout present in the AB and CD headsprings, indicating that tui chubs are not a preferred food for these trout at the time of the McEwan's study. Insects appeared to be the most important food item for the trout. McEwan postulates that the trout are selecting for food items which require less energy to capture. The overlap of prey items, particularly chironomids, between trout and tui chubs suggests some competition for food resources is occurring. He also suggested that the trout's diet might shift to include chubs as the trout grow larger (only small ones were observed)

(McEwan, 1989). In fact, numerous trout were observed in the 1999 monitoring of the CD spring, while tui chub were absent (Malengo, 1999). McEwan also observed potential predation by black crowned night herons and great blue herons. The herons cause trout losses at the Hatchery as well.

4.0 Appropriate Habitats within the Long Valley Caldera

The essential requirements for Owens tui chub habitat appear to be: 1) physical isolation from non-native fish; 2) vegetation; 3) low-velocity waters; 4) sufficient food sources (larvae and detritus); 5) water temperature and quality within its tolerance range. Of these, isolation is probably the most important.

The Owens Basin Wetland and Aquatic Species Recovery Plan (US Fish and Wildlife Service, 1998) describes actions necessary to restore populations and enhance habitat for the Owens tui chub and other threatened or endangered species so they no longer require protection of the Endangered Species Act. It is a broad ecosystem-based recovery plan. The Plan identifies a number of potential Conservation Areas, or landscape units characteristic of the Owens Basin valley-floor that include habitat for rare species, where impacts to existing land and water uses are minimal and chances for recovery of candidate species are greatest. The Conservation Areas include: Little Hot Creek and Hot Creek in Long Valley; Round Valley, Fish Slough, Warm Springs, Blackrock and Southern Owens in the Owens Valley; and Mule Spring in the Inyo Mountains. These habitats are on lands owned by Los Angeles Department of Water and Power, Bureau of Land Management, and US Forest Service. Besides the difficulty of obtaining cooperation from these entities, one problem of this multi-species plan with respect to the Owens tui chub is maintaining isolation on a stream system such as Little Hot Creek. If non-native fish are present within the Conservation Area, an Owens tui chub population will probably not be viable.

The success of the Owens tui chub at Sotcher Lake indicates that it is adaptable, even to habitats out of its native range. Within the Long Valley Caldera, suitable habitat for Owens tui chub may exist in isolated ponds or impoundments that could be stocked with the fish. The landowner, however, would have to agree to the restrictions on land use and potential responsibilities of maintaining an endangered population.

5.0 Conclusions

Owens tui chub habitat in the Long Valley Caldera is typically low velocity waters with abundant vegetation, and includes a wide range of water temperatures. Waters vary from the consistently warm temperatures of the Fish Hatchery Springs and Little Hot Creek impoundment (14-18 °C and 21-25 °C, respectively) to the seasonal variations observed in the Upper Owens Gorge and various holding ponds where temperatures can range from 2-25 °C within a year.

Perhaps the greatest challenge to the Owens tui chub is locating habitats that are free of non-native fish, for its biggest threat appears to be introduced exotics such as the Lahontan tui chub with which it readily interbreeds and predatory fish such as brown trout and largemouth bass.

6.0 References

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Habitat	*Temperature (° C)*	*Water Quality (mg/L)*	*Vegetation*	*Population*
AB Springs Hot Creek (McEwan, 1989); (CDFG, 1998)	14.5-16.0 16.3-18.0	DO 5.4-6.8; Alkalinity 68.0-81.6; PH 6.6-6.9	Abundant floating vegetation	Native. 334 +/- 105 individuals in 1988. 180-245 in 1999.
CD Springs Hot Creek (McEwan, 1989); (CDFG, 1998)	14.5 14.5-16.8	DO 5.8-7.0; Alkalinity 74.8-88.4; PH 6.7-7.0	Abundant in 1988; absent in 1999.	Native. 523 +/- 146 individuals in 1988. Not observed in 1998-1999.
Upper Owens River Gorge (Jenkins, 1990; Malengo, 8/1999)	3.5 – 19 11-14.4	Alkalinity 106; TDS 250 pH 7.8 DO 5.2-6.9 PH 8.1-8.6	Abundant in pools where chubs observed	Native. Less than 5000 in 1989. 28 observed in 1999.
Waterfowl Impoundment Little Hot Creek (Parmenter, 2003)	21-25	NA	NA	811 transplants from CD Springs and Upper Owens in 1988.
UC White Mountain Research Station ponds (CDFG, 2003) (Malengo, 9/1999)	2-25 14.2-19.6	DO 5.6-9.3 pH 7.8-8.9	Thick algae	24 transplants from Lower Owens Gorge relocated in 1997. 40 chub moved to new pond in 1999.
Cabin Bar Ranch pond (Malengo, 6/1999)	20.1	DO 2.8-3.2 pH 7.7-8.2	Dense aquatic vegetation	273 trapped in 1999 monitoring;
Mule Spring (Malengo, 6/1999)	21.1	DO 5.8 pH 8.2	Cattails along edges	52 transplants from Cabin Bar in 1990. Few in 1999.
Sotcher Lake Madera County	NA	NA	NA	Incidental population

Table 1. Selected Characteristics of Owens tui chub habitat.

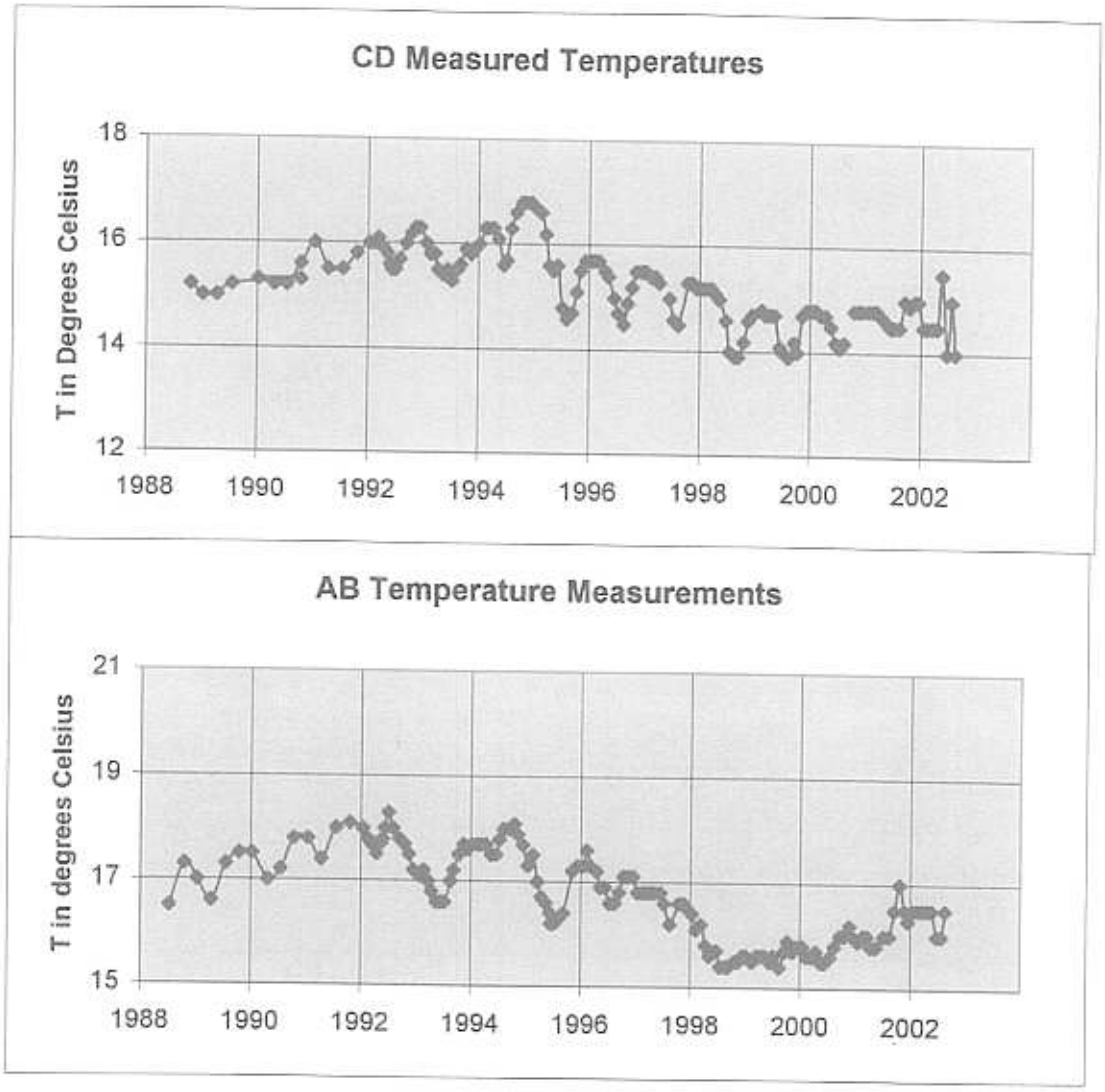

Figure 1. Temperatures in Fish Hatchery Springs AB and CD
Evaluation of Owens Tui Chub Habitat